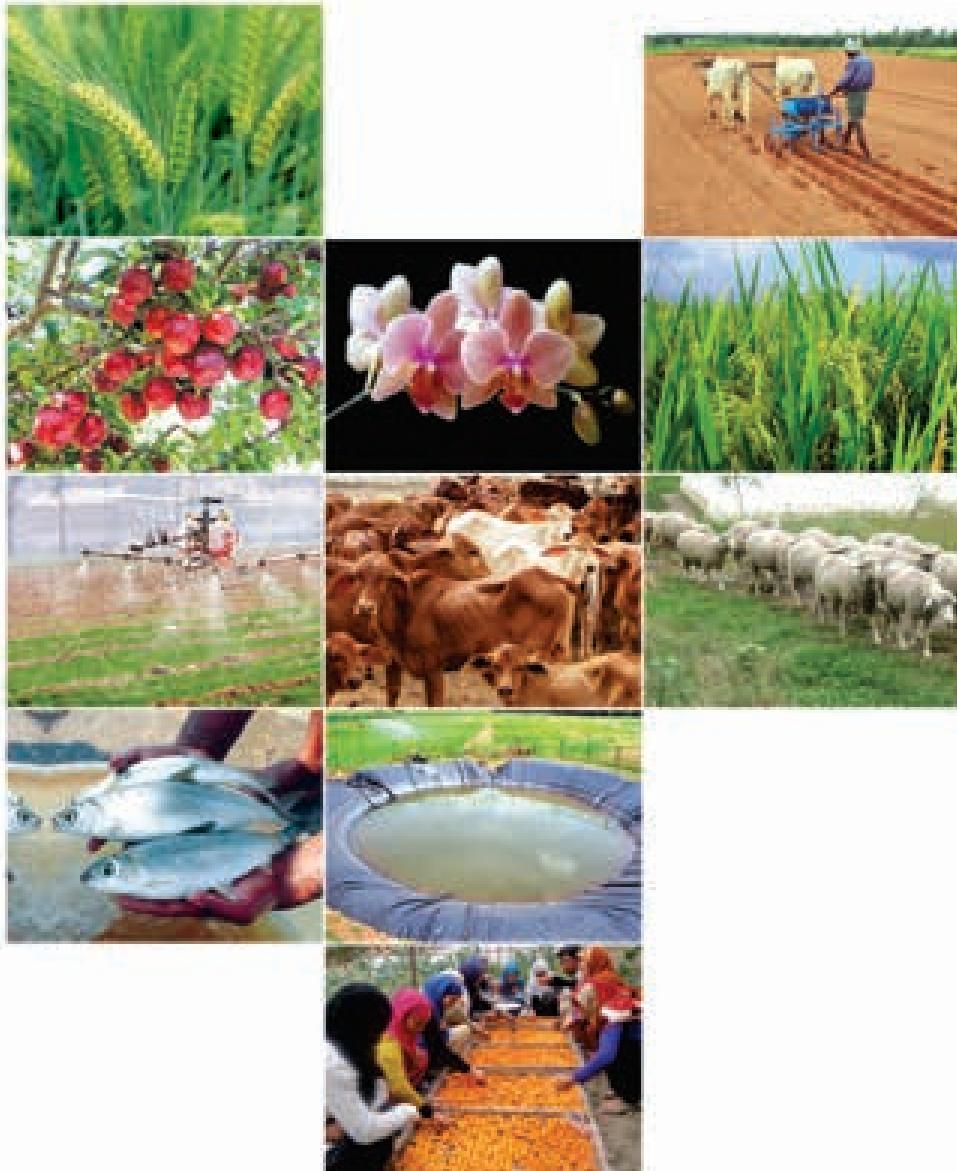


ANNUAL REPORT

2019-20



Department of Agricultural Research and Education
Ministry of Agriculture & Farmers Welfare
Government of India

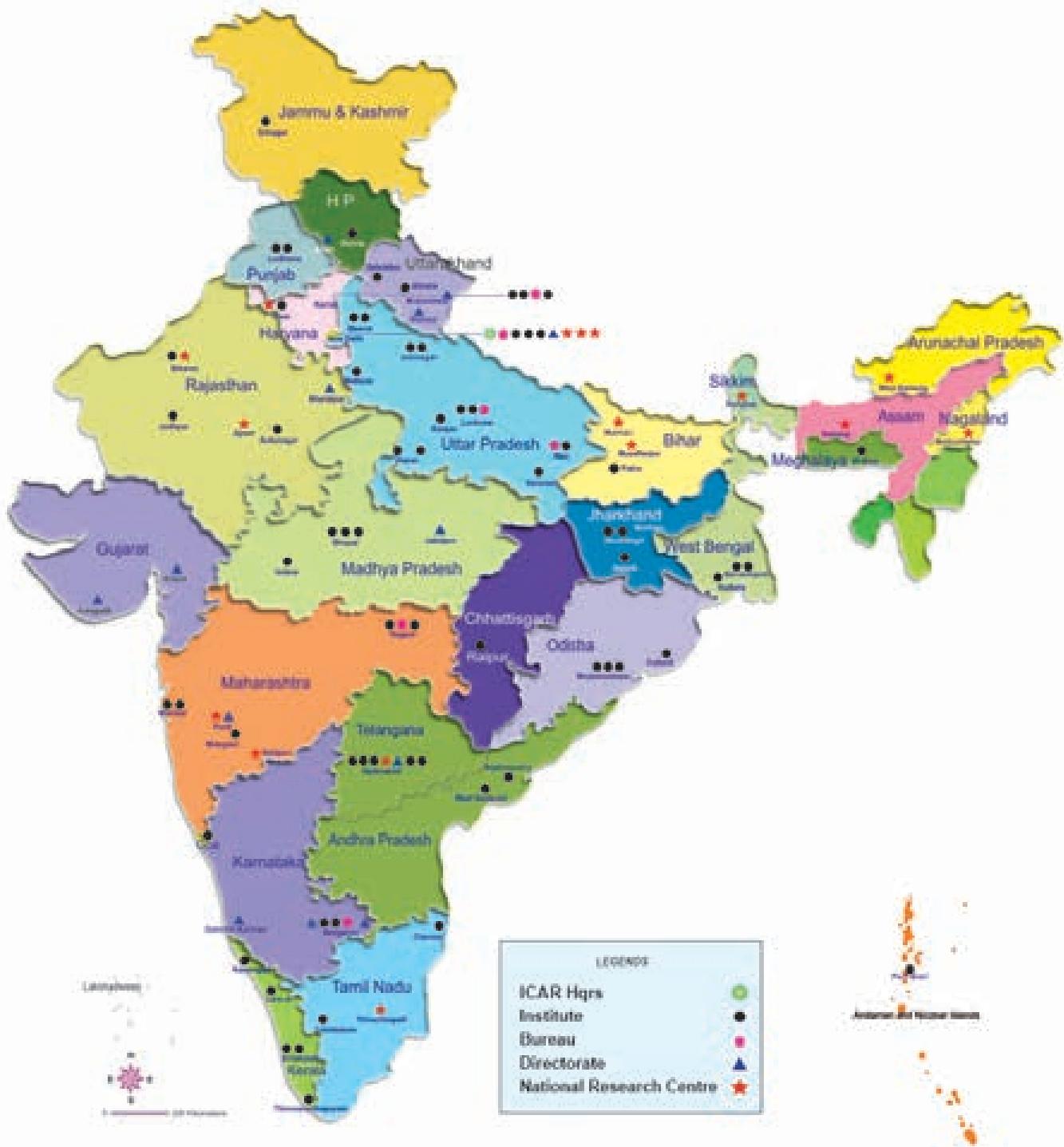


Indian Council of Agricultural Research
New Delhi



INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Institutes, Bureaux, National Research Centres
and Directorates



Annual Report

2019-20



सत्यमेव जयते
Department of Agricultural Research and Education
Ministry of Agriculture and Farmers Welfare
Government of India



Indian Council of Agricultural Research
New Delhi

Foreword

Agriculture, with its allied sectors, is unquestionably the largest livelihood provider in India, more so in the vast rural areas. It also contributes a significant share to the Gross Domestic Product (GDP) of country. Sustainable agriculture, in terms of food security, rural employment, and environmentally sustainable technologies such as soil conservation, sustainable natural resource management and biodiversity conservation, are essential for holistic rural development. Indian agriculture and allied activities have witnessed green revolution, white revolution, yellow revolution and blue revolution to improve overall growth of various sectors.

Presently special emphasis has been on micro level agricultural land use planning, soil and water conservation, water harvesting storage and groundwater recharge, improving water productivity and nutrient use efficiencies, integrated nutrient management, resource conservation technologies, organic farming, integrated farming system including agroforestry, waste water utilization, hill and coastal agriculture, bio waste management, weed management, climate resilient agriculture, abiotic stress management cutting across the states/UTs. An e-ATLAS on Micronutrients in Indian Soils was developed to address the problem of micronutrients deficiency in different soils of the country. Climate resilient integrated organic farming systems were developed for small and marginal farmers for semi-arid region and sloppy land of NEH region.

During this year, a total of 220 varieties of food crops were notified and released for commercial cultivation. These varieites comprised cereals (96), oilseeds (37), pulses (51), commercial crops (18) and forage crops (18). Besides, 20 biofortified varieties of different crops including rice, wheat, maize, sorghum, pearl millet, linseed and finger millet were developed through genomic selection. The CRISPR-Cas9 genome editing technology was standardized for different crops to enhance stress tolerance and nutritional quality. A total of 133 varieties of horticultural crops were notified and released for commercial cultivation consisting of varieties of vegetable crops (71), spices (14), seed spices (15), potato (5), tuber crops (18), fruit crops (6), and plantation crops (4).

A decision support system for precision nitrogen application saving up to 26 kg nitrogen/ha thus reducing the substantial cost of cultivation was developed. Conservation agriculture (CA)-based ICM module and cotton-wheat system were recommended, which gave higher system productivity. Drone remote sensing method for field phenotyping was developed with multi-

spectral sensor for monitoring nitrogen and drought stress in wheat. Various machines and suitable methodologies were developed to mechanize different labour intensive farm operations in plains and hilly regions.

On the request of DARE, Government of India issued Gazette Notification to provide legal protection to the registerd animal breeds and for developing mechanism of benefit sharing among the animal keepers. Presently 184 indigenous animal breeds have been registered under livestock and poultry in India. The cattle improvement through selection programme covers Gir, Kankrej and Sahiwal breeds. Elite herds of Jaffarabadi, Surti, Bhadawari and Nili Ravi breeds of buffaloes were established in their respective breeding tracts, and semen freezing laboratories were established there. AICRP on Goat Improvement has bagged Breed Survivor Recognition for Malabari, Jamunapari and Surti goats. Highly sensitive diagnostic methods were developed for FMD, bluetongue virus antigen, food-borne pathogens, and avian influenza. Pen-side diagnostic kits for detection of porcine circovirus and porcine parvo virus of pig was developed, which can detect virus within 1 hour.

An online information system, AqGRISI (Aquatic Genetic Information System of India) was developed to provide information on different aspects of native fishes of India. For the first time five aquatic species from Indian waters in different states were reported. Endemic, rare and threatened catfish species from Western Ghats, viz. *Hemibagrus punctatus* and *Clarias dussumieri*, were captive bred with wild collected broodstock. For restoring fisheries diversity of river Ganga, large scale ranching of Indian major carp fingerlings produced by induced breeding of wild broodstocks was undertaken. A Hilsa ranching station was also established at Farakka, West Bengal for its restoration and conservation. For onsite estimation and monitoring of water quality for aquafarming a multi-parameter water analysis kit, was developed. CarryCap-Aquaculture planning tool was designed for assessing carrying capacity of natural water bodies for planning expansion of aquaculture. Trademark for the technologies CAGEGROW®, CIFRI GI CAGE®, CIFRI PEN HDPE® and CIFLIN®, were registered.

Quality assurance of Agricultural Universities (AU) was ensured through accreditation and ranking of the AUs. 24 new experiential learning modules were supported under student READY component. Financial support was also provided for strengthening, renovation and modernization of student hostels, laboratories,



examination halls and smart classrooms to various AUs. An android app called KISAAN-Krishi Integrated Solution for Agri Apps Navigation, which provides an integrated interface for more than 110 apps in agriculture and allied areas developed by ICAR institutions, was launched.

National level Cluster Frontline Demonstrations (CFLDs) on Pulses were initiated to demonstrate the production potential of new pulses varieties and the related technologies. During the year, 39,648.14 q seed of pigeonpea, blackgram, greengram, lentil, chickpea, field pea and lathyrus was produced and made available to farmers. Capacity development of 1.16 lakh extension personnel was carried out through 3,948 courses in the country. ICAR awards were given in 21 different categories to 150 awardees, comprising 101 scientists, 8 administrative personnel, 3 journalists and 20 farmers. MoUs and Workplans for Cooperation in the field of

Agricultural Research and Education were signed between ICAR and several international organizations.

The DARE/ICAR has made significant progress during the year 2019 and continuously working on several innovative plans to facilitate agricultural research and technology development for the benefit of Indian farmers. I hope the *DARE/ICAR Annual Report 2019–20* will provide useful information to the diverse stakeholders and prove to be a helpful compilation for planning future programmes for agriculture research and education in India.



(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 Radha Mohan Singh (Till 30 May 2019)
Shri Narendra Singh Tomar (From 30 May 2019)

Union Ministers of State for Agriculture

: Shri Parshottam Rupala (Till 30 May 2019;
From 30 May 2019)
Shri Gajendra Singh Shekhawat
(Till 30 May 2019)
Smt Krishna Raj (Till 30 May 2019)
Shri Kailash Choudhary (From 30 May 2019)

Secretary, DARE and Director General, ICAR : Dr Trilochan Mohapatra

Additional Secretary, DARE and Secretary, ICAR : Shri Sushil Kumar

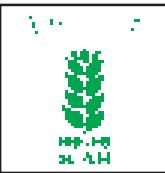
Additional Secretary and Financial Adviser,
DARE/ICAR : Shri B. Pradhan



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.

ICAR



1.

Overview

The Indian Council of Agricultural Research (ICAR) is the harbinger of Green Revolution in India and instrumental in subsequent advances in agriculture sector in India through its significant achievements in research, extension and education. It has empowered the country to increase the production of food grains by 5.4 times, horticultural crops by 10.1 times, fish by 15.2 times, milk 9.7 times and eggs 48.1 times, since 1951, thus making a visible impact on the national food and nutritional security. The ICAR has played a pivotal role in promoting excellence in higher education in agriculture, while also engaging in innovative areas of science and technology development by its research, which is acknowledged nationally and internationally. In the recent years, ICAR has been playing an important and proactive role in the agricultural technology dissemination through its strong network of Krishi Vigyan Kendras and supporting farmers in all possible ways. ICAR is sturdily contributing towards the efforts and initiatives of government to double the farmers' income by 2022 by its research on farming systems, policy inputs and coordination with state agencies.

To increase the production of food crops in India, the ICAR led the National Agricultural Research System (NARS) in developing location-specific new high yielding varieties/hybrids and their matching production and protection technologies of food and horticultural crops. As a way forward to take the new crop varieties to the farmers' fields, the ICAR also shoulders the responsibility of producing breeder seeds, which is further converted to foundation and certified seeds by the developmental agencies for commercial cultivation by the farmers. Protagonist role of such an institutional arrangement towards the enhancement of productivity paved the way for the country to attain thumping achievements in food security. Further research in agricultural sciences has been focusing on employing modern tools of crop breeding and techniques to insulate major biotic (diseases/pests) and abiotic stresses (heat, drought, cold/frost, salinity/alkalinity, acidity, etc.) of food crops with great success. Novel ideas such as nutri-gardens, nutri-farms and nutri-smart village concepts should be piloted for upscaling and outscaling apart from achieving climate resilience and sustainability in food production systems through diversified agriculture *per se*.

Soil and water productivity: The special thrust is on micro level agricultural land use planning, soil and water conservation, water harvesting, storage and groundwater recharge, improving water productivity and nutrient use efficiencies, integrated nutrient management, resource conservation technologies, organic farming, integrated farming system including agroforestry, waste water utilization, hill and coastal agriculture, bio waste management, weed management, climate resilient

agriculture, abiotic stress management cutting across the states/UTs. Land Resource Inventory (LRI) on 1:10,000 scale for 27 aspirational district of India was prepared to workout block level land use planning. Potential areas for sesame in Andhra Pradesh, Telangana and West Bengal; oil palm in Andhra Pradesh; pomegranate in Karnataka and Madhya Pradesh were identified. For drought proofing in Bundelkhand region, *Haveli System* was rejuvenated to enhance system productivity. Subsurface drip irrigation for sugarcane cultivation in waterlogged saline Vertisols was standardized. The subsurface drip irrigation resulted in higher cane yield (131.0 t/ha) compared to surface drip method (124.4 t/ha) and furrow irrigation (105.0 t/ha) method. HDPE Embedded *Gabion* structures established in drainage channels reduced the sediment concentration by 70% over the traditional gabion check-dams without using plastic films, and stored 9,000–15,000 m³ water resulting in rise in water-table in wells by 0.6 m and irrigated area of 1 ha. An e-ATLAS on *Micronutrients in Indian Soils* was developed to delineate micronutrients deficiency in different soils of the country. A microbial bio-formulation 'Halo-CRD' consisting of two efficient and compatible halophilic bacterial lingo-cellulolytic strains was developed for *in-situ* decomposition of rice crop residues in salt-affected soils.

Climate change and resilient agriculture: A district level vulnerability map of Indian agriculture to climate change was updated with 5th Assessment Report (IPCC 2014) climate projections. Climate resilient integrated organic farming system model (one ha) was developed for small and marginal farmers for semi-arid region and sloppy land of NEH region. The carbon footprint of milk production for small (2–3 cattle), medium (4–6 cattle) and large dairy (>10 cattle) farmers was calculated as 1.03, 1.01 and 1.27 kg CO₂-eq/kg FPCM (Fat Protein Corrected Milk) respectively. An excel based model was developed for life cycle assessment of greenhouse gas from dairy farms of Karnataka. The estimation of annual enteric methane emission revealed that livestock at national level emit about 2.62 Mt methane/km². In Bihar, West Bengal, Uttar Pradesh, Assam, Jharkhand and Andhra Pradesh more enteric methane is produced than the national average owing to dense livestock population ($\geq 204/\text{km}^2$). A comprehensive database of differentially expressed miRNAs in cattle during thermal stress was developed. Broiler litter was found to be a methanogenic substrate, but hatchery and slaughter wastes and dead birds were suitable for composting.

Genetic resources: Important plant genetic resources collected include cold tolerant barley and wheat (46) and *Allium* spp. (21) from Uttarakhand and Jammu and Kashmir; landraces of paddy (93), taro (10), chilli (9),





cowpea (12) and urd (8) from Assam, rice landraces (32) from Manipur, rice landraces (28) and legumes (mainly urd and pigeon pea) from Meghalaya; rice landraces (15) from Upper Siang, Arunachal Pradesh; vegetables (189) from Tripura; maize (11) from Mizoram; cucurbits (65) from Bihar; coriander (54) from Madhya Pradesh; and tropical underutilized minor fruits (39) from Goa and Konkan regions. Overall 2,623 accessions were collected during this year from 23 explorations. The National Herbarium of Cultivated Plants (NHCP), New Delhi has a total of 23,942 specimens of which 376 specimens have been added during the reporting period. Currently the base collection of National Genebank has a total of 4,42,909 accessions with the addition of 12,417 accessions during this year. The *in vitro* Genebank, has a total collection of 1,879 accessions in the form of ~38,000 *in vitro* cultures of 54 genera of which 24 accessions have been added during the reporting period. In the Cryogenebank, 491 accessions of seeds pollen and genomic resources of different crop species were successfully cryopreserved, leading to total collection of 13,814 accessions belonging to 820 species. A total of 1,59,687 samples were imported from 40 countries, and 2,041 samples were exported under various collaborative research projects. A database to identify rice varieties/germplasm was developed using 729 diverse rice varieties with 35 SNP and 36 SSR markers for identification of an unknown sample by comparing profile with the database. A total of 15,465 accessions comprising different crops namely wheat, barley, maize, small millets, ricebean, cowpea, sesame, linseed, mustard, vegetable crops, etc. were characterized for agromorphological descriptors at NBPGR. Detailed evaluation for biotic and abiotic stresses in crops, viz. wheat (912 acc.), rice (1,000 acc.), chickpea (300 acc.) and for biotic stresses in okra (532 acc.) was done at hot spot locations/artificial conditions. DNA fingerprinting of 180 samples of crops (cotton, pearl millet, soybean, paddy, mung bean, foxtail millet, finger millet, wheat, cowpea, walnut, sesame, sponge gourd, pigeon pea, maize, chilli, melon, toria, mustard, linseed and bottle gourd) from public and private sector organizations including released varieties was done.

A total of 13 germplasm accessions of pomegranate, 33 exotic accessions of banana, nine lemon varieties from USA and five lemon varieties from South Africa were collected/procured through NBPGR. On the basis of morpho-taxonomic characterization, seven new banana (*Musa* sp. & wild relatives) germplasm accessions were identified and added to core collection. In grapes, genotypes with prominent berry diameter (14), bunch compactness (3) and coloured pulp (6) were identified. In date palm, one early maturing (mid July) elite seedling variant (CIAH/DP/S-2) was identified.

Presently National Agriculturally Important Microbial Culture Collection (NAIMCC) at National Bureau of Agriculturally Important Microbes, Maunath Bhanjan holds more than 6,800 agriculturally important microbes including bacteria, fungi and cyanobacteria, to which 135 new accessions have been evaluated and added during the current year. In addition to thousands of

dead insect collections, over 110 live insect cultures are being maintained and frequently shared with stakeholders (farmers, KVKS, Research organizations and students) for experimental studies related to biological control.

The Breed registration Committee approved registration of 15 new breeds of livestock and poultry. The total number of indigenous breeds now registered in the country are 184. Government of India on the request of DARE, Ministry of Agriculture and Farmers' Welfare, issued a Gazette Notification on 14 October 2019 recognizing 184 registered indigenous breeds of livestock and poultry. The Gazette Notification provides legal support to Intellectual Property Rights (IPRs) to the registered breeds and for developing mechanism for sharing benefits among the animal keepers. A draft map of genome of Malnad Gidda cattle was established, which will provide a valuable resource for accelerated research to identify molecular underpinnings for the unique biological traits in Malnad Gidda cattle in particular and *Bos indicus* cattle in general. The database on categorized Friesian crossbred bull spermatozoal transcripts was developed to use as a non-invasive tool for prediction of male infertility in crossbred bulls. Study on correlation of different semen quality parameters with expression profiles of genes showed that *AKAP4* had significant correlation with both semen quality parameters. Acrosome integrity was also found correlated with the expression profiles of *SOD*, *PKM2*. Phylogenetic analysis of the assembled mithun mitochondrial genome and other available *Bos* species demonstrated the inclusion of mithun and gaur (*Bos gaurus*) in the same cladogram suggesting their common origin from an ancient *Bos* species, which might be extinct now. The genetic distance calculated using genome wide SNPs in the Indian yaks revealed that Ladakhi and Sikkim yak populations are distinct.

Five new aquatic species were recorded from Indian waters, viz. *Aenigmachanna mahabali*, from a well in Kerala; *Cypselurus opisthopodus*, from south-eastern Arabian Sea; *Bathymyrus simus*, from Arabian Sea and Bay of Bengal; *Leptojulis lambdastigma* from Andaman and Nicobar Islands and *Thor hainanensis*, an ornamental shrimp from Agatti Island, Lakshadweep. An online information system, AqGRISI (Aquatic Genetic Information System of India) was developed to provide information on different aspects of native fishes of India. Characterised natural populations of *Chitala chitala*, *Mugil cephalus*, *Silonia silondia* and *Tenualoosa ilisha* using mitochondrial markers for population divergence and genetic stock identification. Molecular markers for diagnosis of EUS (Epizootic Ulcerative Syndrome) disease resistance/ susceptibility in fishes were ascertained. Genes involved in muscle growth, lipid synthesis and immune system of hilsa (*T. ilisha*) were identified. Full reference transcriptome sequences were generated separately for male and female fish parasite, *Argulus siamensis* for its efficient control. Established protocol for producing sterile triploid rainbow trout, *Oncorhynchus mykiss* for its production enhancement.

Crop improvement: During reported period, a total



of 220 varieties were notified and released for commercial cultivation. These comprised 96 of cereals, 37 of oilseeds, 51 of pulses, 18 of commercial crops and 18 forage crops. Besides, 20 biofortified varieties of different crops including rice, wheat, maize, sorghum, pearl millet, linseed and finger millet were also developed. Six varieties of different cereal and pulse crops, viz wheat, maize and chickpea were developed through genomic selection. The CRISPR-Cas9 genome editing technology was standardized for different crops to enhance stress tolerance and nutritional quality. In rice, CRISPR-Cas9 genome editing was used to develop mutants of *DST* (*Drought and Salt Tolerance*) gene for improving salt and drought tolerance. Phenomics technology was used to identify germplasm and breeding lines with high water use efficiency and drought tolerance in the major food crops. Genotypes using significantly less water than that of Nagina 22 in rice and RILs of wheat superior to C 306 in WUE were identified. Total breeder seed production in field crops was 115,293.4 q against the indent of 83,690.1 q. The major share in total breeder seed production belonged to cereal crops, i.e. 61,976.6 q against indent of 36,814.1 q. In addition, quality seed including all classes was 468,610 q against the target of 388,137 q was also produced. For horticulture crops, 178.1 lakh planting material and 12.2 lakh tissue culture plantlets were produced against the targets of 193.5 and 5.1 lakh, respectively.

During reported period, a total of 133 varieties of horticultural crops were notified and released for commercial cultivation; comprising varieties of vegetable crops (71), spices (14), seed spices (15), potato (5), tuber crops (18), fruit crops (6), and plantation crops (4). Arka Suprabhat mango, a double cross hybrid between Amrapali × Arka Anmol was developed. It bears in bunches with a fruit yield of 35–40 kg/tree. A promising coconut hybrid BGR × ADOT (Tall × Tall) with 81.4 nuts/palm/year yield was developed. Cocoa hybrids, viz. VTLCP 8 and VTLCP 9, with high yield potential, were found suitable for high density planting under arecanut and coconut plantation. Oil palm hybrids (Godavari Swarna, Godavari Ratna and Godavari Gold) with higher yield were identified. Arka Sharath, and Kashi Rajma French beans with parchment less pods and having high yield potential were developed. The genetically modified and biofortified banana cultivars Rasthali and Grand Naine with enhanced pro-vitamin-A were developed. The protocol for large scale micropropagation of Elakki Bale banana using embryogenic cell suspension was developed. SCAR (Sequence Characterized Amplified Region) molecular markers for identification of arecanut inter-specific hybrid were developed and validated. Whole genome of an androgenic potato dihaploid C-13 was sequenced with reference assembly. Overall, 30,241 genes were identified in C-13 genome, of which 15,538 genes were characterized by the GO terms.

Livestock improvement: The indigenous cattle breed improvement program is being undertaken in Gir, Kankrej and Sahiwal breeds. The average first lactation (305 days or less) milk yield at their germplasm (GP) units

was 2,344.4 kg in Gir, 2,258.17 kg in Kankrej and 1651.62 in Sahiwal breed respectively. The progeny testing project envisages to test Frieswal (HF×Sahiwal) bulls under field conditions at four agro-climatic locations in India; and at all places, first lactation milk production showed an increasing trend over the years while the age at first calving recorded a decrease. The overall mean 300 days milk yield in crossbreed Frieswal was 3,335.82 kg. Progeny testing in Murrah buffalo was carried out at six participating institutional/SVU centres. The weighted average of 305 days lactation milk yield in Murrah buffalo revealed an overall 58.98% improvement since inception of the project. Elite herds of Jaffarabadi, Surti, Bhadawari and Nili Ravi breeds of buffaloes were established in their respective breeding tracts, and semen freezing laboratories were also established there. Mega Sheep Seed Project has cooperating units for Mandya, Mecheri, Sonadi and Malpura sheep for improvement of farmers' flocks. CSN1S1 polymorphic pattern provides an opportunity to select and bred goats for producing milk with desired protein content. AICRP on Goat Improvement has bagged Breed Survivor Recognition for Malabari, Jamunapari and Surti goat breeds. Male lines, viz. PD-1 (Vanaraja male line) and PD-6 (Gramapriya male line) and female lines, viz. PD-2 (Vanaraja female line) and PD-3 (Brown egg layer line) were maintained for use in developing rural chicken varieties. The egg production and egg mass at 40 weeks of age increased considerably from the last generation. Layer lines (IWH, IWI, IWK, IWD, IWF and control) showed increase in egg production in all the selected lines over the previous generation. Under AICRP on Poultry Breeding, all the 12 centres were working on the development and propagation of location specific chicken varieties. Under Poultry Seed Project, 12 centres distributed 647,194 birds of improved chicken varieties to the farmers in their respective regions/states during the reported period.

Breeding protocol was developed for marine ornamental shrimps, *Ancylotaris brevicarpalis*, *Gnathophyllum americanum* and *Stenopus hispidus* from Lakshadweep Islands, while the larval rearing is in progress. Broodstock development for *Thor hainanensis* and *Lysmata amboinensis* is in progress. Marine ornamental fish Cloudy Damsel, *Dascyllus carneus* and coldwater ornamental fish species *Garra gotyla* and *Garra annandalei*, were successfully bred from wild-caught broodstock. The endemic catfish species from Western Ghats, viz. *Hemibagrus punctatus* (Critically endangered) and *Clarias dussumieri* (Near threatened) were bred with wild collected broodstock. Three-tier cage farming of seabass in mangrove regions of Sindhudurg, Maharashtra by SHGs generated total revenue of ₹ 12 lakh from 40 cages of 4×4×2 m each in 8 months. For restoring fisheries diversity of River Ganga, large-scale ranching of Indian major carp fingerlings produced by induced breeding of wild broodstocks collected from river Ganga, was undertaken. Hilsa ranching station was established at Farakka, West Bengal for stock enhancement of Hilsa in Ganga.

Crop management: A horticulture crop-based





integrated farming system with a net income of ₹ 2.4 lakh/acre/year was developed. A decision support system for precision nitrogen application was developed, which saves up to 26 kg nitrogen/ha thus reducing cost of cultivation and adverse environmental impact. Conservation agriculture (CA)-based ICM module was developed in pigeon pea with 1.92 t/ha yield and profitability of ₹ 82,776/ha. CA based cotton-wheat system was developed, which gave 44.1% higher system productivity than conventional tillage with a saving of 25–30% N and emerged as a superior alternative to rice-wheat system. Drone remote sensing method for field phenotyping was developed with multispectral sensor for monitoring nitrogen and drought stress in wheat. In a collaborative study with ISRO and NASA, eight horticultural crops in Sabour, Bhagalpur region of Bihar were mapped. Crop residue burning is a major problem in Punjab and Haryana. A method was developed for real-time monitoring of crop residue burning by using thermal image acquired from seven satellites at the IARI satellite ground station. The impact of conservation agriculture in groundnut + pigeon pea and groundnut + cotton cropping systems in light black soils was studied. Groundnut pod and haulm yield were found highest with normal tillage, pigeonpea grain yield and stover yield were highest under conservation tillage while seed cotton yield and stalk yield were higher under minimum tillage. Fungal isolates were evaluated *in vitro* for their capacity to solubilize insoluble zinc phosphate. Identified bacterial zinc solubilizers are from different species of *Enterobacter*, *Pseudomonas*, *Acinetobacter* and *Microbacterium*. Crassulacean acid metabolism (CAM) transited groundnut genotypes were identified which can be cultivated with 20–70% less water without any significant loss in yield. Drought-tolerant CAM variants (DGRM 3, DGRMB 5, DGRMB 13, DGRMB 17, DGRMB 19, DGRMB 29 and DGRMB 31) of a popular groundnut variety TG37A, were evaluated along side TG 37A with only two irrigations. While the pod yield reduction in TG 37A was around 49%, it varied between 32 and 40% in the CAM variants.

High density (800 plants/ha at 5 m×2.5 m spacing) and ultra-high density (1,600 plants/ha at 2.5 m×2.5 m spacing) orchards of acid lime cv. Pramilini produced 12.87 to 17.81 t/ha as against 6.62 t/ha in conventional planting (400 plants/ha). Dogridge was identified as the best rootstock for Fantasy Seedless variety with a higher berry diameter (18.34 mm) and yield (10.5 kg/vine) in Maharashtra. Thompson Seedless grapes grown under plastic cover showed a better yield (18.42 t/ha) as compared to anti-hail net (16.8 t/ha) and open condition (13.09 t/ha). Three new amino acid based micronutrient formulations were developed for nutrient management in different stage of fruit development in pomegranate. The foliar application of Formulation I and II increased (41.23%) fruit yield.

A two stage composting using coconut leaf vermin-composting earthworms effectively recycled the recalcitrant wastes to useful manure rich in organic carbon and plant-beneficial microbiota. Introduction of the Indian honey bee through hives with two openings

helped in orienting honey bees towards cucurbit flower in poly-house and assisted pollination resulted in 88.5% fruit set compared to zero fruit set in bagged flowers. Highest gross (₹ 2,52,928) and net returns (₹ 1,77,928) were recorded with drip irrigation (9 litre/clump/day) in combination of 100% RDF through drip with B:C ratio 3.37 in cardamom. A package of practices comprising soil application of phosphate solubilizing bacteria (PSB @15 kg/ha) or *Azospirillum* (15 kg/ha) along with NPK (60:40:30 kg/ha) was standardized in coriander. It gave enhanced yield of 47.6% and net profit of ₹ 98,750. Banana stem weevil was controlled by spraying with *Beauveria bassiana* (1×10^7 spores/ml) at 5th, 6th and 7th month after planting. Serious infestation of invasive Jack Beardsley mealy bug was observed on the fruit of many banana cultivars and effective natural enemies of the mealy bug were identified. Application of *Isaria fumosorosea* fungus strain was effective in managing rugose spiralling whitefly *Aleurodicus rugioperculatus* when applied at a spore concentration of 130×10^4 in oil palm. A modified integrated disease management schedule was tested in a bacterial blight affected pomegranate orchard with 40% incidence. The modified IDM schedule gave 100% blight tree yield of 11.45 kg/plant. The incidence of fungal spots/rots was below 2%.

Livestock management: A new method was developed for production of carnitine chelated trace minerals, viz. Cu, Zn, Mn and Cr, which help in improving bioavailability and thereby improving production performance in ruminants. Correction of zinc deficiency in soil improved zinc content in jowar fodder by over 16 ppm. Its feeding to sheep enhanced their growth rate by over 40% compared to control. The extracts of *Sapindus mukorossi* fruits, *Ficus bengalensis* leaves and *Eucalyptus globulus* essential oils and their blends have the potential to act as anti-methanogenic agents. Appropriate feeding modules to maximize the meat production potential in Avishaan sheep were developed. It may prove to be a good choice for intensively fed sheep for meat production in peri-urban and urban areas. FCR and feed cost per kg gain was better in pigs at 10% supplementation of vegetable silage in the diet. Inclusion of vegetable oil on isocaloric basis in diet during summer improved egg production and antioxidant status in laying chicken. In an on-farm trial in rural type chickens, Oxycure supplementation (500 g/t) of feed increased body weight gain. Supplementation of inorganic or organic Fe (100–300 ppm) significantly increased the egg Fe content without affecting feed intake and egg quality traits. Dietary level of 0.25 ppm of selenium or 16 mg/kg copper was optimum during summer, and nano-selenium or nano-copper (NS or NC either commercial or green) proved to be better than inorganic or organic sources for improved performance, immunity, cost of production and welfare of broiler chickens.

Prostasomes, isolated from seminal plasma of KF and Sahiwal, interacted with spermatozoa in semen and improved the semen quality. The number of semen doses available for Gir, Kankrej and Sahiwal were 160,708, 71,436 and 88,642, respectively. A new buffalo specific



semen extender improved post-thaw sperm motility and viability of cryopreserved buffalo semen. The aim of the project on 'Production of multiple copies of elite buffalo bulls using animal cloning technology', is to produce multiple clones of elite buffalo bulls, improve production efficiency of clones and evaluate clones for health and reproductive performance. Use of paddy straw as roofing material and changes in roof design and axis orientation of cow-shed, favourably changed the micro-environment of shed, augmented the milk yield, enhanced comfort indices and positively modulated the expression of milking behaviours of dairy crossbred Jersey cows. The research efforts yielded successful pregnancy at the age of 2 years in camel. A scorecard was developed for prediction of estrus in mithun and proper timing of AI. The protocol of cryopreservation of semen of PD-6 chicken line was optimized, and a fertility of 65% was obtained after AI in PD-3 females. Heat stress decreased growth hormone in Nicobari chickens, and supplementation of fermented yeast culture reversed it and showed beneficial effects on body weight and egg production. Floor space of 540 sq cm/laying bird was sufficient to have better production and welfare in laying birds.

The monthly disease outbreaks in various states at district level were predicted two months in advance. A forecasting bulletin is released for initiating preventive action. None of the tested equines were found positive for equine influenza, equine infectious anemia, brucellosis and *Salmonella Abortus equi*. Three hundred ninety one outbreaks of FMD were recorded in the country during the period; 56% of the outbreaks were in southern region of the country. Under National FMD Serosurveillance, overall seropositivity in 20.02% samples/animals was observed, which is comparatively lesser than the previous year's average of 21.2%. The outbreaks of H5N1 viruses in Bihar and Odisha were found epidemiologically distinct and caused by independent introduction events. The persistence and cross border movement of the H5N1 viruses circulating in South Asia indicated that there is a need for continuous active surveillance. Highly sensitive diagnostic methods were developed for FMD, bluetongue virus antigen, food-borne pathogens, and avian influenza. Pen-side diagnostic kits for detection of porcine circovirus and porcine parvo virus of pig was developed, which can detect virus within 1 hour. Multiplex RTqPCR assays were developed and adapted in the form of kit for diagnosis in field samples. The infrared thermography (IRT) is effective, non-invasive, on-site diagnostic technology for assessment of physiological-pathological status and offers a unique opportunity to investigate temperature variations in udder tissue for udder health assessment; thermogram of affected quarter had a high-density red spot area indicating severe inflammation. A recombinant Hep1 antigen ELISA, developed for the diagnosis of glanders and EIA, was duly validated in India and in the OIE Reference Laboratory, Germany. It showed excellent sensitivity (97.2%) and specificity (99.6%), and is highly economical as compared to imported kit. Indirect ELISA was developed for detection of JEV specific antibodies in horse and pig. An image

based system for identification of individuals, breeds and diseases of pigs was developed, which allows individual animal identification. This helps producers to keep records of animal's parentage, birth, production records, health history and is also useful for precision farming system and implementation of different governmental plans and policies to animal farming. CSF vaccine was developed, which provided 100% protection, and induces protective immunity till 18 months as per the testing trials. A simple and rapid method to synthesize metal oxide nanoparticles providing an assortment of nanoparticles was developed. It gave a much higher yield as compared to conventional methods. The results on bacteriophages against *Staphylococcus* spp revealed that the synergistic effect of bacteriophages and antibiotics may provide a better alternative to kill virulent bacteria than either treatment given individually in mastitic bovines.

A hybrid peptide nano system (RR28) was designed from infectious pancreatic necrosis (IPN) and beta noda viral proteins which forms non covalent complex with plasmid DNA (pDNA). The peptide based nano system may be an alternate DNA delivery vector for fish cells and can also provide insights into transfection of fish cells with peptide. Seven cell-penetrating peptides (CPPs) were designed/identified from fish viral proteins, which can be modified to make suitable peptide based delivery vectors for various biological applications. Vaccine against Gram negative bacteria, *Flavobacterium columnare*, was developed. Functional aquarium feed Kalor FishPlus was developed with optimum nutrients, colour enhancement properties and highly digestible ingredients to reduce waste generation in aquaria. For onsite estimation and monitoring of water quality for aquafarming, a multi-parameter water analysis kit was developed. CarryCap- Aquaculture planning tool was designed for assessing carrying capacity of natural water bodies for planning expansion of aquaculture. Trademark for the technologies CAGEGROW®, CIFRI GI CAGE®, CIFRI PEN HDPE® and CIFLIN®, were registered.

Mechanization and energy management: Machines and suitable methods were developed to mechanize different labour intensive farm operations. The newly developed machines included the following: multi-crop thresher for hill farming, which is lightweight for transportation, and portable for easy assemble and dismantle; garlic weeder for raised bed cultivation; hydraulically operated two-row pigeon pea harvester; cassava harvester cum lifter; fertilizer applicator for top dressing; cotton stalk puller; model farm machinery package for different agro-climatic zones of India; pneumatic precision planter; automated control system for tractor implements; package of machinery for banana crop; auger plough for green manuring and straw incorporation; irrigation channel former; vegetable transplanter for cell feed nursery; sprayer to control whitefly in cotton crop; intra-cum-inter row weeder for orchards; ginger harvester-cum-elevator; low heat grinding machine; alert system for chaff cutters; finger millet thresher; improvement of visibility of tractor cabin for operators. Some animal draught machines are found





more economical and suitable to the hilly terrain such as weeder-cum-fertilizer applicator; multi-crop planter for intercropping; and a package of bullock drawn implements comprising MB plough, stubble collector, seed drill, fertilizer applicator-cum-ridger and maize dehusker-cum-sheller etc. Farmers reported that they could save 15–20% time of sowing and 25–30% labour cost in weeding as compared to traditional practice. A postural support system with plastic belts and plastic mould system was developed, which gives back support and transfers some of the load on back to legs of the worker reducing discomfort. Annular core biochar reactor with a capacity of 50 litre was developed. Micro algae harvesting system having harvesting efficiency of 93% was developed. The Water Balance Simulation Model (WBSM) was developed to simulate the performance of rainwater harvesting (RWH) system under different climatic regions. The simulation model analyzes the combination of different roof sizes, demand and sizes of tank for planning, design and implementation of RWH system in different agro-climatic regions.

Post-harvest management and value addition: A rice flaking machine (capacity 80 kg/h), continuous makhana seed washer (120 kg makhana seeds/hour), dried chillies destalking machine (6.5–7 kg/h), and to assure the phytosanitary requirement for export (especially *Drosophila suzukii*) of Indian grapes, automated commercial fumigation chamber for treatment of grapes with SO₂ and CO₂ (1.50 tonnes grapes/batch) was designed, fabricated and established at M/s Sahyadri Farmers Producer Company Limited, A/P Mohadi, Nashik (Maharashtra). A modular storage system for onion of 1 tonne capacity costing ₹ 16,000 with sensor network (excluding blower) and an infrared pretreatment system for pulse milling to reduce milling energy and time were developed during the period.

A rapid and easy method of aflatoxin detection, a serious threat to food safety, using Vis-NIR hyperspectral imaging of maize has been tested. Paper strip assay, developed for pesticide residues in milk, is cost effective and gives result in real time compared to chromatographic techniques. The technology can be applied successfully to screen water, milk (raw, pasteurized, dried), processed fruit juices, cereal based foods, feed, fodder, fermented feed, soil, water in dairy farm for different pesticide groups complying codex/ FSSAI regulatory limits. An anti-hypertensive nutraceutical (Cadalmin™ AHe) was developed from seaweed to combat patho-physiology related to hypertension. Analytical methods for determination of contaminants in fish and fishery products, a high-throughput method for species authentication of commercially important shrimps, a prototype of portable fish freshness sensor for mackerel and transport system for live fish were developed and tested. In addition numerous high value products from different crops/commodities were also developed.

The Meat speciation laboratory of ICAR-NRC on Meat, Hyderabad, was accredited by National Accreditation Board for Testing and Calibration Laboratories and awarded with ISO/IEC 17025:2005 certificate. Strip based test for detection of urea, glucose,

sucrose and colour based test for rapid detection of detergent in milk; anionic mineral mixture for reducing post-partum problems in cattle and buffaloes; spore based kit for detection of antibiotic residues in milk at dairy farm; technology of sour dahi using prolific acidifying lactic cultures; process technology for palada payasam mix preparation by dry crystallization method in a mechanical unit and design of mechanized system/machines for makhana popping were licensed to different private companies for commercialization.

Agricultural education: Quality assurance of Agricultural Universities was ensured through accreditation and ranking of the AUs. Fifteen programmes supported under Niche Area of Excellence including seven new programmes were sanctioned. Libraries were strengthened with e-books/print books in various disciplines. New experiential learning modules (24) were supported under student READY component. Financial support was also provided for strengthening, renovation and modernization of student hostels, laboratories, examination halls, smart classrooms. HRD programmes/activities, which facilitated promotion and execution of ICAR sponsored schemes which include—centralized admissions in UG/PG and PhD to reduce academic inbreeding, infuse merit and promote national integration; fellowships to attract and retain the talent and promote merit; admission of foreign students for globalization of Indian agricultural education system; capacity building of faculty through summer-winter schools and Centre of Advanced Faculty Training; National Professorial Chairs and National Fellow Scheme for promotion of excellence; Emeritus Scientist/Emeritus Professor Schemes as a structural method of utilizing skill bank of the outstanding superannuated professionals. The support for Girls' hostels, under the scheme of Agricultural Education Division helped increase the number of girls in higher agricultural education to 42%, and also increased the overall intake of the students. The improved and modern infrastructure pertaining to teaching and learning facilities and capacity building of the faculty also enhanced the number of research publications in high impact journals out of PG research.

NAHEP-Achievements: 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. Out of 75 participating Agricultural Universities (AUs), 44 AUs were awarded under Institutional Development Plan (IDP), Centres for Advanced Agricultural Sciences and Technology (CAAST) and Innovation Grants (IG) component. Under Component 2 (Investments in ICAR for Leadership in Agricultural Higher Education) to IASRI was awarded as lead center and NAARM, Hyderabad and NIAP as cooperating centers. Under IDP, 39 new facilitative units (IIIC-Industry Institution Interaction Cell/Start up cell/incubation cell/experiential learning unit/placement cell etc.) for strengthening of teaching and research infrastructure were established. Under Training and capacity building, select students from 19 participating AUs and faculty members were sent for overseas training.





About 280 students (UG, PG and PhD) received international trainings under the 3 sub-components of NAHEP. About 85 Faculty members from participating AUs underwent training in various International Universities. Ten MoUs have been signed with overseas universities such as University of Arkansas and University of North Georgia for student and faculty training and exposure visits.

Agricultural economics and policy: ICAR-NIAP provided technical facilitation in designing the framework for Ease of Doing Agriculture Index. The index will help in fostering agricultural development among various states. Land holding size showed a significant negative impact on the probability of shifting from cultivation to livestock. Also, household size was a significant driving force responsible for farmers shifting to other source of income. In the last decade, the compound growth rate of cumulative patent filed in the agricultural sector in India was 12.5%, which was higher than the growth rate of global total (11%). The study suggested more efforts and investment in promoting and filing of patents for public institution are required. In the technology foresight project, emerging genome editing techniques, its application in crops, and policy challenges in India, were reviewed. The newer breeding technologies (NBTs) offer easier way to do cisgenic breeding (no-foreign DNA). One of the key questions is to decide whether the crops developed through these technologies are to be considered as GM or non-GM. The authorities in India had decided to review on case-by-case basis and also it has to go through review at state level. Another major concern is access to this technology are issues of patenting and commercialisation which might make the method more expensive in developing countries. The climatic shocks are location-specific, there is a need to strengthen location-specific early warning systems to provide timely information to farmers on weather conditions so that they are better-prepared to choose crops and other agronomic practices in anticipation of a weather shock. Analysis of livelihood security status of agro-climatic zones suggested the need for prioritizing vulnerable/less developed areas to arrest regional imbalances, prevent overexploitation and to leverage unutilized potential of agro-climatic zones. A study emphasized a much needed cropping pattern re-alignment across the zones based on water availability and footprints. Productivity growth in agriculture has improved despite absolute decline in number of farmers and agricultural laborers. Results showed that marginal and small farm households are more likely to shift from agriculture, and such shift intensifies with exposure to distress factors. The labor shift and resulting wage growth in agriculture led to mechanization in farm operations; though replacing labor with machines could be difficult, reducing the cost of hiring machines would enhance mechanization.

Statistics and computer applications: An innovative methodology to estimate the extent of household poverty in different districts, was developed. These estimates of rural poverty incidence will be useful for policy research and strategic planning. The global use of

germplasm is often encountered with sovereignty and access benefit sharing (ABS) issues. VISTA—World's first rapid crop variety identification system, was developed to store genotypic data. The tool can be pivotal in management and implementation of material transfer agreement, trans-border movement, varietal piracy, patent dispute, sovereignty issues, Nagoya protocol and ABS issues, traceability and adulteration. PolyMorphPredict, a rapid microsatellite marker polymorphism discovery tool, would be of immense use in diversity estimation along with crop variety, animal and fish breed identification, population structure, MAS, QTL and gene discovery, traceability, parentage testing, fungal diagnostics and genome finishing. KRISHI Portal has details of 525 technologies from 46 Institutes; about 21,300 publications and 470 data sets in the public domain. Sampling methodologies for estimation of harvest and post-harvest losses were developed for horticultural crops (fruits and vegetables), livestock (meat and milk), and fish (capture and culture fisheries). India is the only country that has carried out two nation-wide sample surveys on food losses along the entire supply chain for 45 commodities. The FAO, up-graded the method to Tier II; hence country now has an internationally accepted methodology for measuring food losses along production and supply chains.

Women empowerment: A gender sensitization hub was designed to sensitize various stakeholders for engendering agricultural research and extension. Forty two selected women friendly technologies were identified. Capacity building and skill upgradation programmes on improved methods of paddy cultivation, cropping pattern for year round vegetable cultivation, pro-tray method of nursery raising and plasticulture in agriculture were organized. Women farmers were trained on improved aquaculture practices to enhance household fish consumption and enhance income. A prototype of tent type solar dryer was also made for hygienic drying of SIFFS. In peri-urban dairy farming, skill oriented capacity development programme, access to input resources and marketing opportunity were identified as the major limitations. An action research was conducted to develop a suitable model for FPP (Family Poultry Production) especially for women farmers. Integrated floating cage aquaponics system (IFCAS) was designed for growing vegetables as well as fish for nutritional security and economic fortification of farm families. The benefit: cost ratio of this model was 1.4 during one season. Under the AICRP on Ergonomics and Safety in Agriculture, a multipurpose harvesting bag and women friendly power operated groundnut decorticator were developed. The AICRP on Home Science focused on gender mainstreaming and empowerment of rural women. Foods (362) from different major food groups having low glycemic index (GI) were documented. For food processing units, ergonomically designed low working table, storage shelves and portable trolley for the workers were developed. A conceptual framework for scoping IFS models from gender perspective with emphasis on income enhancement was developed, and altogether 37 IFS models were identified based upon agro-climatic





zones. Underutilized fibres, viz. mesta fibre was utilized for sanitary napkins preparation. Intervention packages were developed to improve levels of psychological wellbeing, reproductive health knowledge and maternal and child health knowledge of rural women.

Information, communication and publicity service: The Directorate of Knowledge Management in Agriculture works for swift, effectual and cost effective delivery of relevant information pertaining to good agricultural practices in Indian farms to all the stakeholders in the agricultural sector. *The Indian Journal of Agricultural Sciences* and *The Indian Journal of Animal Sciences* monthly research journals of the Council are available in open-access mode (<http://epubs.icar.org.in/ejournal>). Special issues of the *Indian Farming* were brought out on Success Stories of Farmer FIRST (May 2019, June 2019). The three special issues of *Indian Horticulture* were on Success Stories of Farmer FIRST (Horticulture module, May–June 2019), Beautiful World of Indigenous Ornamental Plants (July–August 2019) and Potato (November–December 2019). During this period, two special issues of *Kheti* the flagship monthly Hindi Journal of ICAR were published. These special issues were based on *Sugarcane and Nutrition*. *Krishi Khabrein deshvidesh ki* column was introduced in the magazine to make it more interesting and informative for readers. The Directorate has facilitated online access to 3,300 journals from a single subscription in more than 152 institution. The ICAR website was updated on regular basis, and daily more than five new pages were created, and total number of page-views have touched 15,300,768 from more than 200 countries. The e-Publishing portal (<http://epubs.icar.org.in/ejournal>), presently has 50 research journals. An android app called KISAAN- Krishi Integrated Solution for Agri Apps Navigation, which provides an integrated interface for more than 110 apps in agriculture and allied areas developed by ICAR institutions, was integrated. The Indian Agricultural Research journals portal (<http://epubs.icar.org.in>) now has 42 journals.

Technology assessment, demonstration and capacity development: A total of 4,750 technologies of various crops were assessed at 15,501 locations by KVKS through conducting 24,016 trials on the farmers' field. Varietal evaluation was the major theme of technology assessment under which 1,091 technologies were assessed through 5,614 trials. Under livestock, 777 technological interventions across 3,832 locations conducting 6,763 trials on animals were taken up for assessment. The major theme was Feed and Fodder Management with 161 technologies and 933 trials at 678 locations. Under enterprises category, 598 technologies were tested at 1,426 locations through 3,653 trials. Besides, 202 technologies exclusively related to rural women were assessed through 2,282 trials at 628 locations. National level Cluster Frontline Demonstrations (CFLDs) on Pulses (75,139 demonstrations) were conducted to demonstrate the production potential of new pulses varieties and the related technologies. In *kharif* 14,300 ha, in *rabi* 17,832 ha and in summer 4,712 ha area were covered under CFLDs on pulses, which resulted in an increase in yield

over national average yield, state average yield and local check. Likewise, 50,669 CFLDs were conducted on oilseed crops. At national level, the yield advantage in oilseed crops over the farmers' practices was recorded highest in linseed (34.60%) due to suitable technology interventions and skilling of farmers. Besides, 69,597 demonstrations other than CFLDs on different crops, 7617 on farm machineries, 19,811 on livestock and fisheries and 21,217 demonstrations on other enterprises were also conducted. A total of 17.98 lakh farmers/farm women, rural youth and extension personnel were trained on various aspects of agriculture and allied sectors through 64,620 training programmes including the sponsored training courses out of which 14.98 lakh farmers and farm women were trained in 49,833 training courses. Training courses (10,839) for the capacity development of rural youth (1.84 lakh) were organized in which 36.43% were young women. Capacity development of 1.16 lakh extension personnel (female participants 23.45%) was carried out through 3,948 courses in the country. KVKS organized extension programmes/activities (6.30 lakh), which were attended by 183.66 lakh participants. Messages (1,207,561) were sent by KVKS benefiting 1,049.56 lakh farmers on various aspects of farming. During the year, 2.01 lakh q seeds, 348.01 lakh quality planting materials, 2,61,301.91 q bio-products (bio-agents, bio-pesticides, bio-fertilizers, vermicompost, mineral mixture etc.), 409.06 lakh livestock strains, poultry birds and fish fingerlings were produced and provided to farmers. The 5.60 lakh soil samples were analysed and Soil health cards (12.27 lakh) were issued to farmers by KVKS. During the reporting period, 6.66 lakh farmers visited Agricultural Technology Information Centres for obtaining solutions related to their agricultural problems. Under ARYA project, 6,487 rural youths were trained on 13 broad group of agro-based enterprises in the country. Besides, 1,949 agro-based enterprise units were established in villages under 12 broad categories benefiting 3,790 rural youth. The Technology Demonstration Component (TDC) of NICRA is being implemented by KVKS in 121 vulnerable districts. To speed-up the skill development in agriculture sector, the DARE/ICAR signed an MoU with Ministry of Skill Development and Entrepreneurship. Majority of trainings programmes were organized in the job roles. Under the Farmer FIRST (Farm, Innovations, Resources, Science and Technology) initiative, large number of farm families were covered in different modules, viz. NRM module (8,075), crop module (23,836), horticulture module (16,491), livestock and poultry module (18,293), IFS module (3,420) and extension programme (39,512). Under *Mera Gaon Mera Gaurav* (MGMG), 5,149 scientists covered 5,615 villages and benefited 696,109 farmers. Seed-hubs, set-up at 97 KVKS, produced 39,648.14 q seeds of pigeonpea, blackgram, greengram, lentil, chickpea, field pea and lathyrus and made available to farmers.

Research for tribal and hill regions: The high yielding varieties Vivek Maize Hybrid 57, VL Gehum 697, VL Gehun 2014, VL Gehun 3004, VLB 130 and VL Soya 89, were released and notified. Two varieties





of garden pea, viz VL Sabji Matar 13 and VL Sabji Matar 15 were released and notified for Uttarakhand hills. An animal drawn plough, VL Metallic Plough, was developed which is environment friendly, durable, has operator/animal height adjustments, and 1.5 times more efficient than the traditional wooden plough. Integrated farming system model (one ha) on sloppy land in NEH region was optimised for different components, which gave a net return of ₹ 169,794/ha annually after deduction of total cost of production/rearing of ₹ 315,557. Agri-horti-silvi-pastoral system developed in 1.58 ha area as an initiative for jhum improvement programme showed gross return of ₹ 82,611. An integrated organic farming system (IOFS) model was developed for lowland valley ecosystem to utilize all the resources available on-and off-farm effectively and to improve the income. The total cost of cultivation was ₹ 56,835/year for an area of 0.43 ha while total net return was ₹ 73,903/year. Salinity tolerant rice varieties, viz Goa Dhan 3 and Goa Dhan 4 were released for coastal saline soils of Goa. Bacterial wilt resistant brinjal varieties, viz. Goa Brinjal 1, Goa Brinjal 2, Goa Brinjal 3 and Goa Brinjal 4 and one okra variety Goa Bhendi 1 were released for Goa. The study on genetic root of Trinket cattle, revealed that these cattle belong to *Bos indicus* which is a species or subspecies of domestic cattle originating in the Indian subcontinent.

Tribal sub-plan: Tribal welfare programmes were supported in 11 agricultural universities with financial support of ₹ 29.94 crore. The major activities were promotion of agricultural centric sustainable livelihood security, sericulture, agro-technological intervention, modern goat farming, waste management through vermicomposting, quality planting material production in horticultural crops, agroforestry and non-timber forest product, bee keeping, backyard poultry, sustainable livestock production, small ruminant productivity etc. in different tribal districts of Assam, Bihar, Chhattisgarh, Gujarat, Jharkhand, Jammu and Kashmir, Madhya Pradesh, Odisha and West Bengal.

Administration: A formal comprehensive inter-institutional transfer policy for the officers of the combined cadre of Administrative Officers and Finances and Accounts Officers was implemented during the year through a specially designed ‘Online’ portal. This was done to ensure transparency in the process of transfer/posting. Review of the post of SSS in ICAR was undertaken and a policy in this regard was circulated on 7 March 2019.

Intellectual property and technology management: ICAR assessed its 129 patent applications, viz. filed (41), published (50) and granted (38) by 39 institutes. The cumulative figure of filed patent applications is 1,119 and granted 297. A total of 206 filed copyrights have been thus recorded from different ICAR institutes. Filed design applications (31) were recorded from 7 ICAR institutes. Sixteen trademark applications were filed by 10 ICAR institutes for different products and processes. To protect the Plant Varieties, application of registration for 26 (22 extant and 4 new varieties) varieties were filed to Plant Varieties and

Farmers’ Rights Authority (PPV&FRA).

ICAR institutes (43) finalized 526 partnership agreements with 373 public and private organizations for 183 technologies of agriculture and its allied fields. Out of 183 technologies 40 were protected by filing patents/ copyrights/ trademarks/ plant varieties etc.

Progressive use of Hindi: Individual orders were issued by the Secretary, ICAR in respect of officers/ employees of the council possessing proficiency in Hindi to do their cent percent administrative work in Hindi. Till date, 141 ICAR institutes/centres have been notified in the Gazette. All materials to be presented in the Parliament, works related to annual action report, review of grants, governing body, Standing finance committee, Parliamentary Committee of Ministry of Agriculture and Farmers Welfare, including annual general body meetings of ICAR Society, all proceedings of these various meetings were prepared bilingually in Hindi and English.

Finance: The Revised Estimates in respect of DARE/ ICAR for 2018–2019 was ₹ 7,952.73 crore. An internal resources of ₹ 349.23 crore (including interest on Loans & Advances, income from Revolving Fund Schemes and interest on Short Term Deposits) was generated during the year 2018–19. The total allocation Budget Estimates for 2019–2020 is ₹ 8,078.76 crore.

Technical coordination: ICAR Directors’ Conference and meetings of ICAR Regional Committees No. VI, VII and VIII were held during the reporting period. The Committee provides a forum for liaison and coordination among the institutes of the ICAR, 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 participate in the meeting, which is chaired by Secretary DARE and DG, ICAR. During the reported period the Council provided financial support to 76 societies for the publication of Scientific Journals. Societies/associations/universities were supported for holding National Seminars/ Symposia/ Conferences (113 Nos) and International Seminars/ Symposia/Conferences (50 Nos). The Umbrella Memoranda of Understanding (MoUs) were signed with the Central/State Universities. Besides these 4 Memorandum of Understanding (MoU) were signed with other organization to collaborate research activities of national interest.

Awards: The awards were given in 21 different categories to 150 awardees, comprising 101 scientists, 8 administrative personnel (including 2 women), 3 journalists and 20 farmers (including 4 women farmers). It is heartening to note that of the 80 scientists, 13 are women. Three institutes, 1 university, two AICRPs, 12 KVks were also awarded.

Partnership and linkages: Collaborative research projects were signed between ICAR and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Wheat and Maize Research Centre (CIMMYT) and International Centre for Agricultural Research in the Dry Areas (ICARDA). MoUs





and Workplans for Cooperation in the field of Agricultural Research and Education were signed between ICAR and The State Secretary of Agro-industry of The Ministry of Production and Labour of The Argentine Republic, Western Sydney University and International Bamboo and Rattan Organization (INBAR), PR China for cooperation in Agricultural Research and Education. Work Plans between Indian Council of Agricultural Research (ICAR) and WorldFish (WFC) and International Livestock Research Institute (ILRI) were also signed.

Agrinovate: Agrinovate India Limited (AgIn) was established to enable solutions and capabilities in agricultural technology sector put to maximum use by successfully transferring research applications and innovations for large scale utilisation by private firms and farmers. AgIn is steadily moving towards meeting its objectives and building 'A world of Innovative Partnerships'. AgIn commercialized 15 ICAR technologies in 2018–19 and has already commercialized more than 20 technologies till December 2019 with a revenue realisation of around ₹ 75 lakh. The ABIs (50) facilitated the business environment in the ICAR institutes.

Supporting basic and strategic research: The NASF funded 79 projects, mostly in the consortium mode during 2018–19. To identify QTLs and superior genotypes for water use efficiency in wheat, a recombinant inbred line (RIL) population was phenotyped under normal and drought stress conditions. The RILs were identified with less water use and more yield under both well irrigated and drought stress conditions over both the parents. Potassium phosphite led to complete *in vitro* inhibition of fungal pathogens *Magnaporthe oryzae*, *Rhizoctonia solani*, and *Fusarium fujikuroi*. Chickpea genotypes ICC 13461, ICC 13523, ICC 8397, T39-1, ICC 5912 and ICC 9553 showed higher (>27%) seed protein contents, and 1.10–5.91 mg/100 g zinc and 0.50–8.54 mg/100 g iron. The microbial consortia and accelerated techniques for production of compost were developed, which achieved maturity parameters much earlier in kitchen and farm waste compost under closed static system than un-inoculated control. The gravel bio filters performed most efficiently for total metal removal as compared to Graphite and FRP bio filters. The goats with AB genotype showed highest protein content (3.56%). Supplementation of nano-Se in broiler chicken improved cell mediated immunity.

Strengthening the research system: The Agricultural Scientists Recruitment Board (ASRB) is under the administrative control of Department of Agricultural

Research and Education (DARE), Ministry of Agriculture and Farmer's Welfare, Government of India. During the period, Board advertised 72 Research Management Positions and recruitment action for all the positions is under process. During the year, a combined examination for Agricultural Research Service-2017 (Prelims) and NET 2018 (I) was conducted. Out of 181 recommended candidates, about 79.56% successful candidates were from 10 states (Rajasthan, West Bengal, Karnataka, Kerala, Uttar Pradesh, Tamil Nadu, Madhya Pradesh, Uttarakhand, Bihar, Haryana, Odisha and Telangana). Among 4,135 qualified candidates of NET-2018, 51% were female candidates and 49% were male candidates. Qualified candidates were mostly from rural area.

Training and capacity building: During the year 2018–19, trainings were provided to almost all the category of employees of ICAR and Scientists (1,098), Technical officials (816), Administrative (733) including Finance officials, and SSS (630) were trained. Overall, 3,277 employees were trained which is about 18.2% of the total number of employees in ICAR. Impact Assessment of training programmes attended during 2017–18 by various categories of employees revealed that the overall Impact of training was Considerable - Great Extent.

The Indian Council of Agricultural Research is a time tested premier organization. The Council has always been ahead of its times, it is visualizing the coming agricultural scenario and accordingly ready with appropriate technology for farmers. Developing suitable manpower, reaching to farmers and coordinating with various stakeholders to meet the challenges to Indian Agriculture is key to the success of ICAR. With this commitment that coming years will see much dynamism and greater dedication of ICAR towards the development of agriculture sector, I present the achievements of ICAR in 2019–2020 to the policy planners, researchers and all stakeholders. I do hope that the research results presented here will provide the much needed impetus to agricultural development in the country.

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





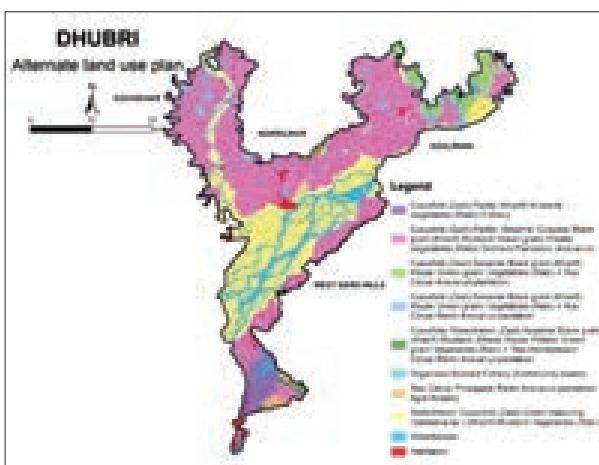
2.

Soil and Water Productivity

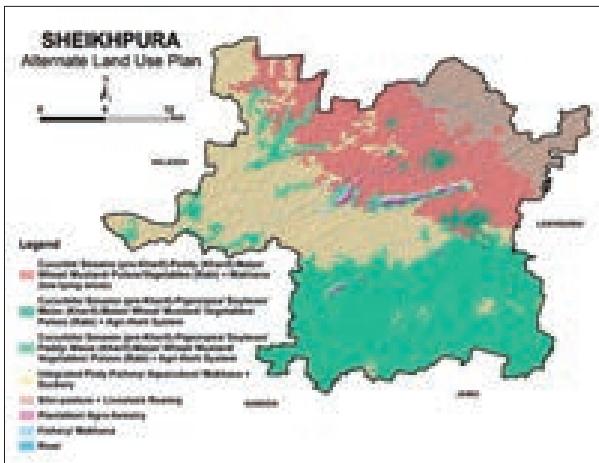
Land use planning for aspirational districts: Land Resource Inventory (LRI) on 1:10,000 scale was prepared for 27 aspirational districts of India to workout block level land use planning. Alternative crops and cropping pattern were suggested for Barpeta, Darrang, Dhubri, Goalpara, Baksa districts of Assam; Bahraich, Balrampur, Chitrakoot, Shravasti, Sonbhadra districts of Uttar Pradesh; Araria, Begusarai, Katihar, Sitamarhi, Sheikhpura districts of Bihar; Kalahandi and Rayagarha district of Odisha; Sahibganj and Pakur district of Jharkhand; Nandurbar district of Maharashtra; Barwani, Damoh, Khandwa, Vidisha and Singroli districts of Madhya Pradesh; and Baran and Jaisalmer districts of Rajasthan. Also, alternative land use plan using LRI data and best management practices was suggested for Goa state; Charilam block of Sepahijala district, Tripura; Maynaguri block, Jalpaiguri district and Rajnagar block of Birbhum district, West Bengal; Baragaon block,

Varanasi district, Uttar Pradesh; Nagrota Bagwan block of Kangra district in Himachal Pradesh; H D Kote, Mysuru district, Karnataka; Odhan block of Sirsa district Haryana; coastal region and Kultali block, 24 Paraganas (S) of West Bengal; and desert of Rajasthan.

Potential crop zones delineated: Area/region specific efficient and remunerative crops and cropping sequences were delineated based on soils, landforms, rainfall, temperature, length of growing period and irrigability. Potential crop zoning involves development of land management units (LMUs), bio-physical suitability evaluation and linking of bio-physical suitable maps to



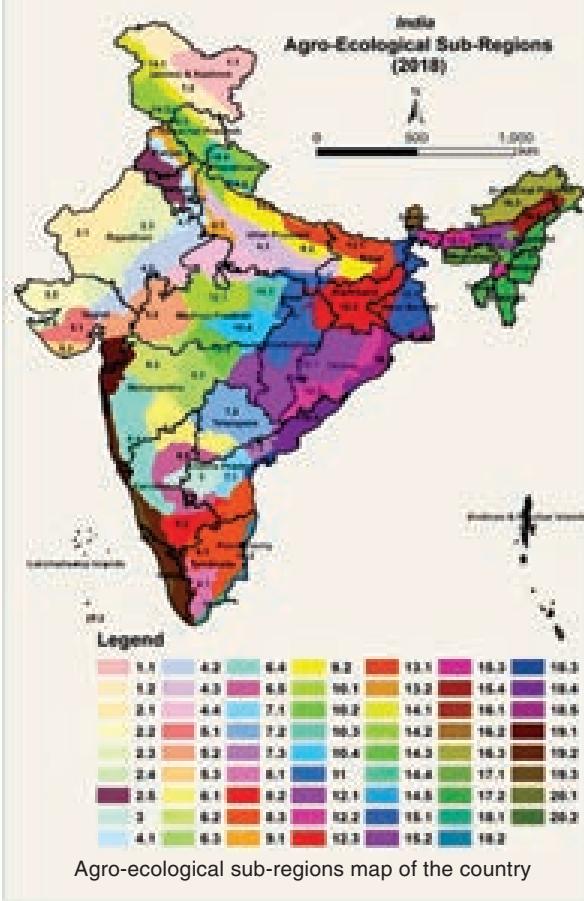
Alternate land use plan for Dhubri district, Assam

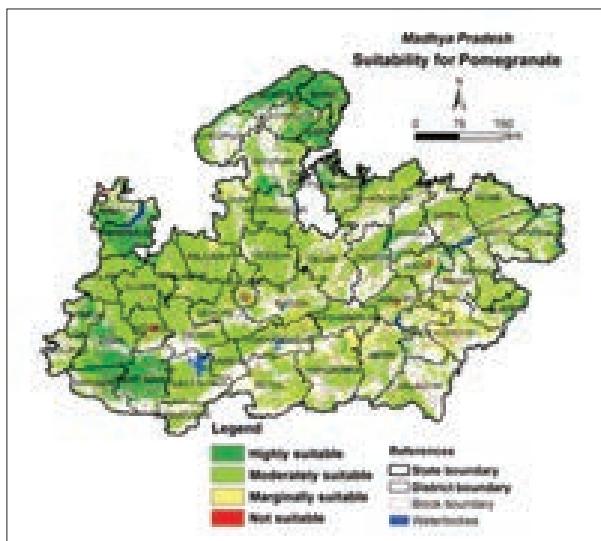


Alternate land use plan for Sheikhpura district, Bihar

Agro-ecological region based land planning

Agro-ecological region (AER) map of the country was developed with 20 units, based on the bio-climate and length of growing period (LGP) using physiography as the modifier of climate for sustainable agriculture. The agro-ecological units were further sub divided into agro-ecological sub-region (AESR) with 62 units based on bio-climate and length of growing period (LGP) using sub-physiography as the modifier.





Soil suitability maps for pomegranate in Madhya Pradesh

the relative spread and productivity of reference crops and cropping sequences.

The potential area for sesame was identified in Andhra Pradesh, Telangana and West Bengal. Suitability for oil palm cultivation in Andhra Pradesh, pomegranate in Karnataka and Madhya Pradesh was evaluated. Soil suitability evaluation for cotton, wheat, mustard and cluster bean was done for Odhan block, Sirsa district, Haryana, while soil suitability maps were delineated for commercial crops, i.e. coffee and coconut in Bilalgodu microwatershed of Chikkamagaluru district; rubber in Elamdesam, Idukki district; 7 principal crops for the watershed of Shidlaiahankote village, Chitradurga district, Karnataka.

HDPE embedded gabion structures: A technological intervention using HDPE embedded gabion structures was established in drainage channels for harvesting runoff and maintaining base flow and reducing sediment loss. In watersheds, loose boulder structures or gabion check dams are constructed in upper reaches to stabilize the gully or stream and reduce the flow velocity and, thereby, minimizing the soil erosion. The gabion structures were embedded with 1 mm HDPE film at the centre of the structure. These plastic embedded structures were constructed and evaluated in the farmers' fields/ watershed areas of the project cluster. These plastic film embedded gabion structures reduced the sediment concentration by 70% over the traditional gabion check dams which do not use plastic films. It was able to store water ranging between 9,000–15,000 m³, raised watertable in wells by 0.6 m, impacted by provision of irrigation in area of 1 ha.

Subsurface drip irrigation for sugarcane cultivation: Evaluation of subsurface drip irrigation on yield of salt tolerant sugarcane in saline vertisols at Agricultural Research Station, Gangavathi revealed higher cane yield (131 t/ha) in subsurface drip followed by surface drip method (124.4 t/ha) and least in furrow irrigation (105 t/ha) method. Among irrigation levels, significantly higher yield (124.7 t/ha) was recorded at 1.2

ET irrigation level followed by 1 ET (121 t/ha) and least in case of 0.8 ET (114.7 t/ha). The interaction effect between irrigation methods and levels was non-significant.

Among irrigation methods, significantly higher water use efficiency (WUE) of 83 kg/ha/mm was recorded in subsurface drip irrigation followed by surface drip (78.6 kg/ha/mm) and least in furrow irrigation (66.4 kg/ha/mm) methods. Among irrigation levels, significantly higher WUE (83.2 kg/ha/mm) was recorded at 0.8 ET followed by 1 ET (75.9 kg/ha/mm) and least in case of 1.2 ET (68.9 kg/ha/mm). The sugar water use efficiency (S-WUE) was calculated based on brix percentage, yield and total water applied. In case of irrigation methods, significantly higher S-WUE was recorded in subsurface drip irrigation (1.72 kg/m³) followed by surface drip irrigation (1.59 kg/m³) and least in furrow irrigation (1.34 kg/m³) method. Among irrigation levels, significantly higher S-WUE was recorded at 0.8 ET (1.66 kg/m³) followed by 1 ET (1.57 kg/m³) and least in case of 1.2 ET (1.43 kg/m³) irrigation level.

Deficit irrigation with saline water: In arid and semi-arid regions, limited availability of good quality water for irrigation necessitates the conjunctive use of the saline water to overcome drought and increase crop yield. To develop proper soil-water-crop management practices for

Bajra-Napier hybrid for livestock

A drive was launched to promote the Bajra Napier Hybrid (B-N Hybrid) varieties to improve the green fodder availability. Farmers, farm women, and rural youth were targeted through demonstration of B-N Hybrid at institute farm, organization of workshop, farmers interface meet, training, YouTube videos (https://www.youtube.com/watch?v=Ro_Hjb2UGGc&t=42s), WhatsApp group of Napier growers, developing a mobile app on Napier cultivation, All India Radio, DD News and publishing success story of B-N Hybrid in



newspapers, etc. The YouTube video on B-N Hybrid was viewed by 24,585 viewers across the country and phone calls were received from 162 farmers of 11 states for procurement of B-N Hybrids' cutting. The feedback from the farmers indicated that Napier growers are further distributing the stem cuttings to other farmers and area under B-N Hybrid cultivation has increased, which was not in practice in Bareilly district earlier. The farmers reported that regular availability of green fodder to the livestock increased length of lactation period of milch animals, thus, enhancing their household income.





Rejuvenation of Haveli system for drought proofing in Bundelkhand Region

"*Haveli* system", earthen bunds across the stream built to impound water during the monsoon, was developed to overcome water scarcity during the period of Chandelas and Bundelas (nearly 400 years back). The water harvested during the monsoon period recharges open wells and also serves as an irrigation source during the critical stage for *kharif* crops in the surrounding areas of *Haveli*. The impounded water is drained-out during the month of October and the *Haveli*-bed is used for cultivating *rabi* crops. The drained water from *Haveli* system is also used for the pre-sowing irrigation by the lower reach farmers. Wheat and chickpea are generally cultivated in *Havelis* using the residual soil moisture. Over the period, *Havelis* have become defunct due to damaged outlet, leakage in embankment, excessive siltation, breaching of embankment, etc.

The *Haveli* system that existed at Parasai-Sindh watershed in Jhansi district of Bundelkhand region was rejuvenated through community participation. A drop spillway (rectangular weir) outlet was constructed to drain

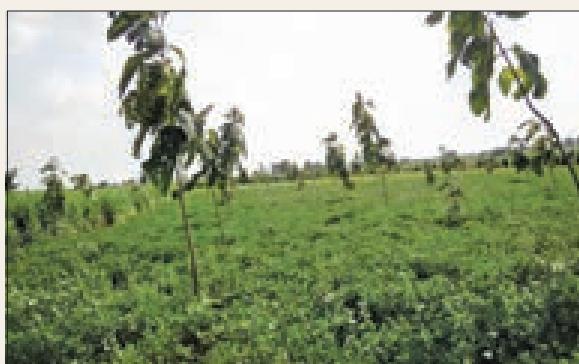
excess runoff during the rainy season. The weir was constructed at a height of 1.45 m from the bed level. The earthen embankment along with core wall was constructed in 50 m breached area. To control seepage, 147 m stone masonry wall was constructed along the embankment of *Haveli*. Submergence area of the structure is about 8.0 ha with harvesting capacity of 73,000 m³. Due to multi filling, about 1.5–2.5 lakh m³ runoff is now being harvested during normal monsoon season that completely resolved the water scarcity issues of Parasai village. The cost of rainwater harvesting in *Haveli* is about ₹ 4.53/m³ of storage. Renovated *Haveli* with due support from series of check dams in ephemeral streams resulted in 1,15,000 m³ surface water storage besides saturation of weathered zone in the watershed. Increased groundwater level (2–5 m) and base flow (2 to 3 times) and reduced stream flow made it drought resilient even in years with 25–30% deficit rainfall. About 176 ha *rabi* fallow was brought under cultivation. Productivity of different crops increased in the range of 20–70%.



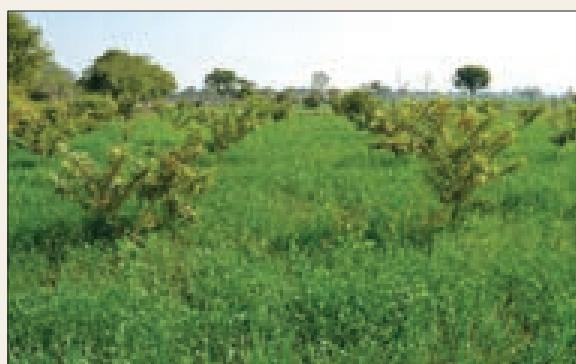
Rejuvenated *Haveli* system



Rainwater harvested in *Haveli* system



Teak based agroforestry intervention



Guava based agroforestry intervention

such situations, a study comprising saline water irrigation with conservation agriculture (CA) was taken up to manage intra/inter seasonal root zone salinity for increasing system productivity and profitability. Tillage treatments, viz. zero tillage-reduced tillage (ZT-RT), conventional tillage-conventional tillage (CT-CT) and zero tillage-zero tillage (ZT-ZT) were evaluated in combination with saline water irrigation (EC_{iw} 8 dS/m) at 100, 80 and 60% of water requirement (WR) in wheat under rice straw mulch (0 and 5 t/ha) in sorghum-wheat cropping system. Five year study established that CA based management with saline water irrigation

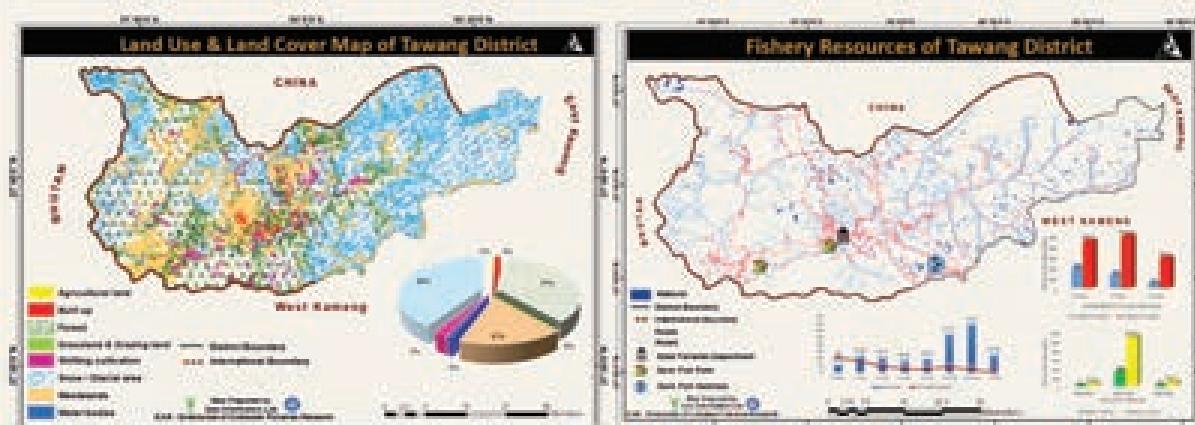
(EC_{iw} 8 dS/m) had no adverse effect on dry matter content. Rice straw mulching reduced irrigation requirement by 40% and produced significantly higher wheat yield (5.9 t/ha) compared to 100% irrigation application without mulching (5.39 t/ha). Yield increment in different years ranged between 8–10% with CA based management along with saline water irrigation. Deficit saline irrigation at 60% WR maintained highest N and protein content in sorghum. Therefore, under limited irrigation conditions in salt-affected soil, CA based management (ZT, residue retention) is effective in increasing yield, nutrient content and system productivity.





Coldwater fisheries resources of Arunachal Pradesh

Tawang, West Kameng and Lower Subansiri districts of Arunachal Pradesh were investigated for the aquatic resources and potential fisheries development sites using GIS based mapping. High potential areas for fish farming were identified. Attempt was made to select potential areas where fisheries developmental activities such as culture and seed production can be undertaken.



GIS based mapping of coldwater fisheries resources of Arunachal Pradesh

The 60% WR saline irrigation showed greater values of Soil Quality Index (SQI) after harvest of sorghum and wheat than 100% WR. Mulching also improved SQI after sorghum and wheat.

e-Atlas for micronutrients in Indian soils: An e-ATLAS on *Micronutrients in Indian Soils* was developed to address the problem of micronutrient deficiency in different soils of the country and their impact on crop production and crop quality. It contains taluka wise soil micronutrients status of 536 different districts of 23 states of the country with recommendations in terms of rate, time and source of micronutrients for different crops and cropping systems for use by different stakeholders.

Rhizobial diversity in the rhizosphere of pigeonpea: Diversity of microorganisms in the rhizosphere soil samples of pigeonpea, collected from 18 different sites of six districts of Madhya Pradesh was estimated by 16S rRNA gene sequencing. Most of the strains belonged to *Bradyrhizobia* sp. Abundance of rhizobial strains were enumerated by MPN to ascertain the presence of rhizobia in soil. Plant nodulation and symbiotic efficiency test of isolates was carried out by sand culture technique. About 700 strains of rhizobia were isolated and out of these 127 isolates were efficient for nodulation. Based on biochemical properties and PGPR attributes best 56 strains were further evaluated. DNA from these strains was isolated by alkali lysis method and BOX-PCR was performed in order to examine similar strains on the basis of banding pattern. Thirty-two strains were selected for 16S rRNA sequencing, acetylene reduction assay and whole genome sequencing. These strains exhibited high N fixing potential and nodulation efficiency compared to known strains.

Microbial mediated *in situ* crop residue decomposition: In rice-wheat cropping system, huge

quantities of rice straw are left for disposal after harvest of the crop and most of this remains unutilized in the field, encouraging the farmers to burn it especially in areas where the succeeding crop is to be sown only after a few days. The microbial consortia of two efficient and compatible halophilic bacterial lingo-cellulolytic strains having plant growth promotion traits were prepared in suitable standardized media as bio-formulation 'Halo-CRD' as decomposer for crop residues. These efficient degrading microbes can decompose crop residues and help in build up of soil carbon that can facilitate reclamation of sodic and saline-sodic soils.

Inocula of consortia of CDMs along with whey resulted in decrease of stubble weight by 46.7% with maximum reduction of 59.8% compared to the initial weight of stubble. The C:N ratio of the residue material (stubbles and straw) decreased to 24:1 from 66.5:1, 35 days after inoculation of consortia with whey. The *in situ* degradation of paddy residue also significantly enhanced the yield of succeeding wheat crop. Three season data indicated that inoculation of residue with consortia of degrading microbes along with whey helps in faster *in situ* degradation of paddy residues. The outcome of the study will facilitate utilization of the residues for recycling nutrients, enhance soil microbial activity and C enrichment to promote bio-remediation apart from saving energy that helps in achieving desired level of production and health management of salt-affected soils.

Fodder: Chinese cabbage, a short duration fodder crop of rabi season, has potential to be cultivated as a catch crop and provides green fodder during scarcity period. Experiments of Chinese cabbage revealed that application of camel manure and chemical fertilization significantly improved the fodder yield.





3.

Climate Change and Resilient Agriculture

District level vulnerability maps of Indian agriculture

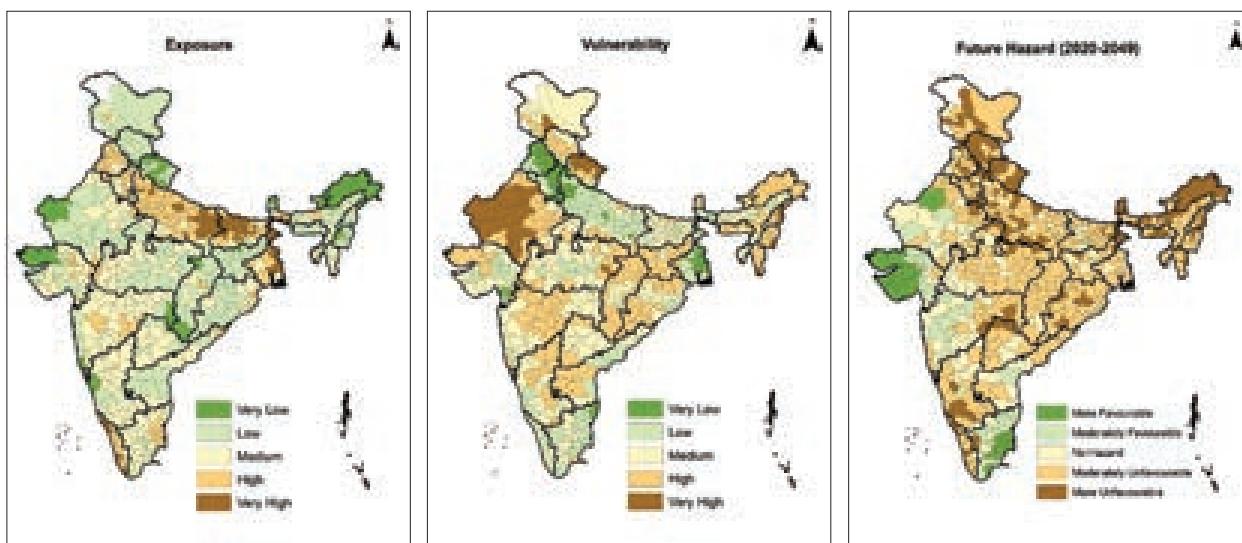
District level vulnerability maps of Indian agriculture to climate change were updated with 5th Assessment Report (IPCC 2014). These maps give climate projections based on ‘Representative Concentration Pathways’ (RCPs). The climate change hazard was derived using the climate change projections for RCP 4.5 for the period 2020–49. The output of the analysis of the three determinants of risk based on a number of indicators is given here.

Climate resilient integrated organic farming system model: Climate resilient integrated organic farming system model for semi-arid region has been developed in one ha area for small and marginal farmers facing problems due to various kinds of abiotic stresses. Out of one ha area, 2500 m² has been assigned to vegetable crops, 2500 m² for sugarcane-based cropping sequence, 1000 m² for fodder crops, 1000 m² for cereals and pulse crops, 2000 m² for orchard crops (pomegranate, sapota, custard apple, mango), 100 m² pond for storage of water to provide irrigation to crops through drip and

500 m² for poultry (Vanaraja, Kadaknath and ornamental breed), goatry (Osmanabadi breed), cattle (ghir) and compost unit. A solar-operated water pump (3 KV) has been installed near water storage pond for supporting irrigation to the crops. Efforts are being made to achieve 100% organic and self-dependent in nutrient requirement of the crops as well as feed and fodder requirement for livestock. Mango, lemon, dragon fruit and papaya have been planted on borders of all the experimental plots. Intercropping of chickpea was done in orchard crops for revenue generation from orchards during initial years. Similarly, intercropping of drumstick has been done with Napier grass for getting maximum return. To ensure regular and daily income, vegetable crops such as bhindi, cowpea, cabbage, tomato, bottle gourd, pumpkin, onion, garlic, coriander and sweet corn crops were planted in an area of 2500 m².

Livestock

Mobile App “COOWLER”: App was developed to deal with information related to summer stress



Classification of districts based on exposure, vulnerability and climate change hazard



Crop component



Animal component



Utilization of farm waste

Integrated Farming System (IFS) model





management in cattle. It is useful for farmers, cattle owners, Veterinary Officers, Animal Health Department officials, students, industry professionals and other stakeholders to deal with cattle rearing and managemental practices during summer.

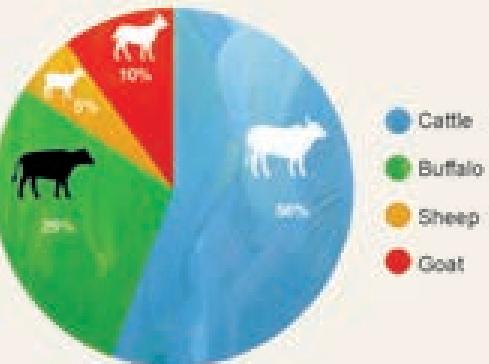
Reducing enteric methane emission: The effect of dietary supplementation of silkworm (*Bombyx mori*) pupae oil on enteric methane emission was assessed in sheep. The oil (2% of basal diet) was fed daily or intermittently in alternate week. The results revealed a significant reduction (12–15%) in enteric methane emission in the silkworm pupae oil supplemented groups due to significant reduction in rumen protozoal population.

Annual enteric methane emission: A comparison for the annual enteric methane emission considering the livestock density in unit km² was carried out for all the Indian states. The estimate revealed that livestock at national level emit about 2.62 Mt methane/km². In Bihar, West Bengal, Uttar Pradesh, Assam, Jharkhand and Andhra Pradesh, more enteric methane is produced than the national average due to dense livestock population ($\geq 204/\text{km}^2$). Cattle, with an annual emission of 4.92 Tg emerged as the largest enteric methane producer (56% of the total) in the country, while buffalo, sheep and goats contribute 29, 5 and 10%, respectively.

miRNA transcripts during thermal stress: A total of 420 miRNAs in PBMCs (peripheral blood mononuclear cells) of Frieswal cattle were identified, and it was observed that 65 were differentially expressed during peak summer. Reporter assay revealed that bta-miR-2898 can target bovine HSPB8 gene in stressed bovine PBMC cell cultured model.

GHG emissions from dairy farms

Greenhouse gas (GHG) emissions occurring at different stages of dairy farming were assessed by conducting life cycle assessment of GHG emissions from selected dairy farms of Karnataka. The respective carbon footprint of milk production for small (2–3 cattle), medium (4–6 cattle) and large dairy (>10 cattle) farms was calculated as 1.03, 1.01 and 1.27 kg, CO₂-eq/kg FPCM (fat protein corrected milk). An excel based model was developed for life cycle assessment of greenhouse gas from dairy farms of Karnataka.



Species-wise enteric methane emission in India

Functional IRES at bovine heat shock protein 90: A putative internal ribosomal entry site (IRES) was identified in bovine heat shock protein gene for the first time, which was found functional. The identified bovine heat shock protein IRES was used to develop an artificial expression cassettes for simultaneous translation of two genes from a same reading frame.

Circulatory miRNAs in Sahiwal: The investigation aimed to identify differentially expressed miRNAs during thermal stress in Sahiwal (*Bos indicus*) cattle, adapted with tropical climate. Stress responses of the animals were characterized by determining various physiological as well as biochemical parameters and differential expression profile of major heat shock protein genes. Analysis identified a set of differentially expressed miRNAs during summer and winter and most of the identified miRNAs were found to target heat shock responsive genes especially members of heat shock protein (HSP) family. Analysis of selected miRNAs revealed that bta-miR-1248, bta-miR-2332, bta-miR-2478, and bta-miR-1839 were significantly over expressed while bta-miR-16a, bta-let-7b, bta-miR-142, and bta-miR-425 were significantly under expressed during summer compared to winter. The present study enlists differentially expressed miRNAs at different environmental temperatures in Sahiwal that may be important for further understanding the role of miRNAs on thermo-regulatory mechanisms.

Database on stressed cattle miRNA: A comprehensive database on the list of differentially expressed miRNAs in cattle during thermal stress was developed.

Regulation of physiological responses during heat stress: The fibroblast cells were subjected to acute heat shock (41°C) (control at 37°C) and processed for isolation of RNA and subsequently processed for synthesis of cDNA library and analysis. High quality RNA purified from cells was analysed with whole transcriptome and microRNA specific sequencing study to identify all the microRNAs/transcripts present in fibroblast cell line. A total of 24,997 transcripts were mapped to *Sus scrofa* genome out of which 651 genes were differentially expressed. There were 255 and 396 differentially expressed genes (DEG) that were up- and down-regulated respectively. The functional annotation of the DEGs were conducted using online programmes (Pantherdb and g:Profiler) to generate information of the enriched pathways and functions associated with these genes.

Poultry: Out of layer excreta, broiler litter, hatchery and slaughter wastes and dead birds, only broiler litter was found to be methanogenic substrate. Other wastes were suitable for composting. Carbonaceous materials, i.e. plant leaves, paddy straw and sawdust had almost similar efficacy in aerobic composting of poultry excreta at 30:1 C:N ratio and at 50–55% moisture. Composting of poultry excreta using agro-forestry waste during summers revealed significantly higher bin temperature in all the treatment groups than control group;





significantly higher pH in control group; significantly higher TBC and *E. coli* in control group while negligible numbers in treatment groups and higher germination percentage in treatment groups as compared to control. C:N ratio in treatment groups was maintained at 30:1 and water content at 50–55%. Ferrification (0.1 M) and

acidification (0.1 M) of poultry biogas resulted in reduction of H₂S and NH₃ level below 4.0 ppm and CO₂ below 16% in dilution-acidification-carbonization (DAC) technology developed at CARI, Izatnagar. Simultaneously, CH₄ level rose to almost 79%. □





4. Genetic Resources

Germplasm augmentation, conservation and use:

A total of 23 explorations were undertaken and 2,623 accessions were collected (2,026 cultivated and 597 wild) from parts of Assam, Arunachal Pradesh, Andaman and Nicobar, Bihar, Karnataka, Odisha, Meghalaya, Himachal Pradesh, Madhya Pradesh, Maharashtra, Nagaland, Tripura, Telangana, Tamil Nadu, Uttar Pradesh, Uttarakhand and West Bengal. Important germplasm lines collected included cold tolerant barley and wheat (46), *Allium* spp. (21) from Uttarakhand and Jammu and Kashmir; landraces of paddy (93), taro (10), chilli (9), cowpea (12) and urd (8) from Assam; rice landraces (32) from Manipur; rice landraces (28) and legumes (mainly urd-1; pigeonpea-10) from Meghalaya; rice landraces (15) from Upper Siang, Arunachal Pradesh; vegetables (189) from Tripura; maize (11) from Mizoram; different cucurbits (65) from Bihar; coriander (54) from Madhya Pradesh; and tropical underutilized minor fruits (39) from Goa and Konkan region of Maharashtra. Among the collected wild relatives of different crops, mainly of

wheat and barley (*Elymus* spp.-34; *Leymus secalinus*-11) were collected from the cold desert of Himachal Pradesh and Jammu and Kashmir; and wild okra (43) from Uttarakhand and Uttar Pradesh. A total of 376 herbarium specimens were processed (in addition to 886 virtual herbarium specimens) and added to the National Herbarium of Cultivated Plants (NHCP), New Delhi bringing the holdings to a total of 23,942 specimens.

Germplasm conservation: A total of 12,417 accessions of orthodox seed species were added to the National Genebank for long-term storage and currently the base collection of National Genebank has a total of 4,42,909 accessions. A total of 24 accessions of fruits, tubers, bulbs and medicinal plants were added to the *In Vitro* Genebank, making the total collection of 1,879 accessions in the form of ~38,000 *in vitro* cultures of 54 genera. In the Cryogenebank, 491 accessions of seeds, pollen and genomic resources of different crop species were successfully cryopreserved, leading to total collection of 13,814 accessions belonging to 820 species.

Germplasm exchange: A total of 1,59,687 samples were imported from 40 countries including 46,145 germplasm accessions and 1,13,542 samples of CGIAR trials/nurseries. A total of 2,041 samples were exported under various collaborative research projects. The important trait specific accessions imported are: (1) Wheat: High yielding lines (EC968386-968435) from Mexico, double haploid lines (EC968471-969176) from UK; DH lines (EC972065-972390) for screening against rust resistance from Germany; landrace *Nobeoka Bozu* (EC976846) moderately resistant to *Fusarium* head blight from Japan; (2) Paddy: High Zn content lines (EC963570-966583) from IRRI, Philippines; (3) Maize: Large white Cuzco Corn kernels (EC967289-967291) from CIMMYT, Mexico; stem borer especially fall army worm resistant lines (EC977839-977867) and lines for silage, stem borer resistant (EC979442-979458) from CIMMYT, Mexico; (4) Soybean Landraces: from Japan (978204-978213); (5) Vegetables: Restorer and maintainer lines (EC994252-994258) of Chilli from Taiwan; wild species of Tomato (*Solanum chmielewskii*) from USA (EC1000250); accessions resistant to Poty virus Y in potato (EC965736-965722) from CIP, Peru; high yielding, powdery scab resistant and early to mid-season maturing potato varieties, viz. Sage Russet, Blazer Russet, Mountain Gem Russet, Gem Star Russet, Premier Russet and Defender (EC1001459-1001464) from USA; (6) Fruits: Apple accessions resistant to fire blight and *Phytophthora*, excellent anchorage, drought tolerant, resistant to collar rot and woolly aphid (EC971990-971991) from USA; improved varieties of Citrus from USA (EC976849-976857) and South Africa (EC978218-



Cowpea landrace collected from tribal belt of Odisha



Variability in grain cowpea collected from Karnataka



Variability for pod length, pod shape, seed shape and seed colour in Drum stick germplasm from Maharashtra and Karnataka

978222); improved cultivars with High TSS in Kiwifruit from USA (EC977548-977574).

Export: One set each of 353 samples of wheat advanced lines and varieties were sent to Bangladesh and Bolivia for screening against blast disease under collaborative research project. Total 1,688 samples have been exported to 8 countries (211 accessions each to Burkina Faso, Ghana, Kenya, Mali, Niger, Tanzania, Nigeria and Uganda) belonging to crops, viz. dolichos (50), mungbean (50), horsegram (50), cowpea (9), pigeonpea (2) and mothbean (50) under collaborative research project entitled 'Evaluation of stress tolerant orphan legumes for dryland farming system across Sub-Saharan Africa and India'.

Germplasm characterization/evaluation: Total 15,465 germplasm accessions were characterized for different agro-morphological traits at New Delhi. Agromorphologically diverse core set is being developed in barley, lentil and linseed. Screening against biotic, abiotic stresses and herbicide resistance in different crops was done in 810, 1,025 and 2,014 accessions, respectively. Biochemical evaluation of 2,500 accessions of different crops was undertaken for oil content, fatty acid profile, protein, sugar, minerals, amino acids, antioxidants and active principles. Germplasm field days were organized for wheat and barley, lentil and linseed at New Delhi, rice in NRRI, Cuttack, and mothbean, mungbean, cowpea and cluster bean at Jodhpur.

Plant quarantine: A total of 41,160 imported samples including transgenic and trial materials were processed

for quarantine clearance. Of these, 1,186 samples were infested/infected with different pests, 1,039 samples were salvaged through physio-chemical methods and 147 samples were rejected due to fungal and viral pathogens of quarantine importance. Important fungal interceptions included *Fusarium solani* in soybean from USA, *Puccinia helianthi* in sunflower from Australia, *Bipolaris maydis* in maize from Mexico, *Phoma hebrarum* in bittergourd from Thailand; important insects intercepted include *Sitotroga cerealella* in *Zea mays* from Thailand and *Oryza sativa* from Philippines; important nematodes include *Aphelenchoïdes besseyi* on *O. sativa* from Brazil, Philippines and USA, *Meloidogyne incognita* and *Aphelenchus avenae* on *Malus domestica* rooted plants from USA; and weeds intercepted include *Bromus secalinus*, *Echinochloa crus-pavonis* and *Lolium rigidum*. Besides a total of 1,513 samples of exotic germplasm of various legume crops were indexed for viruses after growing in PEQ greenhouses and detected 17 viruses, viz. ArMV, BCMV, BBSV, BBWV, BPMV, CLRV, CMV, CPSMV, GFLV, PSbMV, RCVMV, RpRSV, SMV, SBMV, TBRV, ToRSV and TSV. Of these, six viruses, viz. BBSV, BPMV, CLRV, CPSMV, RpRSV and ToRSV were quarantine viruses for India which resulted in rejection of 59 accessions of soybean. A total of 25 post-entry quarantine inspections were carried out by plant quarantine scientists for imported consignments at indentors' site. A total of 2,550 samples were processed for export after issue of 15 phytosanitary certificates. Out of these 1,715 samples were subjected to X-ray





radiography and 2,595 were released after prophylactic fumigation.

Seed health testing for pest-free conservation: A total of 15,334 indigenous samples were processed for pest-free conservation of which 2,906 samples were subjected to X-ray radiography. A total of 1,074 samples were infested with insect-pests and of the total infested/infected, 190 samples were rejected due to heavy insect infestation/fungal infection and rest were released for pest free conservation. A total of 82 *in vitro* accessions comprising *Dioscorea* (54) and *Rubus* (28) were virus-indexed for associated viruses.

Plant germplasm registration: During the period under report, total of 105 genetic stocks belonging to 33

species were registered. Some notable registered germplasms were Herbicide tolerant rice mutant; Rice resistant to Brown plant hopper; Soft grained wheat suitable for biscuit making; Barley with high grain zinc content; Black Pepper with very long spike (29.3 cm); Safed Musli with high root weight and high saponin; *Solanum viarum* with prickleless plant type and high alkaloids. Total trait based germplasm thus registered is 1,528 now.

DNA fingerprinting: A database to identify rice varieties/germplasm has been developed using 729 diverse rice varieties with 35 SNP and 36 SSR markers for identification of an unknown sample by comparing its profile (SNP and SSR) with the database (<http://>

Plant germplasm registered by PGRC

Crop	National Id	INGR No	Trait for which registered
Rice	IC0619319	19001	Tolerant to alkalinity stresses up to pH 9.9 and salinity stress, long slender grain.
Rice	IC0628569	19002	Herbicide tolerant mutant.
Rice	IC0628571	19003	Potential donor for resistance to plant hoppers (Brown plant hopper and white backed plant hopper). Exhibits resistance during vegetative and reproductive stages of crop growth.
Rice	IC0413644	19004	Tolerant to combined stress of drought and salinity. Tolerant to vegetative stage salt stress and stagnant flooding.
Rice	IC0413644	19005	Resistant to brown plant hopper.
Rice	IC0574806	19006	High anaerobic germination.
Rice	IC0599610	19033	Kamini (AC 44118) tolerant to salinity stress.
Rice	IC0596460	19034	Tolerant to salinity stress at vegetative stage.
Rice	IC0599610	19035	Tolerant to salinity stress both at seedling and reproductive stage.
Rice	IC0632071	19036	The new rice line, RP5972-13-1-6-67-129-266 developed in the background of MTU1010 showed tolerance to low soil phosphorous condition.
Rice	IC0121865	19037	Resistance to blast disease.
Rice	IC0199562	19038	Resistance to blast disease.
Rice	IC0632074	19039	Mutant NH 219 gives higher yield than Nagina 22 in normal and high temperature conditions. Dark green leaves, drought tolerant. Seed hull dark and apiculus black.
Rice	-	19040	Mutant NH 162 is drought tolerant, gives higher yield than Nagina 22 in normal, drought and aerobic conditions. It is functionally stay green-with dark green leaves, drought tolerant, higher yielder in aerobic condition. Seed hull dark and seed type is slender.
Rice	IC0632075	19041	Novel donor for resistance to Brown planthopper (BPH) <i>Nilaparvata lugens</i> in rice and possesses high resistance at vegetative and reproductive stages. Present in the elite genetic background of popular commercial variety Swarna.
Wheat	IC0536365	19007	Resistant to all prevailing stem, leaf and stripe rust pathotypes of India due to the synergistic combination of minor and major rust resistance genes. Presence of leaf tip necrosis (LTN), a phenotypic marker for the presence of minor/APR genes.
Wheat	EC574482	19008	Resistant to the entire prevailing stem, leaf and stripe rust pathotypes of India due to the synergistic combination of minor and major rust resistance genes. Presence of leaf tip necrosis (LTN), a phenotypic marker for the presence of minor/APR genes.
Wheat	IC0628570	19009	Resistant to stripe rusts with additional resistance to Karnal bunt and powdery mildew.
Wheat	IC0628572	19010	Soft grain genotype (very low grain hardness index). Suitable for better biscuit making.
Wheat	IC0628573	19011	High grain protein content.
Wheat	IC36761A	19032	Drought tolerance.
Wheat	IC0415843	19042	Tolerance to waterlogging. Resistance to spot blotch.
Wheat	IC0630581	19043	Short duration genotype. High 1000-grain weight.
Wheat	IC0529962	19044	Highly resistant to spot blotch (<i>Bipolaris sorokiniana</i>). Stability for grain yield performance.



**Plant germplasm registered by PGRC (Continued)**

Crop	National Id	INGR No	Trait for which registered
Wheat	IC0529684	19045	Highly resistant to spot blotch.
Wheat	IC0290150	19046	Resistant to stem rust, leaf rust and stripe rust pathotypes prevalent in Indian condition. Based on linked marker analysis, this germplasm has combination of different leaf rust, stem rust, stripe rust and spot blotch resistance genes Lr46+, Lr67+, Yr5, Yr15, Yr36, Yr48, Sr13, Sr24/Lr24, QSb.bhu-2B.
Wheat	IC0630582	19047	New CMS (A) line in PBW 343 background with diversified CMS source (CMS1A) along with maintainer (B) line.
Wheat	IC0630583		
Wheat	IC0630584	19048	New CMS (A) line in PBW 343 background with diversified CMS source (CMS 10A) along with maintainer (B) line.
Wheat	IC0630585		
Wheat	IC0630586	19049	New CMS (A) line in PBW 343 background with diversified CMS source (CMS 12A) along with maintainer (B) line.
Wheat	IC0630587		
Wheat	IC0630588	19050	New CMS (A) line in PBW 343 background with diversified CMS source (CMS 13A) along with maintainer (B) line
Wheat	IC0630589		
Wheat	IC0630590	19051	New CMS (A) line in PBW 343 background with diversified CMS source (CMS 17A) along with maintainer (B) line.
Wheat	IC0630591		
Wheat	IC0632081	19052	Soft grain genotype.
Wheat	IC0632082	19053	High sedimentation value.
Wheat	-	19054	The High phytase level in the background of PBW 502, a high yielding wheat variety for NWPZ. Low phytic acid.
Barley	IC0626293	19012	High grain zinc content.
Barley	IC0626294	19013	High grain iron content.
Barley	IC113045	19055	Extra dwarf plant stature along with early maturity in six-rowed and hulled genetic background.
Barley	IC113052	19056	Long spikes coupled with more number of grains/spike in two-rowed and hullless genetic background.
Barley	EC667420	19057	Early maturing hooded barley in six-rowed and hulled genetic background.
Barley	EC492301	19058	Awnless spikes.
Barley	IC0542197	19059	Early maturity in two-rowed and huskless genetic background.
Sorghum	IC0632083	19060	IVDMD 56%. Anthracanose resistance.
Sorghum	IC0632070	19064	Sorghum forage line derived from intergenic cross between sorghum and maize. Low HCN. High IVDMD.
Chickpea	IC0627616	19014	Wilt resistant. Semi-erect plant type, single pink coloured flower per peduncle. Tuberculate seed testa with large sized brown colour desi type seed.
Cowpea	EC724523	19065	Resistant to root-knot nematode, <i>Meloidogyne incognita</i> .
Cowpea	EC723686	19066	Resistant to root-knot nematode.
Cowpea	EC725122	19067	Resistance to root-knot nematode.
Lentil	IC559673	19068	Resistant to root-knot nematode.
Lentil	IC208329	19069	High protein content (27.4%–28.5%).
Lentil	IC0208326	19070	High protein content (27.4%–28.06%).
Lentil	IC0559890	19071	Resistant to root-knot nematode.
Lentil	IC317520	19072	Extended funiculus. Fast water uptake.
Mothbean	IC0120963	19073	Extra early maturing (53 days).
Mungbean	IC039289	19074	Early maturing genotype (50 days).
Pea	IC0241565	19075	Post emergence herbicide (Metribuzin) tolerant.
Pea	IC0630592	19077	Capable to produce 3–5 pods/peduncle at multiple flowering nodes (Multi-podded genotype).
Pigeonpea	IC0632084	19076	Moderately resistant to pod borer. Indeterminate growth habit. Early maturing (130–140 days).
Soybean	EC390977	19015	Photoperiod insensitivity. Source of recessive alleles e3 and e4. Early maturity.
Soybean	IC0538550	19016	Photoperiod insensitivity. Source of recessive alleles e2, e3-tr. Extra early maturity.
Soybean	IC0630595	19090	Free from Lipoxygenase 2. Free from Kunitz trypsin inhibitor.
Soybean	EC34101	19091	Photo insensitive. Source of recessive photoperiodic allele e3. Source of earliness.
Soybean	EC150149	19092	Long juvenility character. Wider adaptation to latitudes and sowing dates. CAPS marker for marker assisted breeding.
Castor	IC0625992	19017	Pistillate line with Papaya leaf type. Non-spiny capsules.
Castor	IC0546708	19018	Resistant to leafhopper
Castor	IC0628058	19019	High ricinoleic acid content (91%).
Indian mustard	IC0625996	19020	Double low (<2% erucic acid in oil and < 30 µmoles glucosinolate/g of defatted seed meal). White rust resistant. Yellow seed coat.
Indian mustard	IC0628059	19021	Multiple disease resistance (White rust, powdery mildew and <i>Alternaria</i> blight).



Plant germplasm registered by PGRC (*Continued*)

Crop	National Id	INGR No	Trait for which registered
Indian mustard	IC0630607	19084	High tolerance to Salinity (ECe 14–15 dS/m) and Alkalinity (pH 9.4–9.5). High 1000- Seed Weight (8.0–9.0 g). High Photosynthetic efficiency under salinity stress.
Indian mustard	IC0632085	19085	Drought tolerance
Indian mustard	IC0520764	19086	High temperature tolerance at seedling and terminal stage heat stress.
Indian mustard	IC0632086	19087	Drought tolerance.
Indian mustard	IC0632087	19088	Thermo tolerance at juvenile stage coupled with high seed and oil yield.
Indian mustard	IC0628060	19104	Allohexaploid (<i>Brassica juncea</i> + <i>Sinapis alba</i>). Resistant to <i>Alternaria brassiceae</i> and <i>Sclerotinia sclerotiorum</i> . Tolerant to temperature.
Linseed	IC0621697	19022	Early maturity for southern zone.
Linseed	IC0268345	19089	High seed oil content along with more number of primary branches.
Safflower	IC0625999	19023	High oil content (34.7%).
Groundnut	IC0630593	19082	High oleic acid content.
Groundnut	IC0630594	19083	High oleic acid (80%) content.
Buffel grass	EC397366	19061	Rich in sugar (more than 7%). Suitable for ensiling (Silage preparation). Prostrate growth habit.
Buffel grass	IC0630758	19062	High water soluble carbohydrate. Good for silage preparation. Leaf colour pale, low chlorophyll content.
Buffel grass	IC0630759	19063	High water soluble carbohydrate. Good for silage preparation.
Black pepper	IC0619910	19024	Very long spike (29.3 cm; reported range is 3.7 to 17.1 cm).
Isabgol	IC0627267	19025	Yellow leaf tip. Downy mildew resistance.
Isabgol	IC0627269	19026	Tetraploid isabgol.
Withania	IC0627268	19027	Male Sterile Line at 10–30°C at RH 50–60% and 20–40°C at RH 40–50%.
Safed musli	IC0586912	19028	High root weight. High saponin.
Barbados aloe	IC0112532	19029	High leaf weight. High mucilage content.
Tropical soda apple	IC0629502	19030	Prickle less plant type. Alkaloids content higher than the prickly plant type.
Flame of forest	IC0629501	19031	Trifoliate leaflet has acute apex (occasionally penta-foliate). Larger flower with dull orange colour with early biological maturity.
Cauliflower	–	19078	Ogura based cytoplasmic male sterile line of early maturity group (25–30°C) of Indian cauliflower. CMS line with dwarf plant type. Good combiner for earliness and curd yield in early maturity group of Indian cauliflower.
Cauliflower	–	19079	Cytoplasmic male sterile line of early maturity group (25–30°C) of Indian cauliflower. Carry Ogura sterile cytoplasm. Good combiner for earliness and curd yield.
Cauliflower	–	19080	Downy mildew resistance genotype of cauliflower and resistance is governed by single dominant PPa3 gene. The resistance locus PPa3 is mapped with molecular markers. A genotype of medium maturity group cauliflower.
Watermelon	IC0627526	19081	Stable andromonoecious sex form.
Basil	EC174527	19093	Essential oil rich in Linalool content (~ 61.18 ± 4.41%) in oil isolated from aerial plant parts.
Velvet bean	IC0599290		19094 High L-Dopa content in seeds of <i>Mucuna pruriens</i> accession IC599290 (7.1% DWB).
Calla lily	IC0630596	19095	Trumpet flower shape. Bright yellow flower colour. Stalk length >40 cm.
Calla lily	IC0630597	19096	White flower colour and large spathe. Stalk length (>80 cm).
Gerbera	IC0623707	19097	Double flower shape. Standard size (>10 cm flower diameter). Red flower colour.
Gerbera	IC0623708	19098	Semi double flower shape. Standard size (>10 cm flower diameter). Yellow orange flower colour.
China aster	IC0624189	19099	Flower colour: NN155D, White group, Fan 4, New flower form: Semi-double with pseudo ray florets.
China aster	IC0624190	19100	Flower colour: N81A, Purple Violet group, Fan 2, New flower form: Semi-double with pseudo ray florets.
Ber	I0625848	19101	Fruit fly resistant.
Ber	IC0625849	19102	Stoneless ber.
Potato	IC0630606	19103	Interspecific potato hybrid with diverse genetic base [interspecific potato somatic hybrid P8 (<i>Solanum tuberosum</i> + <i>S. pinnatisectum</i>) x cv. Kufri Jyoti (<i>S. tuberosum</i>)]. Very high resistance to potato late blight disease. High tuber dry matter content.
Potato	IC0625993	19105	Better water use efficiency than popular cultivars. High yield.





webtom.cabgrid.res.in/ricegis). In case of brinjal, no adventitious presence of transgenes was found in samples collected (175) from north-eastern states bordering Bangladesh. GM testing services were provided for 68 samples of 27 consignments of different crops to public and private sector. Visual and real-time construct specific loop-mediated isothermal amplification (LAMP) assays of insecticide resistance/herbicide tolerant GM events were developed with acceptable specificity and limit of detection (0.01%). A total of 6,100 plant DNA samples are conserved in National Plant Genomic Resource Repository. Bioinformatics analysis pipeline for plant genome and transcriptome was developed.

Microbial genetic resources: National Agriculturally Important Microbial Culture Collection (NAIMCC) is a designated national repository for conservation of agriculturally important microorganisms (AIMs). It maintains microbial cultures of agricultural importance in India and is an affiliate member of World Data Centre for Microorganisms (WDCM). Currently, NAIMCC holds more than 6,800 AIMs including bacteria (both actinomycetes and archaea) and 3,809 fungi and cyanobacteria. In the year 2019, 380 microbial strains have been accessioned and preserved in NAIMCC. A novel species of moderately haloalkalophilic actinobacteria isolated from salt crusts of Panamik hot spring, Leh, Ladakh and new nomenclature proposed is *Nesterenkonia icaraensis* sp. nov. Some rare cyanobacteria namely, *Chamaesiphon* sp. SB2, *Leptolyngbya antartica* SK2, *Hapalosiphon* sp. BG2, *Trichormus azollae* SB1, *Hapalosiphon* sp. SB10 *Chroococcidiopsis cubana* HC1, *Pleurocapsa* sp. HC3, *Chroococcus* sp. SB4 were isolated from extreme environments (Atri hot springs, Brahamagiri and Bhiterkanika, Odisha and Leh). NAIMCC has supplied more than 60 microbial cultures to different private and government institutions for research purposes. A total of 30 microbial cultures have been accessioned under safe deposition from different government and private institutions.

HORTICULTURE

Collection of germplasm from exotic sources: In all, 13 germplasm accessions of pomegranate (12 from France, 1 from USA); 33 exotic accessions of banana; nine lemon varieties from USA and five lemon varieties from South Africa, were collected.

Introduction of rootstocks: Bitters, Carpenter, Furr, Swingle, *Citrus volkamariana*, Sour orange (*Citrus aurantium*), Flying dragon (*Poncirus trifoliolate* strain), Rich 16-6 (*Poncirus trifoliolate* strain) and Rubidoux (*Poncirus trifoliolate* strain) were collected from USA.

Collection of germplasm from indigenous sources: Survey led to collection of 14 *Musa* accessions from lower and upper Dibang districts of Arunachal Pradesh; 16 elite clones comprising three high yielding Grand Naine, two ultra dwarf and three dwarf Grand Naine, six high yielding Ney Poovan including a shy suckering (without side suckers) type and two high yielding



Musa sадdлensis—bunch and fruit with seeds



Musa thomsonii—bunch and fruit with immature pink seeds

Nendran having green pseudostem from Tamil Nadu and Karnataka; one thornless accession of wild ber (*Zizyphus rotundifolia*) from Bikaner, Rajasthan; 11 bael, 9 guava, 3 acid lime and one each of lemon, Manila tamarind and jamun from Gujarat, Maharashtra and Uttar Pradesh; 299 germplasm of 36 vegetable crops from hilly and border area of Tripura; 118 new collections of tropical tuber crops including 29 sweet potato, 21 taro, 20 greater yam, 8 elephant foot yam, five each in bunda and aerial yam, four in cassava, 26 minor tuber crops from different sources/regions; 95 seed spices germplasm lines from Uttarakhand, Bihar and Rajasthan; 170 new wild mushroom germplasm accessions (important edible specimens of mushrooms *Agrocybe aegerita*, *Auricularia* sp., *Flammulina velutipes*, *Agaricus* sp., *Pleurotus* sp., *Ganoderma* sp., etc.) from the forest of Himachal Pradesh, Maharashtra and Chhattisgarh. Strains (30) of mushrooms as pure tissue cultures were conserved in the Gene Bank.

Characterization and identification of germplasm:

On the basis of morpho-taxonomic characterization, seven new banana germplasm accession were identified



Collection of new edible mushroom



**Chemical profiling of *Dendrobium nobile* orchid**

GC-MS analysis of methanol extract of native *Dendrobium nobile* orchid revealed presence of 16 compounds having several medicinal properties.

and added to the core collection. In grape germplasm, accessions with prominent berry diameter (14 nos), bunch compactness (3 nos.) and coloured pulp (6 nos.) were identified. In date palm, one early maturing (mid July) elite seedling variant (CIAH/DP/S-2) with 18–20 berry per strand; 10 g berry weight and 37 kg/palm yield was identified. Three arecanut accessions SCRDTC-18, Kamrup and Dangapara indicated higher tender nut yield potential. In cocoa, VTLC 13 and VTLC 20 clones of Nigerian origin, with 3 kg dry bean yield/tree/year, were identified as promising clones for cultivation in arecanut and coconut cropping systems. In water melon, a high carotenoid (7 to 7.2 µg/g FW) content germplasm accession (YF 5-2-7) was identified. Onion genotypes [W 208, Acc. 1630, Acc. 1622, and RGP5 (advance line)] tolerant to excess soil moisture stress with good survival (100%) and recovery (>80%) under artificial waterlogging condition, were identified. Four onion genotypes (Acc. 1656, W 448, W 397, RGP 3) tolerant to limited moisture stress with less than 30% reduction in bulb yield were identified. Improved germplasm accessions of coriander (UD-353) with higher yield (12.03 q/ha), two cumin accessions with higher seed yield (AC-WMT-16-40 with 5.63 q/ha and CE-15 with 4.94 q/h), one fenugreek (B5-5-6-1 with 9.7 q/ha), two fennel accessions (AF-01-521 with 25.92 q/ha seed yield and AF-164 with 1.83% essential oil) were identified. High yielding germplasm accessions of nigella (AN-19 with 10.3 q/ha yield), two dill accessions (AD-S-1-28 with 24.25 q/ha yield and AD-S-44 with 23.75 q/ha), one ajwain (AA-3 with 17.35 q/ha yield), two celery accessions (A-Cei-14-34 with 17.08 q/ha seed yield and K-24 with 2.28% essential oil content) and an early maturity (155–160 days), dwarf (65–70 cm height) mutant fennel accession (RF/225/37/10) were identified.

Germplasm registration: A total of 32 unique *Musa* germplasm accessions (IC 0627968 to IC 062799); promising genotypes of khejri (Thar Shobha-IC No. 622024; Khejri Sel-2-IC No. 622065) and DWS-10



DWS 10 (male sterile) can reproduce itself by selfing under long-day condition

(IC0627268, INGR19027), a male sterile line of ashwagandha, were registered with ICAR-NBPGR, New Delhi.

LIVESTOCK**New breeds registered**

Breed Registration Committee approved registration of 15 new breeds of livestock and poultry. These include two breeds of cattle; three of buffaloes; six of goats; and one each of sheep, pig, donkey and chicken. Total number of indigenous breeds now in the country is 184, which includes 43 cattle, 16 buffaloes, 34 goats, 43 sheep, 7 horses and ponies, 9 camel, 8 pigs, 2 donkey, 1 yak, 19 chicken, 1 duck, and 1 of geese.

Ladakhi cattle: Ladakhi cattle (INDIA_CATTLE_0700_LADAKHI_03042), native to Ladakh region, are small, short statured, black or brown animals well adapted to extreme cold climatic and hypoxic conditions. Body is compact with short legs. These cattle are reared under extensive system for milk, draught and manure purposes. Horns are curved slightly upward and forward ending with pointed tips over the forehead. Forehead is straight, small and hairy with slightly long face. Udder is small and bowl shaped. Milk yield 2 to 5 kg/day, milk fat 5%, and is used mainly for producing butter and *churpi*, an important part of local diet.



Konkan Kapila: Animals of Konkan Kapila (INDIA_CATTLE_1135_KONKANKAPILA_03043), distributed in Konkan region of Maharashtra and Goa, are predominantly of reddish brown/black coat; however white/grey, mixed, fawn are also available. The animals are small to medium with compact body, straight face, small to medium size hump and dewlap. Generally straight and small size horn emerge from side of the poll behind and above eyes in outward and going upwards and backwards ending with pointed tips. Konkan Kapila cattle are low milk producers (around 2.25 kg/day) and possess good draught ability suited to hilly terrain and hot and humid climate of its native tract.

Luit buffalo (Swamp): The Luit swamp buffaloes (INDIA_BUFFALO_0212_LUIT_01014) are distributed mostly in upper Brahmaputra valley of Assam and in some areas of Mizoram, Manipur and Nagaland bordering Assam. Luit is a medium size black buffalo with compact body and strong built up. Forehead is broad with conical face and wide muzzle. Eyes are prominent. Horns are broad at base, curved upward to form a semi circle and taper to a narrow tip. Light white stockings up to the knee are present in both fore and hind legs. Tail is short reaching up to the hocks. Udder is bowl shaped and small in size. Lactation milk yield ranges from 385 to 505 kg. Bullocks are excellent draught animals for carting and ploughing especially in muddy field for paddy cultivation.





Bargur buffalo: These Bargur buffaloes (INDIA_BUFFALO_1800_BARGUR_01015) are found in the Bargur hills in Tamil Nadu. Coat colour varies from black



to light brown or brownish black. Greyish white stockings from carpal/tarsal joint to fetlock are present predominantly in females.

These buffaloes are maintained under extensive system and are reared for manure, milk and meat (male calves are sold for carabef). Their milk yield ranges from 1.5 to 2.0 kg/day.

Chhattisgarhi buffalo: These Chhattisgarhi buffaloes (INDIA_BUFFALO_2600_CHHATTISGARHI_01016) are distributed throughout the Chhattisgarh state and are reared under extensive system for providing draught, milk and meat. Coat colour is black. Animals are of medium built with proportionate body. Horns are medium to large with pointing tips directed laterally backwards and then upwards. Males have excellent ploughing ability and preferred over cow bullocks specifically in rice fields. Milk yield ranges from 3 to 6 kg/day.

Panchali sheep: Panchali (INDIA_SHEEP_0400_PANCHALI_14043) is a dual purpose sheep reared for milk and meat in Panchal area of Gujarat. Animals are large, having long legs and excellent migration ability. Coat colour is white. Head or facial parts are black, blackish brown, brown and light brown. Ears long, pendulous; tail long; udder well-developed. Milk yield ranges from 0.4 to 1.2 litre/day. Animals attain 18 to 20 kg body weight at 3 to 4 months of age. Adult weight varies from 53 to 82 kg in males and 32 to 73 kg in females. Wool is coarse and average annual production is nearly 1 kg.

Kahmi goat: The Kahmi goat (INDIA_GOAT_0400_KAHMI_06029) is native to Saurashtra region of Gujarat and is reared for meat and milk. Coat colour is unique — neck and face are reddish brown while rear abdominal part is black. Ears are long, tubular, coiled, locally called *veludi*. Wattles are present in majority of goats. Forehead is convex. Horns are directed upwards and backwards. Average milk yield is 1.7 kg/day. Adult body weight is 56 kg in males and 48 kg in females. Average litter size is 1.4.

Rohilkhandi goat: This goat (INDIA_GOAT_2000_ROHILKHANDI_06030) is native to Rohilkhand region of Uttar Pradesh and is reared for meat and milk. Coat



colour is predominantly black with star or patch on neck and face in some animals. Majority of the animals are horned which are curved laterally and outwardly. Beard and wattles are absent in both sexes. Forehead is slightly convex. Tuft of hair (black or brown) is present in thigh region. Tail is bunchy. Adult body weight ranges from 25 to 36 kg in males and from

21 to 31 kg in females. Twinning is common and triplets are frequently observed. Average litter size is 1.57. Milk yield ranges from 450- 740 g/day.

Assam Hill goat: The Assam Hill goats (INDIA_GOAT_0213_ASSAMHILL_06031) are distributed in Assam and adjoining areas of Meghalaya, and reared mainly for meat. Assam Hill goats are mostly white with occasional black patches on backline and legs. They are short legged with small body. Both buck and does are bearded and have short cylindrical horns—directed upwards and outwards. Ears are medium size, horizontally placed with pointed tips. This is an important meat type animal with high prolificacy. Adult body weight ranges from 15 to 26 kg. Age at first kidding ranges from 337 to 447 days. Average litter size is 1.6.

Bidri goat: The Bidri (INDIA_GOAT_0800_BIDRI_06032) are black goats found in north-eastern part of Karnataka and reared for meat only. Muzzle, eyelids and hooves are black. Horns are directed backward, outward and downward. Ears are pendulous. Twinning is common but first kidding is single. Average litter size is 1.7. Adult weight varies from 23 to 52 kg in males and 19 to 45 kg in females.

Nandidurga goat: The Nandidurga (INDIA_GOAT_0800_NANDIDURGA_06033) are white goats in southern part of Karnataka and are reared for meat only. Muzzle, eyelids and hooves black; ears leafy and pendulous; horns directed backward, downward and inward touching neck in few animals. Twinning is common. Adult weight varies from 26 to 56 kg in males and 24 to 41 kg in females.

Bhakarwali goat: The Bhakarwali (INDIA_GOAT_0700_BHAKARWALI_06034) are large white goats distributed in Jammu division of Jammu and Kashmir, and are reared for meat and milk. Face or hind quarters are black in some animals. Pure black goats are also found. Whole body is covered with long hair. They have convex head; pendulous ears; screw type horns curving upwards and backwards; pendulous udder. Adult body weight varies from 35 to 60 kg in males and 30 to 50 kg in females. Average milk yield is 900 g/day.

Ghurrah pig: The Ghurrah pigs (INDIA_PIG_2000_GHURRAH_09008) are native to Bareilly division and adjoining parts of Lucknow division of Uttar Pradesh. They are medium sized, black, with flat belly, angular body and long straight snout. Legs below hock joint are white. Thick line of hair is present from neck to shoulders. Head is elongated with triangular face and short leaf like vertically erected ears. Adult males weigh about 46 kg and females about 48 kg. Litter size is 6.85 at birth and 5.65 at weaning.

Halari donkey: The Halari (INDIA_DONKEY_0400_HALARI_05002) are native to Saurashtra region of Gujarat. They are white with black muzzle and hooves; convex forehead; strong built and large size.



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Average height at wither in males is 108 cm and in females 107 cm, and average body length in males is 117 cm and in females 115 cm. They are very docile and are used as pack animals during pastoralist migration and for transportation as donkey cart. Halary donkey can walk approximately 30–40 km in a day during migration.

Uttara chicken: Uttara chicken (INDIA_CHICKEN_2400_UTTARA_12019) are distributed in Kumaon region of Uttarakhand.



Plumage is black and comb is single. These birds have feathered shank which is not present in any other indigenous breed of chicken. About 18% of birds have bunch of feathers on head (crest/crown).

Broodiness is usual. The birds are more noisy and flighty. Annual egg production ranges from 125 to 160 and egg weigh from 49.8 to 52.7 g. Adult weight is about 1.3 kg in cocks and 1.1 kg in hens.

Ex situ conservation

Germplasm repository at the ICAR-NBAGR is being strengthened by preserving diversified form of germplasm (semen, embryos, DNA, epididymal sperms and somatic cells). The germplasm added in the National Gene bank, NBAGR during this year is:

Germplasm	Breed/ population	Number
Semen	Bargur cattle	9,000
Semen	Gaddi goat	500
Semen	Pandharpuri buffalo	8,400
Somatic cells	Nagaland mithun	420
Somatic cells	Laddakhi donkey	555
Somatic cells	Laddakhi yak	384
Total		19,259

Identification and characterization of new livestock populations

Mangadh Dahodi cattle: Survey for characterization of Mangadh Dahodi cattle was undertaken in Mahisagar and Dahod districts of Gujarat. Estimated population of Mangadh Dahodi is around 2 lakh. They are primarily reared for agricultural operations and to some extent for milk production. The herd size varied from 2 to 10 with an average of 5.5 cattle/household. These are reared in low input production system of management. The Mangadh Dahodi cattle are small size with mostly white coat, while few are whitish grey or grey in colour. Males generally have dark grey colour at hump and back as compared to females. Skin grey; muzzle, eyelids and tail switch black; hooves either black or grey; horns greyish black, thick at the base and curved upwards, outwards, inwards and



backwards with pointed tips; ears horizontal; forehead straight; hump medium size in males and smaller in females; dewlap small to medium in size; naval flap and penis sheath flap small size; udder small, bowl shape; teats cylindrical with rounded tip; milk vein is not prominent. Milk yield ranges from 1.5 to 4.5 kg/day. Lactation length ranges from 155 – 220 days. Age at first calving ranges from 4.5 to 5 years. Calving interval varies from 15 to 18 months.

Jhari cattle: Surveys were conducted for Jhari cattle characterization in Adilabad, Asifabad/ Kumuram

Gazette Notification of Registered Breeds of Livestock and Poultry

India has traditionally been a mega biodiversity center and rearing of domesticated animals of different species, viz. cattle, buffalo, sheep, goat, pig, camel, equines (horse, donkey, pony, mule, ass), yak and mithun, and poultry (chicken, duck, geese) has been practised since time immemorial. The country possesses huge as well as diverse animal population distributed over a large range of geographical, ecological and climatic regions, which play a vital role in improving the socio-economic conditions of rural masses.

The indigenous animal genetic resources are characterized involving different agencies in the country under the programmes of ICAR-National Bureau of Animal Genetic Resources (NBAGR), Karnal and further registered following a due process through a Breed Registration Committee constituted by Indian Council of Agricultural Research. So far, 184 indigenous breeds of livestock and poultry have been registered.

India is party to international treaties like CBD, WTO, TRIPS, Nagoya Protocol, Interlaken Declaration on AnGR, etc. and is committed to (i) protect the local animal genetic diversity; (ii) provide recognition to the developers/ breeders of animal breeds; (iii) implement the Global Plan of Action on AnGR; and (iv) ensure that the animal diversity is utilized to promote food security and remains available to future generations. All these require an authentic national documentation system of valuable sovereign genetic resources with well-defined characteristics. The ICAR-NBAGR was documenting the indigenous animal genetic resources, but as indigenous breeds being registered by ICAR-NBAGR were not notified under relevant Official Gazette of Government of India, hence, did not have legal support as far as any IPRs or benefit sharing were concerned.

Government of India on the request of Department of Agricultural Research and Education, Ministry of Agriculture and Farmers' Welfare, issued a Gazette Notification No 3364 (S.O. 3699(E)) dated 14 October 2019 in this regard recognizing 184 registered indigenous breeds of livestock and poultry as the notified breeds of the concerned States as well as of whole of India to be kept and reared for purposes of animal husbandry, production, breeding, conservation, utilization, consumption and trade. The Gazette Notification provides legal support to Intellectual Property Rights (IPRs) of the registered breeds and for developing mechanism for sharing benefits among the animal keepers.





Bheem, Nizamabad and Jagtial districts of Telangana. Jhari name originated from the name of a village of Asifabad district. Grey and white colour animals; grey predominant in males and white in females. Body small to medium, compact and cylindrical in shape; face longer and convex type, major character for differentiating from other cattle populations; longer and thin horns at the base (other differentiating character) as compared to Ongole or its other grades; hump moderate in bullocks and smaller in cows; muzzle and eyelids black; horns black and curved with outward and upward orientation; ears shorter and horizontal in orientation; tail above the hock with black switch. Naval flap small, touching to body. Legs strong and long. Udder mostly bowl shape; teats 6–10 cm long and mostly funnel shaped. Docile temperament. Birth weight ranged from 12–18 kg in female and 14 to 24 kg in males. The estimated average adult body weight is 184.85 ± 3.26 kg in cows and 264.14 ± 12.95 kg in bullocks. Milk yield ranged from 1.0 to 3.0 kg/day. Lactation length varied from 90 to 150 days. Calving interval ranged from 15 to 24 months. A pair of bullock may plough one acre of land in 6 to 8 hours. Bullocks are also used for transportation and load carrying.

Telangana goats: Goats of Telengana include mainly Mahbubnagari also known as Palamoor goats. Goats with coat colour black, white, brown, with or without spots, splashes, with or without facial stripes exist in flocks. Wattles are present in 80% of animals. Prolificacy is good (60% twinning). Animals have long tapering mouth, nose either roman or flat; muzzle black/brown, medium size drooping ears, long and thin legs, thin and pointed horns curving backward. The average body weight of adult mixed colour male goats is 38.70 ± 1.91 and female 37.69 ± 0.68 kg. The body weight of black male goat is 37.27 ± 2.52 and female 40.42 ± 1.02 kg. Prolificacy is good with mostly singlet in first kidding, 60% twinning in subsequent kiddings and rarely triplets and quadruplets.

Camel: Villages in 6 tehsils of Jaisalmer and Barmer district of Rajasthan were surveyed for characterization of Sindhi camel. Sindhi camels are mostly brown or light brown in colour with active temperament. Animals are

of medium built with medium head size, normal forehead, upright and set well apart ears, normal chest pad, medium size hump. The udder is round in shape and milk veins are of normal size. Average age at mating is

3.91 years and age at calving is 4.86 years. Service period ranges from 1–2 years. Average inter-calving period is 2.05 years.

Villages in Pali, Jodhpur, Barmer and Sirohi districts of Rajasthan were surveyed for Marwari camel. They are black, brown, dark brown or light brown in colour with active temperament. Body size was found to be large



in 45% animals, medium in 28% and small in 27%. Head size either large or medium with normal forehead, normal supraorbital fossa chest pad, normal muzzles, normal and closely placed with head ears and slightly turned inward ear tips, either large or medium hump size in more than 75.00% animals. Around 66% animals with round shape udder. Average age at mating is 4.06 years, age at calving 5.03 years, service period range from 1–2 years, average inter-calving period 2.03 years.

Genetic characterization

Cattle

Spermatozoa transcriptogram database (Frieswal bulls): The database on categorized Frieswal crossbred bull spermatozoal transcripts was developed to use as a non-invasive tool for prediction of male infertility in crossbred bulls. Reads were identified among good and poor quality bull spermatozoa based on their conception rate. Post mapping with *Bos taurus* reference genome identified transcripts among good and poor quality RNA libraries, respectively. However, a total number of 3,510 and 6,759 functional transcripts were identified among good and poor quality bull spermatozoa, respectively. Most of the identified transcripts were related to spermatozoa functions, embryonic development and other functional aspects of fertilization. Wet laboratory validation of the top selected transcripts, viz. AKAP4, PRM1, ATP2B4, TRIM71 and SLC9B2, illustrated the significant level of expression in the good quality crossbred bull semen than the poor quality counterparts.

Kisspeptin gene among indigenous cattle breeds: DNA databank of Kankrej (200) and Gir (80) maintained in the laboratory was used to amplify the Kisspeptin gene exon-1 and exon-2 comprising 334 bp and 308 bp amplicons in Kankrej, Gir cattle, respectively. By PCR-SSCP, three genotypes of exon-1 (AA- 39%, AB- 46% and BB- 15%) and two genotypes of Exon-2 (AB- 66% and BB- 34%) were observed. Two missense SNPs ($G' \rightarrow A$ & $C' \rightarrow T$) were observed in exon-1 while one missense ($T' \rightarrow C$) and two synonymous SNPs ($G' \rightarrow A$ & $C' \rightarrow T$) were observed in exon-2 of bovine Kisspeptin gene in Kankrej and Gir cattle. Seven gene bank accession numbers were obtained on SNPs at bovine kisspeptin exonic region in Kankrej and Gir cattle.

OAS1 protein expression at bovine PBMC: The OAS1 protein expression at bovine PBMC was assessed at day 18 post AI in pregnant and non-pregnant animals. Higher expression of OAS1 protein in nulliparous pregnant animals in comparison to open animals was observed but the difference was not prominent. Western Blotting technique revealed that expression of OAS1 was comparatively higher in nulliparous pregnant than that in non-pregnant animals. Further, the quantification of levels of protein revealed that the level of OAS1 protein in nulliparous pregnant animals was higher than the non-pregnant animals.

Association of OAS1 genotypes with milk production traits: Genetic variants in the exonic regions





of 2, 5 oligoadenylate1(OAS1) gene were identified for associating with milk production traits in 250 cows comprising 168 Frieswal and 82 Sahiwal cattle. The genotypes of exon 6 fragment 1 of OAS1 gene had significant association with milk production traits, whereas genotypes identified in exon 2 and exon 5 did not reveal any association in both Frieswal and Sahiwal populations.

Expression of fertility associated genes: Study on correlation of different semen quality parameters with expression profiles of genes like *AKAP4*, *PRMI* and *CAT* showed positive correlation on both acrosome integrity and post thaw motility in Frieswal bull semen. The *AKAP4* had significant correlation with both semen quality parameters. *PRMI* showed high correlation with PTM. Genes, viz. *CLU*, *TPN1*, *TPN2* and *MnSOD* showed positive correlation on PTM of which the *MnSOD* showed correlation at 1% level. Acrosome integrity was also correlated with the expression profiles of SOD, PKM2.

Modulation of thermo-regulatory response in cattle: Characterized bovine HSP90AA1 IRES sequence was subjected for structural prediction and generation of interactome model between the predicted bovine IRES with human 40S Subunit ribosomal protein5 (RPS5) and ribosomal translational initiation factor (TIF). Spectrophotometric readings revealed that the concentration of *in vitro* synthesized RNA eventually increased from 14.4 ng/ μ l (A260/280:1.65) to 2057.8 ng/ μ l (A260/280:2.01). Transfected MDBK cells revealed the AcGFP expression under the control of bovine Hsp90AA1. However, the GFP expression under the control of native IRES (53%) was slightly higher than the Hsp90AA1 IRES (47%). Further, confirmation was made through immunefluorescent assay, which also localized the GFP gene expression under the control of Hsp90AA1 IRES element.

Discovering biomarkers: A total of 1,547 proteins were identified in Frieswal bull spermatozoa using liquid chromatography – mass spectrometer (LC-MS/MS) analysis, which revealed that 558 (36.1%) and 653 (42.2%) proteins expressed differentially among fertile and inferior quality bull spermatozoa, respectively.

Genetic composition of Vrindavani cattle: The precise genetic composition of the Vrindavani crossbred cattle strain was determined by assessing the population structure and admixture levels of the Vrindavani composite population. Genotypic data were generated from randomly selected animals of Vrindavani population and the data for parental breeds, i.e. Haryana, Holstein-Friesian, Jersey and Brown Swiss was retrieved from a public repository. The merged dataset was analysed for assessing admixture levels and population stratification using principal component analysis (PCA), multidimensional scaling (MDS) approach and the model-based approach in STRUCTURE software. The average minor allele frequency (MAF) value for Vrindavani population was estimated to be 0.235. Vrindavani population showed an average ancestry of

Whole genome sequencing Malnad Gidda cattle

The Malnad Gidda is a dwarf cattle breed possessing an array of unique physiological adaptations, but not much information is available at molecular level. With reference to *Bos taurus*, ~700 genes are found to be unique to this genome, of which 171 proteins are supported by proteomic data and orthology evidence. Further, reference-based alignment against *Bos taurus* resulted in ~92% concordant mapping. Phylogenetic tree for the protein SOX 2 between Malnad Gidda and 76 mammalian species was obtained. A draft map of genome of Malnad Gidda cattle was established. The draft map of Malnad Gidda genome will provide a valuable resource for accelerated research to identify molecular underpinnings for the unique biological traits in Malnad Gidda cattle in particular and *Bos indicus* cattle in general.

39.5, 22.9, 26.9 and 10.7% inheritance levels from Holstein-Friesian, Jersey, Haryana and Brown Swiss cattle breeds, respectively. The study concluded that the genotypic data based on Bovine50KSNP BeadChip is applicable to estimate crossbred/composite breed composition. This study will also serve as a benchmark for the characterization of other crossbred populations in the country. This information will be worthwhile in incomplete pedigrees and in the search for the best type of cross or composite of breeds in our country.

Goat

Analysis of genetic diversity: Blood samples collected from genetically different animals of Telangana goats were processed for DNA isolation. A total of 145 alleles were detected in black and 160 in splashed populations of Telangana goats. Difference in the observed and expected number of alleles in both the populations suggested presence of several low frequency alleles in these populations. In accordance with allelic diversity, estimate of observed heterozygosity (H_o) was not very high. Observed heterozygosity was lesser than the expected heterozygosity and correspondingly F_{IS} analysis identified significant heterozygote deficiency. Principal coordinate analysis did not discriminate two groups of populations and genetic differentiation. Nei's genetic identity among the two groups was also very high. Analysis indicated that two groups of Telangana goats differentiated on the basis of coat colour were also not distinct. The study concluded that Telengana goats lack homogeneity at phenotypic as well as genetic level which make these a poor candidate for registration as breed.

Mithun

Genetic characterization of four mithun populations was taken up using whole mitochondrial genome sequencing of mithun (representing four native breeding tracts of NEH region) through next generation sequencing (NGS). Phylogenetic analysis using whole mitochondrial genome of mithun and other available *Bos* species demonstrated mithun and gaur (*Bos gaurus*) in the same





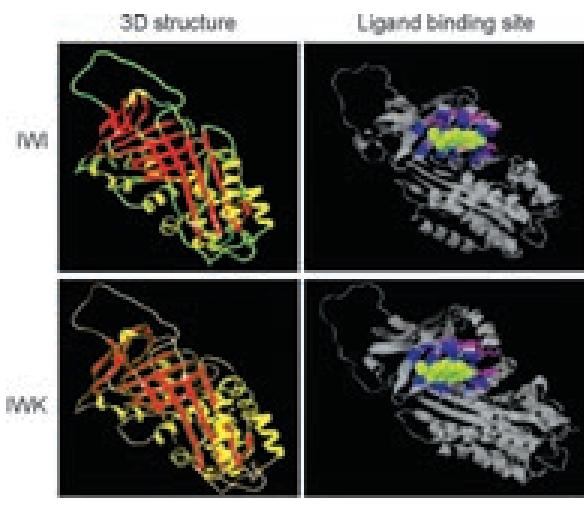
cladogram, indicating common origin from one ancient *Bos* species which is extinct now.

Yak

High throughput sequencing of the DNA samples revealed that total number of SNPs identified RD10 in Arunachali, Himachali, Ladakhi and Sikkimi yaks were 256,051; 241,934; 312,518 and 150,425; respectively. Overall, a total of 579,575 high quality SNPs along with 50,319 INDELs were identified with a coverage of 9.42% in the Indian yaks. The genetic distance calculated using genome wide SNPs in the Indian yaks revealed that Ladakhi and Sikkimi yak populations are distinct.

Poultry

Genomic profiles of chicken lines: Expression of stearoyl coenzyme A Desaturase (*SCD*) and sterol regulatory element binding protein1 (*SREBP1*) genes were analyzed in broiler, layer and indigenous native chicken lines. Highest expression of *SCD* gene was observed on day 14 in Ghagus and on day 42 in control layer and control broiler population. Polymorphism at the promoters of *SCD* and *SREBP1* genes were significantly associated with body weight, serum cholesterol and triglycerides in chicken. The shRNA molecules (10) were studied for silencing these genes in which shRNA1 and shRNA3 of *SCD*, and shRNA1 and shRNA2 of *SREBP1* genes had more than 60% knock down efficiency for expression of 2 genes under *in vitro* system. Further, optimal promoter (1,034 bp) of ovalbumin was identified and its functionality was examined. The construct was efficient for expressing GFP marker gene in magnum primary cell culture. The coding sequence of the ovalbumin gene was characterized, its expression profile explored and polymorphism identified in the 5'-upstream regions of the gene in IWI and IWK lines. In both the lines, an increase in expression of ovalbumin gene was observed after the onset of egg production with peak expression during 40th week of age. The SNPs were identified depicting in the form of three haplotypes namely, H1, H2 and H3; which were



associated with egg weight and age at sexual maturity in IWI line. The single-strand conformation polymorphism study revealed that the exons of *Tapasin* gene were polymorphic with the presence of 8 haplotypes in Ghagus, Dahlem red and Nicobari chicken.

Fish

First record of aquatic species: During the year, five fish/shrimp species were recorded for the first time from Indian waters; they are: (i) *Aenigmachanna mahabali*, a new species of troglophilic snakehead from a well in Kerala; (ii) *Thor hainanensis*, an ornamental shrimp from Agatti Island, Lakshadweep; (iii) *Cypselurus opisthopodus*, rear-fin flying fish from south-eastern Arabian Sea; (iv) *Bathymyrus simus*, a rare eel from Arabian Sea and Bay of Bengal; and (v) *Leptojulis lambdastigma* from Andaman and Nicobar islands.

Natural populations of fish species: The natural populations of *Chitala chitala*, *Mugil cephalus*, *Silonia silonia* and *Tenualosa ilisha* were characterized with mitochondrial markers for population divergence and genetic stock identification. Sub-structuring of populations was observed. In *C. chitala*, genetic clustering and median joining network demonstrated presence of multiple clades, which corresponded to the



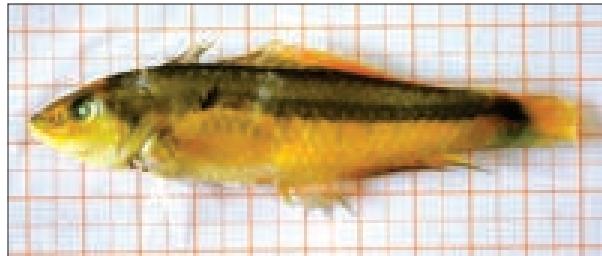
Aenigmachanna mahabali



Bathymyrus simus



Cypselurus opisthopodus



Leptojulis lambdastigma



**Aquatic genetic information system of India (AqGRISI)**

An online information system, AqGRISI was developed to provide information on different aspects of native fishes of India. Presently, it covers 3,137 native finfish species belonging to 1,022 genus, 247 families and 47 orders. It provides information on Systematics, Common name, Synonyms, Biology, Length-Weight, Type specimen, Disease, Habitat, Distribution, Patent, Fish Nutrition and Bibliography. This system also serves as digital repository to hold information on different fish accessions preserved in different storage facilities like; live germplasm, cell lines and museum at ICAR-NBFGR, Lucknow. The system has link to Fish Base, WoRMS, CIFRI, CMFRI, FAO, NCBI, Google Patents and IUCN. The type specimen of each species has link to the different natural history museums of the world, which presents the holotype and other information. Additionally, it presents the molecular information from in-house molecular resources like HRGFish, FMiR, FBIS, Fish Karyome and Fish Microsat. AqGRISI, can be accessed at URL: <http://mail.nbfgr.res.in/agrisi>.

main geographical regions of distribution. The information on natural genetic divergence and stock structure has strong implications for scientific management of the important fishery resource through evolving comprehensive conservation strategies.

EUS disease resistance/ susceptibility in fishes: Epizootic ulcerative syndrome (EUS) is a disease of finfish caused by Oomycetes, *Aphanomyces invadans*. In Hilsa shad, *Tenualosa ilisha* twelve alpha-2-Macroglobulin (A2M) isoforms were reported through SMRT sequencing. Five putative markers of EUS disease resistance in A2M protein, which were present in MG2 domains, classified fishes into two groups, resistant and susceptible to EUS. Potential markers predicted that *T. ilisha* be placed in EUS susceptible category. Putative markers reported in A2M protein may serve as molecular

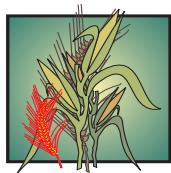
marker in diagnosis of EUS disease resistance/susceptibility in fishes.

Genes for muscle growth, lipid synthesis and immune system in Hilsa: Through RNAseq of muscle, identified 53 genes related to muscle growth and genes associated with different pathways, viz. 75 in PI3/AKT, 46 in mTOR, 76 in MAPK signalling, 24 in Janus kinase-signal transducer and activator of transcription, 45 in AMPK and 27 in cGMP pathways. Among genes involved in lipid metabolism, 32 genes were associated with glycerophospholipid metabolism and 4 were involved in fatty acid biosynthesis. There were 58 immune related genes, in which 31 were under innate and 27 under adaptive immunity.

Transcriptome profile of *Argulus siamensis* parasites: For prevention of argulosis in carps, full reference transcriptome sequences were generated separately from male and female parasites. Total full length non chimeric clustered consensus isoforms for female was found to be 84,337 whereas for male it was 209,271. Species specific genes were identified (105 for male and 10 for female). Overall, the information of *A. siamensis* male and female will help in generating efficient prevention strategies for this parasite.

Induction of triploidy in rainbow trout: Production of sterile triploid rainbow trout (*Oncorhynchus mykiss*) is the major concern for its production enhancement. Better induction of triploidy was achieved on exposure of green eggs to heat shock treatment at 28°C for 10 min, with up to 80% success, 40–46% hatching rate and 57–68% survival up to swim-up fry stage. Triploid fry after yolk absorption exhibited three sets of chromosomes (86–90) and cell size of erythrocytes was 13% bigger. Growth performance of triploids was 9–19% better than the diploids up to fingerlings stage in 90 days. Survival of triploid fingerlings was 48–68%, while that of diploids was 62–72%. □





5. Crop Improvement

Crop Varieties released and notified

Since 1965, 5,163 improved field crop varieties have been developed which include 2,625 of cereals, 864 of oilseeds, 966 of pulses, 187 of forage crops, 364 of fiber crops, 122 of sugarcane and 35 of potential crops. During reporting period, a total of 220 varieties have been notified and released for commercial cultivation which have been mentioned in this chapter.

Cereals

Ninety six high yielding varieties/hybrids of cereals comprising 45 of rice, 15 of wheat, three of barley, 15 of maize, seven of sorghum, six of pearl millet, three of finger millet and one each of little millet and prosomillet were released for cultivation in different agro-ecologies of the country.

List of released varieties/hybrids of cereals

Variety	Area of adoption	Salient features
Rice		
Bhupesh (IET 23324) (CN 1752-18-1-9-MLD19)	Tripura, Odisha, Bihar, Chhattisgarh, Rajasthan and Tamil Nadu	Suitable for all three seasons (<i>Pre-kharif, kharif and boro</i>), average yield 59.6 q/ha, short bold grains, maturity 118–122 days, fertilizer responsive.
Manisha (IET 23770) (CN-2015-5-4)	West Bengal	Suitable for irrigated lands, average yield 55.5 q/ha, long slender grains, maturity 120–126 days, moderately tolerant to bacterial leaf blight (BLB), leaf blast and stem borer.
GNV 10-89 (IET 24716)	Karnataka	Suitable for normal, early and mid-late sown conditions, average yield 65 to 70 q/ha, medium slender grains, maturity 120–125 days, moderately resistant to leaf blast.
GNR-6 (NVSR-2031)	Gujarat	Suitable for rainfed transplanted condition, average yield 40–45 q/ha, long slender grains, maturity 100–105 days, moderately tolerant to stem borer, leaf folder and sheath mite.
GNR-7 (NVSR-6128)	Gujarat	Suitable for normal rice growing areas of south Gujarat, average yield 57.4 q/ha, short slender grains, moderately resistant to BLB, sheath rot, stem borer, leaf folder, sheath mite and tolerant to BPH.
Shalimar Rice-4 (SKUA-408)	Jammu & Kashmir	Suitable for irrigated lower belts of Kashmir valley (≤ 1700 above MSL), average yield 75–80 q/ha, medium bold grains, maturity 135–140 days, tolerant to blast.
Shalimar Rice-5 (SKUA-402)	Jammu & Kashmir	Suitable for irrigated high altitudes of Kashmir valley (2,000–2,250 above MSL), average yield 45–50 q/ha, short bold grains, maturity 135–140 days, tolerant to blast.
Chinsurah Nona-2 (Gosaba-6) (IET 21943)	West Bengal	Suitable for rainfed shallow lowland of coastal saline tract, average yield 52 q/ha, short bold grains, maturity 135 days, tolerant to blast, moderately tolerant to sheath rot, leaf blast and neck blast.
Kalanamak Kiran (PRDF 2-14-10) (IET 24753)	Uttar Pradesh	Suitable for irrigated medium and rainfed lowland areas of eastern UP, average yield 37 q/ha, medium slender grains, strong aroma, maturity 140–150 days, high zinc (20 ppm) content, moderately resistant to major diseases.





Variety	Area of adoption	Salient features
JR 206 (IET 26079)	Madhya Pradesh	Suitable for rainfed and irrigated ecologies, average yield 55–60 q/ha, long bold grains, maturity 120–122 days, resistant to bunt and blast.
CNRH-103 (IET 22866) (Hybrid)	West Bengal	Suitable for irrigated ecology, average yield 53 q/ha, long slender grains, maturity 110–115 days, moderately tolerant to brown and leaf spot.
GRH-2 (Hybrid)	Gujarat	Suitable for transplanted rice growing area of middle and South Gujarat, average yield 60–65 q/ha, maturity 130–135 days, moderately resistant to bacterial leaf blight, leaf blast, grain discoloration, sheath rot, brown plant hopper (BPH), white backed plant hopper (WBPH), leaf folder and stem borer.
LG 93.01(Hybrid)	Uttar Pradesh	Suitable for all ecologies of Uttar Pradesh, average yield 52.2 q/ha, maturity 120–125 days, moderately resistant to leaf and neck blast, brown spot, sheath rot and resistance against bacterial leaf blight.
HKR 128 (HKR 06-47)	Haryana	Suitable for timely transplanting, irrigated paddy growing areas, average yield 48.34 q/ha, maturity 141 days, semi-dwarf, less incidence of WBPH, BPH and leaf folder.
Haryana Basmati-2 (HKR 06-443)	Haryana	Suitable for irrigated paddy growing areas of Haryana, average yield 53.4 q/ha, maturity 143 days, resistant to stem borer, plant hopper, leaf folder, lodging and shattering.
Bidhan Suruchi (IET 25701)	West Bengal, Odisha, Uttar Pradesh and Assam	Suitable for both P-deficient and sufficient soils. Recommended for both <i>boro</i> and <i>kharif</i> , average yield 62.4 q/ha (<i>boro</i>), 56 q/ha (<i>kharif</i>), maturity 110–114 days, moderately resistant to bacterial leaf blight, leaf blast, stem borer and BPH.
Uttar Sona UBKVR-1 (IET 24171)	West Bengal, Bihar, Tripura and Assam	Suitable for both <i>boro</i> (irrigated) and <i>kharif</i> (irrigated and/or rainfed) early sown conditions, average yield 60 q/ha (<i>kharif</i>) and 60 q/ha (<i>rabi</i>), maturity 120 days, tolerant to drought at seeding stage. Resistant to LB and BS, stem borer and no incidence of BPH, WBPH, GM, LF and WM.
BPT 2295 (IET 22188)	Andhra Pradesh	Suitable for irrigated lowland conditions during <i>kharif</i> in place of BPT 5204 in Krishna zone, average yield 65 to 70 q/ha, maturity 150–155 days, medium slender grains, resistant to BPH and BLB.
Pandu Ranga (MCM 100) (IET 22611)	Andhra Pradesh	Suitable for <i>kharif</i> season for entire saline coastal belt of AP, average yield 55.6 q/ha, maturity 145 days, tolerant to leaf blast, brown spot and sheath rot diseases and stem borer. Salinity tolerant, deep root system.
CSR 49 (IET 20329)	Uttar Pradesh	Suitable for irrigated, high fertility, transplanted and high alkaline conditions, average yield 29.4 q/ha, maturity 130–135 days, moderately resistant to leaf and neck blast, brown spot and sheath rot.
CSR 52 (IET 23206)	Uttar Pradesh	Suitable for transplanted irrigated alkaline sodic areas, average yield 28.8 q/ha, maturity 125–135 days, moderately resistant to leaf and neck blast, brown spot and sheath spot, tolerant to hoppers (brown and green), gall midge, case worm and whorl maggot.
Rice VGD 1 (VG 09006)	Tamil Nadu	Suitable for irrigated samba/late samba season, average yield 60.4 q/ha, maturity 127–132 days, moderately resistant to blast and brown spot and leaf folder, aromatic variety for biryani making.





Variety	Area of adoption	Salient features
ADT 53 (IET 23955)	Tamil Nadu	Suitable for irrigated conditions, average yield 66.8 q/ha, medium slender grains, maturity 110–119 days, moderately resistant to blast, sheath rot, brown plant hopper, and leaf folder, brown rice contains high zinc (26.06 ppm) and iron (14.70 ppm).
MP 3030 (IET 25764)	Haryana, Uttarakhand, Maharashtra and Gujarat	Suitable for irrigated ecology, below average rain and rainfed conditions, average yield 69.1 q/ha, maturity 120–125 days, moderately resistant to leaf blast and false smut.
Swarna Shakti Dhan (IET 25640) (RCPR-22-IR84899-B-183-20-1-1-1)	Haryana, Odisha, Bihar, Jharkhand, Chhattisgarh, Gujarat and Maharashtra	Suitable for irrigated and rainfed, shallow under aerobic conditions, average yield 49.6 q/ha, maturity 115–120 days, resistant to sheath blight and false smut, and tolerant to leaf blast, neck blast and brown spot.
Sandhya (IET 25508) (NP 9359-9)	Chhattisgarh and Telangana	Suitable for irrigated and rainfed, shallow under aerobic condition, average yield 54.2 q/ha, short slender grains, maturity 115–120 days, moderately resistant to leaf blast and brown spot.
Uttar Lakshmi (IET 24173) UBKVR-15	West Bengal, Odisha, Tripura	Suitable for irrigated (<i>boro</i>) in medium land situation, average yield 57.6 q/ha, short bold grains, maturity 155–160 days, tolerant to stem borer, leaf folder, gall midge biotype 1 and whorl maggot.
US 380 (IET 25728)	Chhattisgarh and Madhya Pradesh	Suitable for irrigated and rainfed in aerobic conditions, average yield 56.2 q/ha, maturity 121–125 days, resistant to leaf blast and neck blast and moderately resistant to brown spot and BLB.
US 303 (IET 25804)	Chhattisgarh, Maharashtra and Madhya Pradesh	Suitable for irrigated and rainfed conditions under high and medium fertility, average yield 54 q/ha, maturity 130–135 days, resistant to leaf blast, RTD, sheath blight and brown spot and moderately resistant to glume discolouration and BLB.
MRP 5222 MEPH 126 (IET 25269)	West Bengal, Bihar, Odisha and Maharashtra	Suitable for irrigated rice ecology, average yield 60.5 q/ha, maturity 145 days, moderately resistant to leaf blast, neck blast and bacterial leaf blight.
RH 9000 Plus (IET24931)	Maharashtra	Suitable for irrigated conditions under medium to high fertility soils during <i>kharif</i> , average yield 65 q/ha, maturity 125–128 days, moderately resistant to BLB, leaf blast, neck blast, sheath rot, glume discolouration, tolerant to lodging with strong culm.
CR Dhan 312 (CR 3808-13) (IET 25997)	Maharashtra and Chhattisgarh	Suitable for irrigated conditions, average seed yield 64 q/ha, maturity 135–140 days, moderately resistant to leaf blast, neck blast and tungro virus.
Telangana Vari-1 (IET 25330) (WGL-739)	Odisha, West Bengal and Tamil Nadu	Suitable for irrigated conditions, average yield 60.8 q/ha, maturity 135 days, moderately resistant to leaf and neck blast.
Pant Dhan 28 (UPR 3667-2-1-2)	Uttarakhand	Suitable for irrigated transplanted conditions in Uttarakhand plains, average yield 56.6 q/ha, maturity 128–130 days, moderately resistant to leaf blight and stem borer.
CAU-R4 (Eenotphou) (IET 22469)	Manipur	Suitable for semi deep water conditions having a water level of 50 cm, average yield 38–45 q/ha, maturity 140 days, moderately tolerant to rice blast, rice brown spots, rice stem borer and rice gall midge.
CAU-R2 (Tomthiphou) (IET 23540)	Manipur	Suitable for rainfed direct seeded under real jhum rice agro-ecosystem of Manipur and NEH region, average yield 42 q/ha, maturity 125 days, tolerant to rice blast, brown spots, rice gall midge and rice stem borer.





Variety	Area of adoption	Salient features
PR 127 (RYT 3316)	Punjab	Suitable for low land irrigated rice ecosystem, average yield 75.4 q/ha, maturity 140 days, resistant to bacterial blight.
MRP 5626 MEPH-134 (IET 26198)	Bihar	Suitable for dry direct seeded-aerobic conditions with need based irrigation, average yield 50.9 q/ha, maturity 114 days, resistant to leaf blast, neck blast, false smut; less damage due to gall midge biotype 4 and plant hoppers.
MRP 5433 MEPH-129 (IET 25793)	Maharashtra	Suitable for irrigated and transplanted conditions during <i>kharif</i> , average yield 55.6 q/ha, maturity 130 days, moderately resistant to false smut, tolerant/resistant to brown plant hopper.
Him Palam Dhan 1 (HPR 2656)	Himachal Pradesh	Suitable for low and mid hills under upland conditions, average yield 21–32 q/ha, maturity 120–125 days, resistant to blast especially in Himachal Pradesh conditions and tolerant to leaf folder and rice hispa.
Him Palam Dhan 2 (HPR 2880)	Himachal Pradesh	Suitable for low and mid hills under irrigated ecology for transplanting conditions, average yield 55.7 q/ha, maturity 120–125 days, highly resistant to leaf and neck blast and resistant to leaf folder and rice hispa.
Pant Dhan 22 (UPR 2760-10-1-2)	Uttarakhand	Suitable for irrigated transplanted condition in Uttarakhand plains, average yield 54.5 q/ha, maturity 120–130 days, moderately resistant to leaf blight and stem borer.
Sabour Harshit Dhan (IET 25342)	Bihar	Suitable for irrigated and medium upland conditions, average yield 57.6 q/ha, maturity 120-125 days, moderately resistant to BLB, blast and brown spot and tolerant to stem borer, leaf folder and gundhi bug.
CAU-R3 (Mangalphou) (IET 22833)	Manipur	Suitable for irrigated medium and medium upland conditions, average seed yield 40.0 - 45.0 q/ha, maturity 95-120 days, tolerant to blast, brown spot, stem borer, gall midge and resistant to tungro virus.
Wheat		
SHUATS-W 13 (AAI 13)	Uttar Pradesh	Suitable for timely sown, irrigated conditions, average yield 34.8 q/ha, maturity 115–120 days, plant height 95–100 cm, resistant to brown rust and Karnal bunt.
P 12499 WH 1184	Haryana	Suitable for timely sown, irrigated conditions, average yield 61.3 q/ha, maturity 144 days, plant height 99 cm (95–105 cm), highly resistant to yellow and brown rusts, protein content (13.02%), sedimentation value (60 ml).
Karan Narendra (DBW 222)	Punjab, Haryana, Delhi, Rajasthan (excluding Kota and Udaipur division), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh and Tarai region of Uttarakhand	Suitable for timely sown, irrigated conditions, average yield 61.3 q/ha, maturity 143 days, resistant to stripe and leaf rust.
Karan Shriya (DBW 252)	Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal (excluding hills), Odisha, Assam and plains of North Eastern states	Suitable for timely sown, restricted irrigation conditions and salt affected soils, average yield 36.7 q/ha, maturity 127 days, highly resistant to rust and wheat blast.





Variety	Area of adoption	Salient features
Pusa Wheat 3249 (HD 3249)	Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal (excluding Hills), Odisha, Assam and plains of NE States	Suitable for timely sown, irrigated conditions, average yield 48.8 q/ha, maturity 122 days, highly resistant to wheat blast and resistant to leaf and brown rusts. It is a biofortified variety with high zinc content (42.5 ppm).
Pusa Wheat 3271 (HD 3271)	Punjab, Haryana, Delhi, Rajasthan (excluding Kota and Udaipur divisions), Western Uttar Pradesh (except Jhansi division), parts of Jammu and Kashmir (Kathua district), parts of Himachal Pradesh, (Una district and Paonta Valley), Uttarakhand (Tarai region), Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal (excluding hills), Odisha, Assam and plains of N.E. States	Suitable for late sown, irrigated conditions, average yield 32.5 q/ha, maturity 104 days (NWPZ) and 98 days (NEPZ), highly resistant to leaf rust and stripe; moderately resistant to leaf blight, powdery mildew, Karnal bunt and flag smut.
Pusa Wheat 1621 (HI 1621)	Punjab, Haryana, Delhi, Rajasthan (excluding Kota and Udaipur divisions), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh, Tarai region of Uttarakhand	Suitable for timely sown, restricted irrigation conditions, average yield 50.4 q/ha, maturity 147 days, high levels of field resistant to stripe rust and field resistant to leaf rust.
Pusa Wheat 1628 (HI 1628)	Punjab, Haryana, Delhi, Rajasthan (excluding Kota and Udaipur divisions), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh, Tarai region of Uttarakhand	Suitable for late sown conditions, average yield 32.8 q/ha (NEPZ) and 37 q/ha (NWPZ), maturity 102 days in NWPZ and 94 days in NEPZ, high levels of field resistant to stripe and leaf rust, resistant to leaf blight, Karnal bunt and head scab.
PBW 771	Punjab, Haryana, Delhi, Rajasthan (excluding Kota and Udaipur divisions), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh and Tarai region of Uttarakhand	Suitable for late sown irrigated conditions, average yield 50.3 q/ha, maturity 120 days, high degree of resistant to yellow and brown rusts, high zinc concentration (>40 ppm). A MAS derived biofortified variety of wheat.
Him Palam Gehun 2 (HPW 368)	Himachal Pradesh	Suitable for timely sown rainfed and irrigated conditions of mid and low hills of HP, average yield 26 q/ha (rainfed) and 50.9 q/ha (irrigated), maturity 176–185 days, high level of resistant to yellow rust and resistant to powdery mildew, leaf and stripe rusts.
DDW 47	Madhya Pradesh, Gujarat, Rajasthan and Chhattisgarh	Suitable for timely sown restricted irrigated conditions, average yield 37.3 q/ha, protein content 12.69%, maturity 121 days, resistant to black and brown rust, high yellow pigment content (7.57 ppm).
Gujarat Wheat 1346 (GW 1346)	Maharashtra, Karnataka and plains of Tamil Nadu	Suitable for restricted irrigated timely sown conditions, average yield 48.8 q/ha, protein content 12.36%, maturity 122 days, highly resistant to wheat blast, resistant reaction for leaf and brown rusts, Karnal bunt, powdery mildew, flag smut and leaf blight.
Pusa Wheat 8802 (HI 8802)	Maharashtra, Karnataka and plains of Tamil Nadu	Suitable for restricted irrigation and timely sown conditions, average yield 36.0 q/ha, maturity 105–110 days, high level of field resistant to stem and leaf rusts and resistant to Karnal bunt, loose smut, flag smut and foot rot.





Variety	Area of adoption	Salient features
Pusa Wheat 8805 (HI 8805)	Maharashtra, Karnataka and plains of Tamil Nadu	Suitable for restricted irrigation and timely sown conditions, average yield 35.4 q/ha, protein content 12.8%, maturity 105–110 days, high level of field resistant to stem and leaf rusts and resistant to Karnal bunt, loose smut, foot rot and better resistant to flag smut.
UAS-466	Madhya Pradesh, Gujarat, Rajasthan and Chhattisgarh	Suitable for timely sown, restricted irrigation conditions, average yield 38.8 q/ha, maturity 120 days, resistant to leaf, stem rusts and resistant to loose smut.
Barley PL 891	Punjab, Haryana, Delhi, Rajasthan (excluding Kota and Udaipur divisions), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh, Tarai region of Uttarakhand	Suitable for irrigated timely sown conditions, average yield 36.6 q/ha, maturity 137 days, resistant to leaf blight.
Karan Maltsona (DWRB 160)	Punjab, Haryana, Delhi, Western Uttar Pradesh, Rajasthan (except Kota and Udaipur divisions), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh, Tarai region of Uttarakhand	Suitable for irrigated, timely sown conditions, average yield 53.7 q/ha, maturity 131 days, resistant to yellow rust. It has highest malting quality score (68/90).
Him Palam Jau 1 (HBL 713)	Himachal Pradesh	Suitable for cultivation during <i>rabi</i> season under timely sown rainfed conditions, average yield 30–35 q/ha, maturity 170–180 days, resistant to yellow and leaf rusts and less incidence of stem rust.
Maize Shalimar QPMH-1 (KDQH-49)	Jammu & Kashmir	Suitable for cultivation in <i>kharif</i> season, specially in low to medium elevation of Kashmir valley, early maturing (135 days duration) QPM maize hybrid, it has given 58.78 q/ha yield in station and 55.67 q/ha in AICRP trials. Tryptophan content: 0.81%, Lysine content: 2.95%, protein: 10.71%. It has shown resistance to <i>Turicum</i> leaf blight and common rust diseases.
Shalimar Sweet Corn-1 (KDM-1263SC)	Jammu & Kashmir	Suitable for rainfed, <i>kharif</i> , hilly regions, early maturing (105–110 days) sweet corn composite, green cobs yield: 106 q/ha at station and 62.38 q/ha in AICRP trials, it has 14% TSS and shown resistance to <i>Turicum</i> leaf blight and common rust.
SHIATS Makka-2 (IVT DMR 262)	Uttar Pradesh	Suitable for <i>kharif</i> season, average yield 35–40 q/ha, maturity 85–90 days, composite white seeded, resistant to maydis leaf blight, moderately resistant to <i>Turicum</i> leaf blight and to stem borer.
PMH 12 (JH 13347)	Zone III (Bihar, West Bengal, Jharkhand, Parts of Uttar Pradesh and Odisha)	Suitable for irrigated conditions during <i>kharif</i> season, average yield 71.1 q/ha, maturity 90 days, moderately tolerant to maydis leaf blight, <i>Turicum</i> leaf blight, banded stripe downy mildew and post flowering stalk rot.
VL Sweet Corn Hybrid 2 (FSCH 75)	Zone I (Jammu & Kashmir, Himachal Pradesh, Uttarakhand NEH)	Suitable for rainfed agro-ecosystem in <i>kharif</i> , average yield 103.5 q/ha, moderately tolerant to maydis leaf blight, <i>Turicum</i> leaf blight, Sheath blight, curvularia leaf spot.





Variety	Area of adoption	Salient features
Maize VGIH 1 (VaMH 12014)	Bihar, Jharkhand, Odisha, Uttar Pradesh and West Bengal	Suitable for <i>kharif</i> season, average yield 69.4 q/ha (at low plant density 66,000: 64.9 q/ha and at high plant density 83,000: 135 q/ha), resistant to <i>Curvularia</i> leaf spot and Rajasthan downy mildew and moderately resistant to maydis leaf blight, <i>Turicum</i> leaf blight, banded leaf and sheath blight, charcoal rot, <i>Fusarium</i> stalk rot and bacterial stalk rot, possesses good quality attributes.
JKMH 4152 (JKMH 8008)	Punjab, Haryana, Delhi, Uttarakhand, Assam and Uttar Pradesh	Suitable for irrigated condition of rainy season (<i>kharif</i>), average yield 82.3 q/ha, late maturity (94–96 days) (seed to seed), resistant to Maydis leaf blight and charcoal rot, moderately resistant to <i>Chilo partellus</i> . Non-shattering.
PAC 751	Madhya Pradesh	Suitable for irrigated and rainfed ecosystem, average yield 71.6 q/ha, maturity 100–105 days, resistant to common rust, brown stripe, downey mildew, moderately resistant/tolerant to <i>Turicum</i> leaf blight, Maydis leaf blight, Polysora rust and <i>Chilo partellus</i> .
PAC 753	Madhya Pradesh	Suitable for irrigated and rainfed ecosystem, average yield 68.2 q/ha, maturity 100–105 days, resistant to common rust, Rajasthan downy mildew and <i>Curvularia</i> leaf spot, moderately resistant/tolerant to <i>Turicum</i> leaf blight, Maydis leaf blight and <i>Chilo partellus</i> .
Pusa HQPM-5 Improved (APQH5)	NHZ: Jammu & Kashmir, Himachal Pradesh, Uttarakhand (Hill region), North Eastern Hill Region (Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur, Arunachal Pradesh) NWPZ: Punjab, Haryana, Delhi, Uttarakhand, (Plain), Uttar Pradesh (Western region) NEPZ: Bihar, Jharkhand, Odisha, Uttar Pradesh, (Eastern region), West Bengal PZ: Maharashtra, Karnataka, Andhra Pradesh, Telangana, Tamil Nadu CWZ: Gujarat, Madhya Pradesh, Chhattisgarh, Rajasthan	Suitable for irrigated conditions under <i>kharif</i> season, average yield 72.63 q/ha (NHZ); 75.10 q/ha (NWPZ); 53.45 q/ha (NEPZ); 71.2 q/ha (PZ); 51.20 q/ha (CWZ), medium maturity in all zone; late in PZ, MAS derived hybrid, introgression of crtRB1 and IcyE gene, high Provitamin A (6.77 microgram/g) (1.02 in normal maize), lysine 4.25% and tryptophan 0.94% (Normal maize <0.6% tryptophan, <2.5% lysine).
Pusa Vivek Hybrid-27 Improved (APH27)	Bihar, Jharkhand, Odisha, Uttar Pradesh (Eastern region), West Bengal	Suitable for irrigated conditions under <i>kharif</i> season, average yield 48.5 q/ha, early maturing, MAS derived hybrid, introgression of crtRB1 gene, improved Provitamin A (5.49 microgram/g).
Pusa HQPM-7 Improved (APQH7)	Maharashtra, Karnataka, Andhra Pradesh, Telangana, Tamil Nadu	Suitable for irrigated conditions under <i>kharif</i> season, average yield 74.5 q/ha, maturity 90–95 days, MAS derived hybrid, introgression of crtRB1 and IcyE gen, high provitamin A (7.10 microgram/g), lysine (4.19%) and tryptophan (0.93%).
Pusa Super Sweet Corn 2 (ASKH1)	Himachal Pradesh, Haryana, Uttarakhand, Uttar Pradesh, Tamil Nadu, Karnataka, Chhattisgarh, Rajasthan	Suitable for irrigated conditions, high fertility soils during <i>kharif</i> season, average green ear yield 13.2 t/ha (NHZ), 13.6 t/ha (NWPZ), 11.8 t/ha NEPZ), 13.8 t/ha (PZ), 11.4 t/ha (CWZ), cob yield 10.0 t/ha (NHZ), 9.5 t/ha (NWPZ), 8.1 t/ha (NEPZ), 10.2 t/ha (PZ), higher sweetness (15.2% to 17.1 % brix), 50% silking in 53 days, moderately to highly resistant to major diseases and pests.
Pant Popcorn 1 (DPCH-306)	Jammu & Kashmir, Himachal Pradesh, Uttarakhand (Hills), Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, (North Eastern Hill Region), Tamil Nadu, Karnataka, Andhra Pradesh, Telangana, Maharashtra	Suitable for irrigated conditions of <i>kharif</i> season, average yield 39.8 q/ha (NHZ) and 50 q/ha (PZ), maturity 87–92 days, moderately tolerant to <i>Chilo partellus</i> under field conditions.





Variety	Area of adoption	Salient features
PMH 11 (JH 12063)	Punjab	Suitable for irrigated conditions during <i>kharif</i> season, average yield 57.4 q/ha, maturity 96 days, moderately resistant to charcoal rot, Maydis leaf blight, bacterial stalk rot, banded leaf and sheath blight, and stem borer.
Pearl millet RHB 233 (MH 2173)	Rajasthan, Gujarat, Haryana, Madhya Pradesh, Delhi, Maharashtra and Tamil Nadu	Suitable for <i>kharif</i> season, high fertility soil, average grain yield 31.6 q/ha, dry fodder yield 74 q/ha, maturity 80 days, bio-fortified hybrid with high iron (83 ppm) and high zinc (46 ppm) content, higher degree of resistance to downy mildew and smut, resistant to major insect pests such as shoot fly, stem borer, grey weevil, leaf roller, <i>Helicoverpa</i> .
RHB 234 (MH 2174)	Rajasthan, Gujarat, Haryana, Madhya Pradesh, Delhi, Maharashtra and Tamil Nadu	Suitable for <i>kharif</i> season, high fertility soil, average grain yield 31.7 q/ha, dry fodder yield 71 q/ha, maturity 81 days, bio-fortified hybrid with high iron (84 ppm) and high zinc (41 ppm) content, resistant to downy mildew and smut, resistant to shoot fly, stem borer, grey weevil, leaf roller, <i>Helicoverpa</i> etc.
JKBH 1326 (MH 2228)	Rajasthan, Gujarat, Haryana, Madhya Pradesh, Uttar Pradesh and Punjab	Suitable for rainfed, <i>kharif</i> , both high and low fertility soils, dual-purpose hybrid, average grain yield 32.9 q/ha, fodder yield 82 q/ha, maturity 82 days, possesses high level of resistance to downy mildew, rust, smut, ergot and blast, better degree of tolerance to shoot fly, stem borer, <i>Helicoverpa</i> and grey weevil.
MH 2224 (PB 1852)	Rajasthan, Gujarat, Haryana, Madhya Pradesh, Uttar Pradesh, Delhi and Punjab	Suitable for low to medium rainfall (rainfed condition), low to high fertility soil during <i>kharif</i> season in Zone A, dual-purpose hybrid, average grain yield 29.8–36.5 q/ha, dry fodder yield 95 q/ha, maturity 82 days, grain protein 8.8%, fat 5.8%, high iron 56 ppm and zinc 32 ppm, lodging tolerant, suitable for early and late sowing conditions, highly resistant to downy mildew.
MH 2114 (DHBH 1397)	Rajasthan, Gujarat, Haryana, Punjab, Madhya Pradesh, Uttar Pradesh and Delhi	Suitable for <i>kharif</i> , average grain yield 33.2 q/ha, dry fodder yield 75 q/ha, maturity 78 days, resistant to downy mildew.
HHB 311 (MH 2179)	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Maharashtra and Tamil Nadu	Suitable for <i>kharif</i> season and high fertility conditions, average grain yield 31.7 q/ha, average fodder yield 72 q/ha, biofortified (83 ppm), maturity 80–81 days, resistant to major diseases, viz. downy mildew, smut and resistant to major insect pests, viz. shoot fly, stem borer, grey weevil, leaf roller, <i>Helicoverpa</i> .
Sorghum CHS 39 R (SPH 1801)	Maharashtra, Karnataka, Andhra Pradesh and Gujarat	Suitable for deep soils of <i>rabi</i> sorghum growing areas, average grain yield 27 q/ha and fodder yield 68 q/ha, dual-purpose <i>rabi</i> sorghum hybrid with good roti quality, seed to seed maturity 110 days, tall (210–215 cm) plant type, semi compact panicle, resistant to all major diseases and pests.
PDKV Hurda Kartiki (Wani 103)	Maharashtra	Suitable for <i>Hurda</i> or <i>Vani</i> type sorghum, grain yield 45 q/ha (Green <i>Hurda</i>), green fodder yield 200 q/ha, maturity 90 days, non-shattering and non-lodging.
CSV-37 (SPV-2366)	Karnataka, Maharashtra, Andhra Pradesh and Tamil Nadu	Suitable for rainfed ecology of <i>kharif</i> , a dual-purpose sorghum variety having good iron and zinc in the grain, average grain yield 37.1 q/ha, fodder yield 141.48 q/ha, maturity 100–105 days, tolerant to grain mold disease, non-lodging type.





Variety	Area of adoption	Salient features
Nandyala Pachajonna-15 (NJ 2446)	Andhra Pradesh	Suitable for late <i>kharif</i> - rainfed and <i>rabi</i> seasons, average grain yield 25–30 q/ha under rainfed condition, 30–32 q/ha under irrigated condition and average straw yield 86.5 q/ha under varied conditions, late maturity, moderately tolerant to leaf blast, rust diseases, moderately tolerant to shoot fly and stem borer.
Nandyala Pachajonna-5 (NJ 2647)	Andhra Pradesh	Suitable for late <i>kharif</i> - rainfed and <i>rabi</i> seasons, average grain yield 38–45 q/ha under rainfed conditions and 45–62.5 q/ha under irrigated conditions, average straw yield 85.7 q/ha under rainfed conditions, medium maturity, moderately tolerant to leaf blast, rust, shoot fly and stem borer.
Jaicar Nutrigraze (CSV 43 BMR/SPV 2018)	Andhra Pradesh, Telangana, Karnataka, Maharashtra, Tamil Nadu, Gujarat, Madhya Pradesh, Rajasthan, Uttar Pradesh, Uttarakhand, Haryana, Jharkhand	Suitable for rainfed condition in <i>kharif</i> season, average grain yield 50.3 q/ha, crude protein 8.5%, maturity 110–113 days, resistant to grain mold, downy mildew, anthracnose, leaf blight, zonate leaf spot and tolerant to shoot fly, stem borer, aphid and head bugs.
Telangana Jonna 1 (CSV 41/ SPV 2437)	Andhra Pradesh, Telangana, Tamil Nadu, Rajasthan and Gujarat.	Suitable for rainfed conditions under both high/low fertility soils, average grain yield 31.8 q/ha and fodder yield 159 q/ha, protein content 9.72%, maturity 106–110 days, moderately tolerant to grain mold, shoot fly and stem borer.
Finger millet Vegavathi (VR 929)	Andhra Pradesh	Suitable for rainfed <i>kharif</i> season, average grain yield 36.1 q/ha, fodder yield 72 q/ha, maturity 115–120 days, highly resistant to brown spot, banded blight, foot rot and <i>Cercospora</i> leaf spot, resistant to leaf, finger and neck blast, low incidence of grasshopper, <i>Myllocerus</i> weevil and ear head caterpillar, high in Zn (33.2 ppm), Fe (131.8 ppm), Ca (3710 ppm), protein (9.8%), dietary fiber and low in tannin content.
GN 8	Gujarat	Suitable for cultivation during <i>kharif</i> season, average seed yield 30.7 q/ha, maturity 105–110 days, erect and non-lodging plant type, moderately resistant to leaf, neck and finger blast as well as foot rot disease, tolerant to stem borer and aphids.
Tirumala (PPR 1012)	Andhra Pradesh	Suitable for irrigated and rainfed conditions in <i>kharif</i> , average seed yield 20–25 q/ha under rainfed conditions, 30–35 q/ha under irrigated conditions, maturity 115–120 days, highly resistant to leaf, neck and finger blast; moderately resistant to leaf blight and banded blight; resistant to grasshoppers and ear head caterpillars.
Little millet TNPsu 177	Tamil Nadu	Suitable for rainfed condition during June–August and September–October, even under low fertility conditions, average grain yield 15.87 q/ha and 31.09 q/ha of straw yield under rainfed conditions, early maturity 85–90 days, bold grains with high bulk density, tolerant to drought, tolerant to grain smut, sheath blight, shoot fly.
Proso millet PMV 442 (GPUP 25)	Andhra Pradesh, Bihar, Karnataka, Tamil Nadu, Telangana and Puducherry	Suitable for rainfed and irrigated conditions, average yield 18.6 q/ha, maturity 70–75 days, moderately resistant to brown spot incidence.





Oilseeds

Thirty-seven high yielding oilseeds varieties comprising 11 of soybean, nine of mustard, seven of

groundnut, three each of castor and safflower and four of linseed were released for different agro-ecological regions.

Improved released varieties/hybrids of Oilseeds

Variety	Area of adoption	Salient features
Soybean		
Shalimar Soybean-1 (AGR/538)	Jammu & Kashmir	Suitable for early sown condition of the valley, average yield 20.3–25.6 q/ha, oil content 13.56%, maturity 144 days, very bold seeded variety, resistant to yellow mosaic virus and root rot and tolerant to drought.
Jawahar Soybean 20-116 (JS 20-116)	Central Zone, North Eastern Hill and Eastern Zone	Suitable for timely sown conditions under high rainfall, average yield 23.1–23.4 q/ha, oil content (%): CZ (20.22); NEHZ (16.55); EZ (16.32), maturity 97–101 days, resistant to yellow mosaic virus, charcoal rot, SMV, PB (ct), RAB, rust and IBB, stem fly, stem borer and defoliators, possesses excellent germinability and longevity, amenable to mechanical harvesting.
Jawahar Soybean 20-94 (JS 20-94)	Madhya Pradesh, Maharashtra, Rajasthan and Bundelkhand region of Uttar Pradesh	Suitable for medium to high rainfall conditions and medium to heavy soils, especially for YMV and blight prone areas, average yield 19.4 q/ha, oil content 20.35%, maturity 94–110 days, resistant to YMV, blight, bacterial pustules, leaf spots and stem fly, suitable for both sole and intercropping.
AMS-1001 (PDKV Yellow Gold)	Maharashtra	Suitable for rainfed conditions, average yield 20 q/ha, oil content 18.93%, maturity 95–100 days, resistance to root rot, charcoal rot and yellow mosaic virus under field conditions, moderately resistant to stem fly and girdle beetle.
SL 955	Punjab, Haryana, Delhi, Uttar Pradesh (Except Bundelkhand) and Bihar	Suitable for normal sown irrigated conditions, average yield 22 q/ha, protein content 38.97%, oil content 18.85%, maturity 124–128 days, tolerant to YMV.
SL 979	Punjab, Haryana, Delhi, Uttar Pradesh, Uttarakhand and Bihar	Suitable for normal sown irrigated conditions, average yield 23.4 q/ha, protein content 37.9%, oil content 20.6%, maturity 124–130 days, tolerant to YMV and SMV.
DSb 32	Assam and North Eastern States	Suitable for rainfed conditions, average yield 19.2 q/ha, protein content 37.8%, oil content 20.9%, maturity 102 days, moderately resistant to pod blight and resistant to multiple pests and diseases.
DSb 28(DSb 28-3)	Maharashtra, Karnataka, Telangana, Andhra Pradesh and Tamil Nadu	Suitable for rainfed and irrigated conditions, average yield 23.2 q/ha, protein content 38.42%, oil content 20.14%, maturity 95 days, highly resistant to soybean rust caused by <i>Phakopsora pachyrhizi</i> .
Pant Soybean 25 (PS 1556)	Himachal Pradesh and Uttarakhand	Suitable for rainfed and irrigated conditions of <i>kharif</i> season, average yield 22.9 q/ha, protein content 41%, oil content 18.83%, maturity 119 days, highly resistant to YMV, SMV, bacterial pustule and bacterial blight and moderately resistant to RAB, BS, PBct and FLS.
Pant Soybean 26 (PS 1572)	Punjab, Haryana, Uttar Pradesh (except Bundelkhand region of Uttar Pradesh) and Delhi	Suitable for rainfed and irrigated conditions of <i>kharif</i> season, average yield 19.3 q/ha, protein content 40%, oil content 17.92%, maturity 120 days, highly resistant to YMV, SMV, bacterial pustule and BLB and moderately resistant to RAB and BS.





Variety	Area of adoption	Salient features
Uttarakhand Black Soybean VL Bhat 202	Uttarakhand	Timely sown rainfed organic conditions, average yield 16 q/ha, protein content 39.19%, oil content 16.55 q/ha, maturity 110–115 days, moderately resistant against pod blight and bacterial pustules, resistant against aphids, soybean beetles and moderately resistant against white fly and defoliators, for use as pulse.
Groundnut Phule Unnati (RHRG-6083)	Maharashtra	Suitable for irrigated and rainfed conditions during summer and <i>kharif</i> season, average pod yield 39.9 q/ha (Summer) and 28.5 q/ha (<i>Kharif</i>), oil content 51%, maturity 125–130 days, resistant to <i>Spodoptera</i> and rust, tolerant to late leaf spot, and stem rot.
Phule Dhani (JL-1085)	Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for cultivation under rainfed conditions during <i>kharif</i> season, average pod yield 33.3 q/ha and kernel yield of 23.1 q/ha, oil content 50%, maturity 109 days, highly resistant to foliar diseases (LLS and Rust) and for the combined infestation of <i>Spodoptera</i> and <i>Helicoverpa</i> .
Gujarat Groundnut 34	Gujarat	Suitable for irrigated, agro-climatic variables/stresses for summer cultivation, average pod yield 37.2 q/ha, oil content 52.8%, maturity 111–125 days, tolerant to Tikka and rust diseases, and lower incidence of thrips and jassids.
Dheeraj (TCGS 1073)	Andhra Pradesh	Suitable for <i>kharif/rabi</i> irrigated, timely sown conditions, average pod yield 19.1 q/ha (<i>Kharif</i>), 28.4 q/ha (<i>Rabi</i>); oil content 48–50%, maturity 105–110 days (<i>Kharif</i>) and 110–115 days (<i>Rabi</i>), less susceptible to LLS, rust, PBND and PSND; less susceptible to leaf miner and jassids and other sucking insects.
BSG 0912 (INS I 2013-8) Groundnut BSR 2	Tamil Nadu	Suitable for irrigated tracts, average pod yield 22.2 q/ha (<i>Kharif</i>) and 23.6 q/ha (<i>Rabi-Summer</i>), oil content 45%, maturity 105–110 days, moderately resistant to rust, late leaf spot diseases, aphids, thrips, jassids and defoliators.
Central-Pragati (TCGS 894)	Tamil Nadu, Telangana and Andhra Pradesh	Suitable for timely sown irrigated conditions during <i>rabi</i> season, average kernel yield 19.7 q/ha, pod yield 28.16 q/ha, oil content 48%, maturity 100–105 days.
Dh 256	Tamil Nadu, Andhra Pradesh, Karnataka and Telangana	Suitable for rainfed conditions during <i>kharif</i> season, average kernel yield 21.8 q/ha, pod yield 32.6 q/ha, oil content 50%, maturity 113 days, tolerant to mid-season drought stress.
Indian mustard RH 761	Jammu, Punjab, Haryana, Delhi and Northern Rajasthan	Suitable for timely sown and rainfed conditions in <i>rabi</i> season, average seed yield 28.6 q/ha, oil content 40.4%, maturity 141 days, moderately tolerant to white rust and <i>Alternaria</i> leaf blight, low aphid infestation.
Kesari Gold (31J3403)	West Bengal	Suitable for irrigated conditions in <i>rabi</i> season, average seed yield 17.9 q/ha, oil content 40.0–42.3%, maturity 90–100 days, moderately resistant to white rust; tolerant to aphid infestation.
Kesari 5111 (PCJ03-401)	West Bengal	Suitable for irrigated conditions in <i>rabi</i> season, average seed yield 14.8 q/ha, oil content 41.1–42.5%, maturity 92–105 days, moderately resistant to white rust and moderately tolerant to aphid infestation.



Variety	Area of adoption	Salient features
Bayer Mustard 5222	West Bengal	Suitable for irrigated conditions in <i>rabi</i> season, average seed yield 16.8 q/ha, oil content 38.0–39.1%, maturity 105–122 days, moderately resistant to white rust and tolerant to aphid infestation.
TBM-204 (Trombay Bidhan Mustard-204)	Bihar, Jharkhand, Odisha, Assam and Manipur	Suitable for irrigated conditions in <i>rabi/winter</i> season, average seed yield 13.4 q/ha, oil content 41%, maturity 110 days, moderately resistant to <i>Alternaria</i> leaf spot.
SVJ-64	Haryana	Suitable for irrigated conditions under both high and low fertility conditions, average yield 26.2 q/ha, oil content 39.1%, maturity 125–130 days.
Yellow sarson Pant Girija (PYS 2012-6)	Uttarakhand	Suitable for timely sown irrigated conditions for Uttarakhand plains, average yield 14.4 q/ha, oil content 45.30%, maturity 83–128 days, resistant to <i>Alternaria</i> blight, white rust, downy mildew and <i>Sclerotinia</i> rot.
Brown sarson Shalimar Sarson-2 (KBS-49)	Jammu & Kashmir	Suitable for irrigated conditions of J&K at 1,500–1,800 m above MSL, average seed yield 15.0–16.0 q/ha, oil content 42.7%, maturity 205–215 days.
Shalimar Sarson-3 (KBS-3)	Jammu & Kashmir	Suitable for irrigated conditions of J&K at 1,800–2,000 m above MSL, average seed yield 15.0–17.0 q/ha, oil content 41.3%, maturity 200–210 days.
Linseed LSL-93	Maharashtra	Suitable for rainfed conditions, average yield 9.6 q/ha, oil content 37.95%, maturity 105 days, moderately resistant to powdery mildew, <i>Alternaria</i> and rust.
Surya (LCK 1404)	Jammu & Kashmir, Himachal Pradesh, Punjab and Haryana	Suitable for timely sown and irrigated conditions, average yield 14.3 q/ha, oil content 35.49%, maturity 155–172 days, highly resistant to rust, moderately resistant to wilt, <i>Alternaria</i> blight and powdery mildew.
TL 99	Uttar Pradesh, Bihar, Jharkhand, West Bengal, Assam and Nagaland	Suitable for irrigated condition, average yield 12.7 q/ha, oil content 36.56%, a low linolenic variety (4.0%), maturity 115–132 days, moderately resistant to powdery mildew, <i>Alternaria</i> blight, wilt and resistant to rust.
HIM PALAM ALSI-1 (KL-241)	Himachal Pradesh	Suitable for utera system of cultivation under assured moisture condition during <i>rabi</i> season, average yield 7.6 q/ha, oil content 36.15%, maturity 183 days, highly resistant reaction to rust, powdery mildew, wilt and resistant to bud fly.
Safflower Pride (ISF-1)	Telangana, Andhra Pradesh, Madhya Pradesh, Chhattisgarh, Karnataka and Maharashtra.	Suitable for irrigated and rainfed conditions, average yield 12.4 q/ha (rainfed), 18.6 q/ha, (irrigated) and 16.3 q/ha (all India), oil content 30.5% and maturity 127–137 days.
Lakshmi-Priya (ISF-764)	Karnataka, Maharashtra, Telangana, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Bihar, Chhattisgarh, West Bengal, Gujarat and Odisha	Suitable for irrigated and rainfed conditions, average yield 15.8 q/ha (rainfed), 22.7 q/ha, (irrigated) and 20.1 q/ha (all India), oil content 30.6% and maturity 123–133 days.
SSF-12-40	Maharashtra, Karnataka and Telangana	Suitable for irrigated and rainfed conditions, average yield 14.8 q/ha (rainfed) and 20.7 q/ha (irrigated), oil content 32.9%, maturity 123 days, moderately resistant to <i>Fusarium</i> wilt, <i>Alternaria</i> leaf spot and aphids.





Variety	Area of adoption	Salient features
Castor Gujarat Anand Castor 11 (GAC 11)	Gujarat	Suitable for irrigated areas of middle Gujarat, average yield 32.3 q/ha, oil content 48.44%, maturity 87 days, resistant to wilt.
ICH-66	Telangana, Andhra Pradesh, Karnataka, Tamil Nadu and Odisha	Suitable for rainfed conditions, average yield 15.7 q/ha, oil content 48.6%, maturity 115–125 days, resistant to wilt and root rot, moderately resistant to leafhopper under field conditions.
YTP 1 (YRCS 1205)	Tamil Nadu	Suitable for irrigated and rainfed tracts, average yield 31.1 q/ha, oil content 49%, maturity 115–120 days, resistant to wilt, semilooper, <i>Spodoptera</i> , thrips and capsule borer.

Pulses

Fifty one high-yielding varieties of pulses comprising 17 of chickpea, 10 of urdbean, eight of lentil, seven

of pigeon pea, three of mungbean, two of field pea and one each of cowpea, rajmash, horse gram and *Lathyrus* were released for different agro-ecological regions.

Improved released varieties/hybrids of Pulses

Variety	Area of adoption	Salient features
Chickpea Raj Vijay Gram 204 (RVG 204) (RVSSG 8102)	Madhya Pradesh	Suitable for timely sown conditions and amenable to machine harvesting, desi type, average yield 19.8 q/ha, maturity 112 days, 100 seed weight 23.1 g, plant height 59 cm, tolerant to wilt.
Raj Vijay Gram 205 (RVG 205) (RVSSG 32)	Madhya Pradesh	Suitable for timely sown irrigated conditions, green seeded chickpea variety, average yield 17.3 q/ha, 100 seed weight 20.3 g, maturity 114 days, tolerant to wilt.
Raj Vijay Kabuli Gram 111 (RVG 111) (RVSSG 24)	Madhya Pradesh	Suitable for timely sown irrigated conditions, Kabuli type, average yield 16.7 q/ha, 100 seed weight 26.12 g, maturity 117 days, tolerant to wilt.
Raj Vijay Kabuli Gram 151 (RVG 151) (RVSSG 37)	Madhya Pradesh	Suitable for timely sown irrigated conditions, extra-large seeded Kabuli chickpea variety, average yield 17.7 q/ha, 100 seed weight 54.4 g, maturity 113 days, tolerant to wilt.
GNG-2299 (Purva)	Assam, West Bengal, Jharkhand, Bihar, Eastern UP, Manipur	Suitable for late sown irrigated conditions, average yield 14.5 q/ha, 100 seed weight 15.9 g, maturity 116 days, tolerant to wilt (<i>Fusarium oxysporum</i>).
IPC 2006-77	Chhattisgarh, Madhya Pradesh, Gujarat, Southern parts of Rajasthan, Bundelkhand tracts of Uttar Pradesh	Suitable for late sown conditions under rice fallow, average yield 20.7 q/ha, medium small seeds (16.5 g/100 seeds), maturity 112 days, moderately resistant to wilt, dry root rot and stunt.
PDKV Kanchan (AKG-1109)	Maharashtra	Suitable for early sown conditions, average yield 19.4 q/ha, medium bold seed, 100 seed weight 19.7 g, maturity 109 days, resistant to <i>Fusarium</i> wilt.
Pusa Chickpea 10216 (BGM 10216)	Bundelkhand region of Uttar Pradesh, Madhya Pradesh, Maharashtra, Gujarat	Suitable for timely sown rainfed conditions, first MABB derived variety of chickpea in the country, average seed yield 14.8 q/ha, maturity 106 days, 100 seed weight 22.2 g, protein content 22.6%, drought tolerant.
Pusa Parvati (BG 3062)	Maharashtra, Madhya Pradesh, Bundelkhand region of Uttar Pradesh and Southern Rajasthan	Suitable for timely sown irrigated conditions during <i>rabi</i> season, average yield 21.5 q/ha, grain protein content is 20.73%, maturity 108-118 days, highly resistant to wilt, dry root rot and stunt.





Variety	Area of adoption	Salient features
Haryana Chana No 7 (HC 7) (H 12-55)	Punjab, Haryana, Western Uttar Pradesh, Delhi, North Rajasthan, Jammu and Kashmir, plains of Himachal Pradesh and Uttarakhand	Suitable for late sown irrigated conditions during <i>rabi</i> season, average yield 24.1 q/ha, grain protein content 17.23%, maturity 127 days, tolerant to <i>Helicoverpa armigera</i> .
Super Annigeri-1 (MABC-WR-SAI)	Andhra Pradesh, Karnataka, Maharashtra and Gujarat	Suitable for timely sown rainfed/irrigated conditions, MABB derived variety of chickpea, average yield 18.6 q/ha, maturity 104 days, 100 seed weight 18.4 g, protein content 22.4%, drought tolerant.
Phule Vikram (Phule G 08108)	Maharashtra, Gujarat, Madhya Pradesh, Rajasthan and Uttar Pradesh	Suitable for rainfed conditions, average yield 22.7 q/ha, maturity 110–115 days, resistant to <i>Fusarium</i> wilt.
Pant Gram 6 (PG 119)	Uttarakhand	Suitable for irrigated/rainfed late sown conditions, average yield 21.7 q/ha, grain protein content 22.01%, maturity 145 days, tolerant to wilt, botrytis grey mould and pod borer.
Him Palam Chana 1 (DKG 986)	Himachal Pradesh	Suitable for rainfed conditions during <i>rabi</i> season, average yield 16.2 q/ha, maturity 151 days, resistant to <i>Ascochyta</i> blight and tolerant to wilt, root rot, stem rot and rust.
IPC 2004-98 (Desi)	Uttar Pradesh	Suitable for normal sown conditions, average yield 14.3 q/ha, maturity 141 days, moderately resistant to wilt.
IPC 2005-62 (Desi)	Uttar Pradesh	Suitable for late sown conditions, average yield 10.2 q/ha, grain protein content 27.25%, maturity 118 days, moderately resistant to wilt.
Sabour Chana-1(BRC-1)	Bihar	Suitable for normal sowing under rainfed/ irrigated conditions, average yield 22.0–24.0 q/ha, grain protein content 21.66%, maturity 130–135 days, moderately resistant to pod borer.
Greengram (Mungbean) VGG 10-008 (VBN-4)	Tamil Nadu	Suitable for irrigated and rainfed conditions, average yield 10.2 q/ha, 100-seed weight 4–4.5 g, maturity 65–70 days, resistant to mosaic virus and powdery mildew and leaf crinkle virus.
Pant Mung 9(PM 09-11)	Uttarakhand	Suitable for rainfed normal sown conditions for <i>rabi</i> season, average yield 9.6 q/ha, maturity 75 days, highly resistant to MYMV, powdery mildew and tolerant to whitefly and jassid.
SML 1827	Punjab	Suitable for irrigated condition in spring/ summer seasons, average yield 11.6 q/ha, maturity 61–71 days, resistant to YMD, CLS, BLS, anthracnose and web blight and low incidence of bean thrips.
Blackgram (Urdbean) Pant Urd 10 (PU 10-23)	Jammu and Kashmir, Himachal Pradesh, Tripura and Manipur	Suitable for northern hilly regions, average seed yield 12–15 q/ha, 100-seed weight 4.5 g, protein content 25.84%, maturity 85 days, resistant to MYMV, powdery mildew and leaf crinkle virus diseases, erect type.
Ghantasala Minumu 1 (GBG 1)	Andhra Pradesh	Suitable for timely and late sown conditions during all seasons, shiny black bold seeded variety, average yield 10.94 q/ha (<i>Kharif</i>) and 13.29 q/ha (<i>Rabi</i>), 100 seed weight 4.4 g, maturity 70–75 days, resistant to YMV.





Variety	Area of adoption	Salient features
VBN 9(VBG 12-111)	Andhra Pradesh, Tamil Nadu, Karnataka and Odisha	Suitable for rice fallow conditions of south zone, average yield 12.3 q/ha, oil content 22.68%, maturity 72 days, moderately resistant to mung bean yellow mosaic virus, urdbean leaf crinkle virus, leaf curl virus and powdery mildew.
VBN 10(VBG 12-034)	Andhra Pradesh, Tamil Nadu, Karnataka and Odisha	Suitable for <i>rabi</i> season, average yield 11.26 q/ha, oil content 25.28%, maturity 74 days, resistant to mung bean, yellow mosaic virus, urdbean leaf crinkle virus and leaf curl virus.
Pant Urd 7(PU 10-16)	Uttarakhand	Suitable for timely sown rainfed conditions, average yield 9.5 q/ha, grain protein content 23.83%, maturity 86 days, resistant to mung bean yellow mosaic virus, <i>Cercospora</i> leaf spot, powdery mildew and tolerant to whitefly and jassid.
Pant Urd 8(PU 11-14)	Uttarakhand	Suitable timely sown rainfed conditions, average yield 10.8 q/ha, grain protein content 24.07%, maturity 85 days, resistant to mung bean yellow mosaic virus, bacterial leaf spot, <i>Cercospora</i> leaf spot, powdery mildew and tolerant to whitefly and jassid.
Pant Urd 9(PU 11-25)	Uttarakhand	Suitable for timely sown rainfed conditions, average yield 10.9 q/ha, grain protein content 23.90%, maturity 85 days, resistant to mung bean yellow mosaic virus, <i>Cercospora</i> leaf spot, powdery mildew and tolerant to whitefly and jassids.
IPU 13-1	Madhya Pradesh	Suitable for cultivation across different agro-climatic regions of MP, average yield 7.2 q/ha, grain protein content 26.12%, maturity 72 days, resistant to yellow mosaic virus, <i>Cercospora</i> leaf spot, anthracnose, leaf crinkle, powdery mildew, bacterial leaf blight, web blight and tolerant to major insect-pests.
IPU 10-26	Madhya Pradesh	Suitable for cultivation across different agro-climatic regions of MP, average yield 6 q/ha, grain protein content 25.27%, maturity 72 days, highly resistant to yellow mosaic virus, <i>Cercospora</i> leaf spot, resistant to urdbean leaf crinkle virus, stem necrosis, web blight, bacterial leaf blight, anthracnose, powdery mildew and tolerant to major insect-pests.
IPU 11-02	Madhya Pradesh	Suitable for cultivation across different agro-climatic regions of MP, average yield 7 q/ha, grain protein content 26.42%, maturity 71 days, resistant to yellow mosaic virus, <i>Cercospora</i> leaf spot, resistant to urdbean leaf crinkle virus, anthracnose, powdery mildew and tolerant to major insect-pests.
Pigeonpea		
CO 9 (CRG 2012-25)	Tamil Nadu, Odisha, Karnataka, Andhra Pradesh and Telangana	Suitable for rainfed irrigated conditions, average yield 17 q/ha, seed weight 9.9/100 g, protein content 23.65%, maturity 170–180 days, moderately resistant to wilt and SMD diseases, maruca and pod fly.
Bheema (GRG-152)	Madhya Pradesh, Maharashtra, Gujarat, Chhattisgarh	Suitable for irrigated and rainfed areas during <i>kharif</i> season, average yield 19 q/ha, protein content 23.01%, maturity 160–165 days, resistant to wilt and sterility mosaic diseases.
MPV-106 (RANI)	Tamil Nadu, Karnataka, Andhra Pradesh, Telangana and Odisha	Suitable for rainfed with high fertility for <i>kharif</i> season, average yield 15.5 q/ha, protein content 25.87%, maturity 165–174 days, moderately resistant to wilt.



Variety	Area of adoption	Salient features
Pant Arhar-6 (PA 421)	Punjab, Delhi, Haryana and Western Uttar Pradesh	Suitable for rainfed and irrigated conditions of <i>kharif</i> season, average yield 16.7 q/ha, protein content 25.87%, maturity 151 days, resistant to <i>Phytophthora</i> stem blight, resistant to wilt and sterility mosaic diseases, moderately resistant to pod borer (<i>Helicoverpa</i>), maruca and <i>Apion clavipes</i> and bruchid.
Telangana Kandi (WRGE-93)	Tamil Nadu, Karnataka, Andhra Pradesh, Telangana and Odisha	Suitable for rainfed/irrigated conditions during <i>kharif</i> season, average yield 17.0 q/ha, maturity 150–165 days, moderately resistant to <i>Fusarium</i> wilt and moderately tolerant to <i>Helicoverpa armigera</i> .
IPH 15-03	Punjab, Delhi, Haryana and Uttar Pradesh	Suitable for rainfed/irrigated areas for normal <i>kharif</i> season, average yield 16 q/ha, maturity 153 days, resistant to <i>Fusarium</i> wilt, SMD and moderately resistant to <i>Phytophthora</i> blight.
AL 882 (AL 1992)	Punjab	Suitable for irrigated conditions, average yield 14.7 q/ha, maturity 132 days, tolerant to PSB and resistant to CLS and sterility mosaic.
Lentil		
Shalimar Masoor-3	Jammu & Kashmir	Suitable for timely sown conditions, average yield 44.5–12.5 q/ha, 100-seed weight 5–5.5 g, maturity 204 days, tolerant to frost and winter chilling.
Raj Vijay Lentil 13-5	Madhya Pradesh, Chhattisgarh and parts of Rajasthan	Suitable for timely sown conditions, average yield 12.4 q/ha, bold seed size (3.9 g/100 seed weight), maturity 106 days, moderately resistant to wilt.
RVL-13-7 (Raj Vijay Lentil 13-7)	Madhya Pradesh, Chhattisgarh and Rajasthan	Suitable for timely sown conditions, average yield 12 q/ha, large seed size, 3.9 g/100 seed weight, maturity 102 days, resistant to wilt.
LL 1373	Western Uttar Pradesh, northern Rajasthan, Punjab, Haryana and Uttarakhand	Suitable for timely sown irrigated conditions, average yield 15.7 q/ha, grain protein content 27.05%, maturity 124–131 days, moderately resistant to rust and wilt.
L-4729	Madhya Pradesh, Maharashtra, Chhattisgarh, Gujarat, Bundelkhand region of Uttar Pradesh and south east parts of Rajasthan	Suitable for rainfed conditions during <i>rabi</i> season, average yield 17.5 q/ha, grain protein content 24.91%, maturity 96–110 days, moderately resistant to wilt and root rot.
Kota Masoor 3 (RKL 605-03)	Madhya Pradesh, Maharashtra, Chhattisgarh, Gujarat, Uttar Pradesh and Rajasthan	Suitable for rainfed conditions, average yield 18.8 q/ha, grain protein content 23.29%, maturity 105 days, moderately resistant to wilt, less incidence of pod borer and aphids, tolerant to drought and high temperature.
VL Masoor 148 (VL 148)	Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Manipur and Tripura.	Timely sown rainfed conditions, average yield 11.5 q/ha, grain protein content 30.46%, maturity 155–160 days, moderately resistant to wilt and rust diseases and also possesses moderate resistance against pod damage and aphids.
IPL 534	Madhya Pradesh	Suitable for rainfed normal sown conditions for <i>rabi</i> season, average yield 12.04 q/ha, grain protein content 23.3%, maturity 100–107 days, resistant to major diseases including rust, <i>Fusarium</i> wilt, <i>Stemphylium</i> blight and tolerant to black aphid and pod borer.
Cowpea		
Bidhan Sadabahar (BCCP 3)	West Bengal	Suitable for irrigated/rainfed conditions, average pod yield 113.2 q/ha, maturity 85 days, resistant to powdery mildew, anthracnose, ashy stem blight, bacterial blight and stem fly.





Variety	Area of adoption	Salient features
Horse gram Bilasa Kulthi (BSP 15-1)	Chhattisgarh, Maharashtra, Jharkhand and Gujarat	Suitable for rainfed and low fertility conditions, average yield 10 q/ha, maturity 102–107 days, drought tolerant.
Rajmash bean Phule Rajmah (GRB-902)	Maharashtra	Suitable for <i>kharif</i> and <i>rabi</i> season in western Maharashtra, average yield 17–19 q/ha, erect growth habit, maturity 76–78 days, bold seeded (36.50 g/100 g seed), protein content 23.38%, carbohydrate content-63.93%, moderately resistant to <i>Fusarium</i> wilt, CBMV, pod borer and white fly.
Fieldpea Harit (IPF 16-13)	Uttar Pradesh, Bihar, Jharkhand, Assam and West Bengal	Timely sown rainfed conditions, average yield 17.5 q/ha, grain protein content 27%, maturity 140–145 days, resistant to powdery mildew.
VL Matar 61 (VL 61)	Uttarakhand	Timely sown rainfed organic conditions, average yield 11.3 q/ha, grain protein content 28.26%, maturity 150–155 days, moderately resistant to wilt, powdery mildew, aphids, pod and leaf minor.
Lathyrus BK-14-1 (LAT 15-6)	West Bengal	Suitable for irrigated and rainfed conditions, average yield 15.9 q/ha, maturity 108–116 days, resistant to powdery mildew, wilt and low aphid infestation.

Commercial crops

Eighteen high-yielding varieties of commercial crops including six of cotton, three each of jute and mesta, and six of sugarcane were released for different agro-ecological regions.

Improved released varieties/hybrids of commercial crops

Variety	Area of adoption	Salient features
Cotton GN Cot. Hy-18 (GSHH-2759)	Gujarat	Suitable for irrigated conditions across south Gujarat and North Gujarat, average seed cotton yield is 23.6 q/ha, medium maturity (150–160 days), resistant to BLB, and wilt and ALS, and tolerant to sucking pests.
RVK 11 (Raj Vijay Kapas 11)	Tamil Nadu, Andhra Pradesh and Karnataka	Suitable for timely sowing rainfed conditions, average seed cotton yield 20 q/ha, lint yield 699 kg/ha, average bolls/plant 21.2, maturity 150–160 days, tolerant to sucking pests and diseases.
PA 740	Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed, <i>kharif</i> , medium to high fertility zones, average seed cotton yield 13.6 q/ha, maturity 150–160 days, tolerant to bacterial blight and <i>Alternaria</i> leaf spot.
G.Cot.40 (Gujarat Cotton 40) (GSHV 172)	Gujarat, Maharashtra and Madhya Pradesh	Suitable for high-fertility irrigated conditions during <i>kharif</i> season, average yield 23.3 q/ha, maturity 171–181 days, moderately resistant to BLB, <i>Alternaria</i> leaf spot and grey mildew.
G.Cot.42 (Gujarat Cotton 42) (GSHV 180)	Gujarat, Maharashtra and Madhya Pradesh	Suitable for high-fertility irrigated conditions during <i>kharif</i> season, average yield 17.4 q/ha, maturity 165–190 days, moderately resistant for grey mildew, compact variety for high density planting system in rainfed areas.
Central Cotton CCH 14-1 (Sunantha)	Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for irrigated tracts during <i>kharif</i> season, average yield 16.9 q/ha, maturity 150 days, resistant to bacterial leaf blight, and tobacco streak virus and immune to root rot, tolerant to jassids, white fly, thrips, aphids and stem weevil.



Variety	Area of adoption	Salient features
Jute BCCC-2 Bidhan Pat 5	West Bengal	Suitable for rainfed, mid and high land areas followed by transplanted paddy, fibre yield 29.5 q/ha or 16.4 bales/ha, maturity 120 days (fibre), and 170–175 days (seed production), tolerant to stem rot disease, semilooper, BHC and <i>Apion</i> .
Central Kenaf JRHC-3	West Bengal, Odisha, Bihar, Andhra Pradesh, Maharashtra and North Eastern States especially Tripura and Assam	Suitable for rainfed cultivation, average dry fibre yield 28.6 q/ha, maturity 160–175 days, tolerant to foot and stem rot and YVMV.
JROMU-1	West Bengal, Assam, Bihar, Odisha	Suitable for jute growing belt for cultivation, average dry fibre yield 32.9 q/ha, maturity 140–150 days, tolerant to stem rot, <i>Apion</i> , semi-looper, BHC and yellow mite.
Mesta AMV-8 (AHS-216)	Andhra Pradesh, Odisha, Maharashtra, West Bengal and Bihar	Suitable for mid and highland rainfed agro-ecosystem of all mesta growing states, average fibre yield 26.6 q/ha, maturity 140–150 days, stronger (20.46 g/tex) fine (3.08 tex) fibre, moderately tolerant to foot and stem rot disease.
AMV-9 (Aditya) (AHS-230)	Andhra Pradesh, Odisha, Maharashtra, West Bengal and Bihar	Suitable for rainfed mesta growing belt of India for cultivation from May to last week of June sowing, average fibre yield 27.4 q/ha, maturity 140–150 days, stronger (21.03 g/tex) and better fibre fineness (3.05 tex), highly tolerant to foot and stem rot disease.
Central Roselle JRHS-1	West Bengal	Suitable for mid and high land rainfed situation in mesta growing belt of India for mid-April to mid-May sowing, even in nutrient poor soil, average fibre yield 26.3 q/ha, maturity 180–200 days, fibre maturity 140 days, better fibre fineness (3.0 tex), tolerant to foot and stem rot disease, mealy bug and semilooper.
Sugarcane VSI 12121 (VSI 08005)	Maharashtra	Suitable for Autumn/Spring planting season under irrigated conditions, average cane yield 141.24 t/ha, sugar yield (CCS) 20.75 t/ha, mid-late maturity, moderately resistant to smut, red-rot and rust disease and less susceptible to internode borer, non-flowering nature in central and North-East zone, better ratooning ability and drought and salinity tolerant.
CoLk 12207 (Ikshu-6)	Uttar Pradesh, Bihar, Jharkhand, West Bengal and Assam	Suitable for Autumn/Spring planting season under irrigated conditions, average cane yield 75.42 t/ha, CCS yield 8.73 t/ha, maturity 300 days (early), resistant to red rot and smut, non-lodging, non-flowering, better ratooning ability and nutrient responsive.
CoLk 12209 (Ikshu-7)	Uttar Pradesh, Bihar, Jharkhand, West Bengal and Assam	Suitable for Autumn/Spring planting season under irrigated conditions, average cane yield 77.5 t/ha, CCS yield 9.38 t/ha, maturity 360 days (mid-late), resistant to red rot and smut, non-lodging, non-flowering, better ratooning ability and nutrient responsive least susceptible to the main insect pests.
Swarnamukhi (2005T16)	Andhra Pradesh	Suitable for irrigated and timely sown conditions for intercropping, average cane yield 110 t/ha, CCS yield 10.7 t/ha, maturity 300 days (early), cultivation under drought and saline conditions, resistant to red rot, good ratooner; moderately resistant smut, wilt and pokkah boeing.





Variety	Area of adoption	Salient features
Ranga (2009 V 127 (Co V 15-356))	Andhra Pradesh	Suitable for late planting under irrigated, water logged, limited irrigation conditions with saline irrigation water and red rot prone areas, average cane yield 120–130 t/ha, CCS yield 16.43 t/ha, maturity 300 days (early), tolerant to post harvest deterioration, moderately resistant to red rot and smut.
Co 11015 (Atulya)	Tamil Nadu	Suitable for normal recommended cultural practices of Tamil Nadu and Puducherry, average cane yield 142.7 t/ha, maturity 240–360 days, resistant to prevalent races of red rot.

Forage and other crops

Eighteen high yielding varieties/hybrids of forage crops comprising one each of forage sorghum, maize, berseem, Fescue grass, Bundel grass, Dhaman grass and

amaranth, three of fodder bajra, two of oats and six of Napier bajra hybrids were released for cultivation in different agro-ecologies.

Improved released varieties/hybrids of forage other crops

Variety	Area of adoption	Salient features
Forage sorghum Gujarat Fodder Sorghum-6 (SRF-347)	Gujarat	Suitable for <i>kharif</i> under rainfed conditions, green fodder yield 343.3 q/ha, dry fodder yield 112.5 q/ha, late maturing (70–75 days), moderately resistant to foliar and leaf blight diseases.
Forage pearl millet Gujarat Anand Forage Bajra 4 (GAFB 4)	Gujarat	Suitable for <i>kharif</i> season rainfed conditions, green forage yield 580.8 q/ha, dry matter yield 120.3 q/ha, maturity 90–95 days, crude protein 7.66%, no incidence of downey mildew and low incidence of rust and shoot fly damage and no infestation of myllocerous weevil.
TSFB 15-8	Telangana, Tamil Nadu, Karnataka, Kerala, Puducherry	Suitable for rainfed/irrigated conditions of red soils with medium fertility and black soils, green fodder yield 420–430 q/ha and dry fodder yield 80–90 q/ha, maturity 110–120 days, days to 50% flowering 58–62 days, moderately resistant reaction for leaf spot, leaf blight, leaf defoliators and pyricularia leaf spot, high crude protein (9.5–10%) and digestibility (55%).
TSFB 15-4	Telangana, Tamil Nadu, Karnataka, Kerala, Puducherry	Suitable for rainfed/irrigated conditions of red soils with medium fertility and black soils, green fodder yield 410–430 q/ha and dry fodder yield 80–90 q/ha, maturity 110–120 days, days to 50% flowering 60–65 days, resistant to leaf spot and blight and leaf defoliators, high crude protein (10%) and digestibility (58%).
Forage maize TSFM 15-5	Telangana, Tamil Nadu, Karnataka, Kerala, Puducherry	Suitable for rainfed conditions in <i>kharif</i> season, irrigated dry crop during <i>rabi</i> season, red loamy soils with medium fertility and black soils, green fodder yield 450 q/ha and dry fodder yield 101 q/ha, maturity 125–130 days, moderately resistant to leaf spot, leaf blight, leaf defoliators and pyricularia leaf spot.





Variety	Area of adoption	Salient features
Berseem Jawahar Berseem 05-9 (JB 05-9)	Rajasthan, Punjab, Haryana, Uttarakhand	Suitable for rainfed and irrigated under normal fertility conditions, average green fodder yield 650–680 q/ha and dry fodder yield 100 q/ha, seed to seed maturity 190–200 days, least susceptible against leaf blight, aphids and leaf defoliator, annual multicut legume with crude protein (18%) and digestibility (65%).
Grasses Palam Fescue Grass-2 (Hima 14)	Himachal Pradesh, Uttarakhand, Jammu & Kashmir	Suitable for temperate and sub-temperate grasslands and pasture, perennial multicut grass, green fodder yield 250–300 q/ha in 2–3 cuttings, dry matter yield 50–60 q/ha, maturity 200–210 days, seed production during October–November, tolerant to drought, cold and frost, can be propagated by seed or rooted slips.
Bundel Anjan-4 (IG 67-365)	Gujarat, Maharashtra, Madhya Pradesh, Uttar Pradesh	Suitable for pasture land under rainfed conditions as perennial grass, average green fodder yield 2.03 q/ha/day and average dry fodder yield 107.8 q/ha, maturity 75–80 days, highly responsive to fertilizers.
Bundel Dhaman-1IGFRI- 96-706	Rajasthan	Suitable for rainfed ecology, perennial herbaceous grass suitable for pasture lands, green fodder yield 300–350 q/ha and dry fodder yield 80–90 q/ha, multicut, multi tillering propagated through seed or rooted slips, resistant to foliar diseases, suitable for arid and semi-arid zone pastures with crude protein (7%) and digestibility (55%).
Napier bajra hybrid CO 6 (TNCN 1280)	Punjab, Haryana, Rajasthan, Maharashtra, Gujarat, Uttar Pradesh, Madhya Pradesh, Chhattisgarh	Suitable for irrigated ecosystem; perennial multicut, multi tilleder herbaceous grass, green fodder yield 850–1,350 q/ha and dry fodder yield 175–260 q/ha, perennial, non-seed setting, vegetatively propagated through stem cuttings/rooted slips, resistant to leaf blight and moderately resistant to leaf spot and major pests.
Bajra Napier Hybrid PBN 351	Maharashtra, Gujarat, Uttar Pradesh, Madhya Pradesh, Chhattisgarh	Suitable for irrigated ecosystem conditions, perennial multicut multi-tillered herbaceous grass, green fodder yield 1,300 q/ha, dry fodder yield 300 q/ha, resistant to leaf blight, no incidence of pests.
CO 2 (TND 1308)	Punjab, Rajasthan, Uttar Pradesh, Gujarat, Maharashtra, Telangana, Karnataka, Kerala, Tamil Nadu, West Bengal	Suitable for irrigated/rainfed ecology, perennial herbaceous legume, green fodder yield 400–450 q/ha and dry fodder yield 115 q/ha, seed yield 1.7–2 q/ha, seed to seed maturity 130 days, days to 50% flowering 70–75 days, resistant to leaf blight and root rot disease and white flies, legume with high crude protein (15.5%) and digestibility (60%).
TSHL-1 (Telangana Dasharath)	Maharashtra, Gujarat, Madhya Pradesh, Chhattisgarh	Suitable for pasture land under rainfed/irrigated conditions in kharif season, perennial herbaceous legume, average green fodder yield 400–550 q/ha and average dry fodder yield 100–150 q/ha seed to seed maturity 130–135 days, resistant to leaf blight and no infestation of insects, highly responsive to fertilizers, high crude protein (16%) and digestibility (68%).
CO 2 (TNCS 265)	Andhra Pradesh, Telangana, Karnataka, Tamil Nadu	Suitable for rainfed conditions, perennial herbaceous grass suitable for pasture lands, green fodder yield 700 q/ha and dry fodder yield 160 q/ha, propagated through seed or rooted slips, seed to seed maturity 110–120 days, days to 50% flowering 75–80 days, resistant to leaf blight and leaf hoppers, multicut grass with crude protein (8.2%) and digestibility (55%).





Variety	Area of adoption	Salient features
IGPISH as BBS Hybrid-1 (VTPH-3)	Punjab, Haryana, Gujarat, Maharashtra, Himachal Pradesh and Assam	Suitable for rainfed conditions in <i>kharif</i> season, perennial herbaceous grass, green fodder yield 320–350 q/ha and dry fodder yield 90–100 q/ha, maturity perennial, days to 50% flowering 90–100 days, no infestation of insects, facultative apomict and preferred to be clonally propagated, multicut, multi-tillered grass with crude protein (6.5%) and digestibility (53%).
Oat		
SKO-225 (Shalimar Fodder Oats -6)	Himachal Pradesh, Almora, Jammu & Kashmir, Central zone—Jhansi, Anand, Jabalpur, Rahuri, Urulikanchan	Suitable for timely sown, normal fertility and irrigated conditions and hill zone of the country, green fodder yield 315.2 q/ha, dry fodder yield 70 q/ha, crude protein 9.4%, suitable for single cut system. Maturity hill zone (170–175 days), Central zone (140–145 days), moderately resistant to leaf blight and powdery mildew.
Bundel Jai-2015-1	Himachal Pradesh, Jammu & Kashmir	Suitable for irrigated, timely sown conditions in tropical and subtropical areas during <i>rabi</i> season, average green fodder yield 252 q/ha, dry fodder yield 56 q/ha, crude protein 10%, resistant to lodging and a non-shattering variety.
Others		
Grain amaranth		
Chhattisgarh Rajgira-1 (Ambika GA 12-1)	Chhattisgarh	Suitable for <i>rabi</i> under rainfed rice fallow lands, seed yield 18–20 q/ha, maturity 115–120 days, plant height 100–110 cm, resistant to prevailing diseases and pests.

Development of biofortified varieties: Twenty biofortified varieties of different crops including rice, wheat, maize, sorghum, pearl millet, linseed and finger

millet have been developed. Brief description of the varieties with quality traits is as under:

Variety	Salient features	Variety	Salient features
Rice			
Kalanamak Kiran (PRDF 2-14-10) (IET 24753)	High zinc content (20 ppm)	Pusa Vivek Hybrid-27 Improved (APH27)	Improved Provitamin A 5.49 µg/g
Wheat		Pusa HQPM-7 Improved (APQH7)	High Provitamin A 7.10 µg/g, high lysine 4.19% and tryptophan 0.93%
WH 1184	High protein content (13.02%), High iron content (42.5%)	RHB 233 (MH 2173)	High iron (83 ppm) and high Zn (46 ppm)
Pusa Wheat 3249 (HD 3249)		RHB 234 (MH 2174)	High iron (84 ppm) and high Zn (41 ppm)
PBW 771	High zinc content (41.4 ppm)	MH 2224 (PB 1852)	High iron (56 ppm)
DDW 47	High protein 12.7% and high iron content (40.1 ppm.) in grain	HHB 311 (MH 2179)	High iron content (83 ppm)
Pusa Wheat 8802 (HI 8802)	High protein content (13.3%)	Sorghum	
Pusa Wheat 8805 (HI 8805)	High protein content (12.4%) and iron content (40.4 ppm)	Jaicar Nutrigraze (CSV 43 BMR/ SPV 2018)	Crude protein content (8.3%); lignin (6.5 ADL-DM%)
Barley		Linseed	
Karan Maltsona (DWRB 160)	High malt content (68/90 malt score)	TL 99	Linolenic acid (<5%) (normal varieties) (>40%)
Maize		Finger millet	
Shalimar QPMH-1 (KDQH-49)	High quality protein content	Vegavathi (VR 929)	High in grain Zn (33.2 ppm), Fe (131.8 ppm), Ca (3710 ppm) and protein (9.8%). High dietary fibre and low in tannin content
Maize VGIH 1	High starch (75.50%), high protein (10.85%) and high beta-carotene (0.44 mg/100 g), moderate fat (4.05%) and crude fibre (1.33%)		
Pusa HQPM-5 Improved (APQH5)	High Provitamin A (6.77 µg/g) (1.02 in normal maize); High lysine 4.25% and tryptophan 0.94% (Normal maize <0.6% tryptophan <2.5% lysine)		





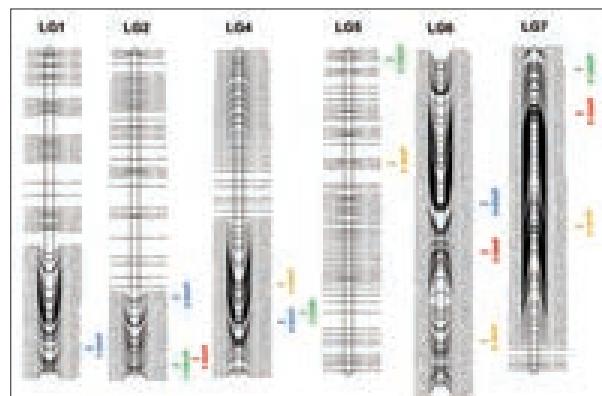
Varieties developed through use of genomic resources: Six varieties of different cereal and pulse crops, viz. wheat (PBW 771), maize [Pusa HQPM-5 Improved (APQH 5), Pusa Vivek Hybrid-27 Improved (APH 27), Pusa HQPM-7 Improved (APQH 7)] and chickpea [Pusa Chickpea 10216 (BGM 10216), Super Annigeri-1 (MABC-WR-SAI)] have been developed through genomic assisted selection. These varieties have been improved by introgression of traits for quality, disease and drought tolerance.

Use of genomic approach for herbicide tolerance and quality improvement: Marker-assisted backcross breeding was employed to transfer a herbicide tolerance mutant allele of *ALS* gene from Robin, an Imazethapyr tolerant EMS-induced mutant of Nagina 22, into two elite Basmati rice varieties, viz. Pusa Basmati 1121 and Pusa Basmati 1509. Genome wide association study (GWAS) was employed in rice to map significant QTLs for Fe and Zn for enhancing the endosperm mineral micronutrient density as rice is widely consumed after polishing. In pearl millet, QTLs for grain Fe and Zn content were mapped using 210 RILs (PPMI 683 × PPMI 627).

Standardization of CRISPR-Cas9 Technology: The CRISPR-Cas9 genome editing technology was standardized for different crops to enhance stress tolerance and nutritional quality. In rice, CRISPR-Cas9 genome editing was employed to develop mutants of *DST* (*DROUGHT AND SALT TOLERANCE*) gene for improving salt and drought tolerance. To reduce the seed phytate content, CRISPR-Cas9 genome editing was used to mutate *GmIPK1* gene. T0 lines showed 6–9-fold reduction in phytate content. Overexpressing abscisic acid receptor *OsPYL10* and *Isopentenyltransferase 9* (*IPT9*) genes were found to confer drought and salt stress tolerance to transgenic rice.

Insect resistance genes from *Cajanus platycarpus* against *Helicoverpa armigera*: *Cajanus platycarpus* is one of the non-crossable wild relatives of pigeonpea possessing resistance to polyphagous insect *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 TTB7, 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*.

QTL mapping of 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



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).

intraspecific 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 (QTLs) associated with drought traits (membrane stability index, relative water content, seed weight and yield under stress condition) accounting for phenotypic variations ranging from 11.8% to 27.1%.

Molecular diversity in jackfruit: A set of primer sequences from SSR flanking regions were identified for the validation of SSRs in a jackfruit germplasm set. Primer sets for 200 genic-SSRs have been custom synthesized in jackfruit for their validation, and molecular characterization of the 224 jackfruit accessions collected primarily from Jharkhand was carried out using these SSR markers. A total of 81 alleles were detected in 224 jackfruit accessions by using 27 SSR markers. The number of alleles ranged from 2 to 4, with an average of 3 alleles per locus. In population structure studies significant, genetic admixing was observed in the jackfruit accessions.

Phenomics for abiotic stress breeding in field crops: Phenomics was used to identify germplasm and breeding lines with high water use efficiency (WUE) and drought tolerance in the major food crops. Genotypes which use significantly less water than that of Nagina 22 in rice and RILs of wheat superior to C 306 in WUE were identified. Elevated CO₂ (EC) mediated decrease in nitrate uptake and assimilation was found to be a cause for reduction in grain quality under EC conditions. Genome-Wide Association Studies (GWAS) and linkage-mapping analyses were used to identify QTLs for stress tolerance and yield in different field and horticultural crops.



Event selection trial of transgenic pigeonpea and chickpea harbouring Bt gene(s): Event selection trials of five transgenic events each of pigeonpea and chickpea harboring *Bacillus thuringiensis*-crystal *lAc/cry1Aabc* genes for gram pod borer resistance trait were conducted to identify the best event in each crop, based on trait efficacy (resistance to gram pod borer), expression of Bt protein at various stages and related agronomic characters including yield. Correlated with protein expression, 61.57–87.77% reduction was observed in the transgenic pigeonpea events over control variety ICPL 87119 (Asha) and 72.51–85.16% reduction in transgenic chickpea events over control variety DCP 92-3.

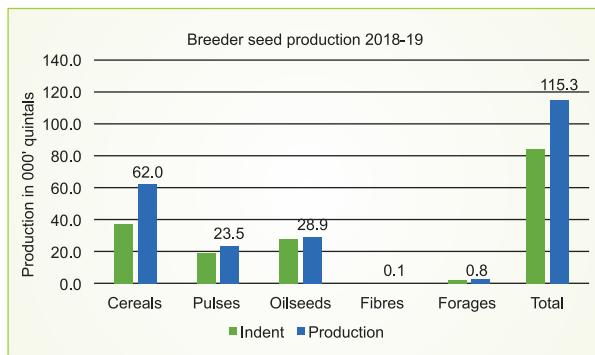
Genome-wide identification of nodule-specific cysteine rich (NCR) peptides in chickpea: Symbiotic nitrogen fixation (SNF) ability of legumes can make them self-reliant for N-requirement, however, that is not the case due to lack of knowledge about critical process of bacteroid differentiation during nodule development, which is mediated by plant derived nodule specific cysteine rich (NCR) peptides. In the present investigation, 67 putative NCR peptides including 30 unique sequences of *Cicer arietinum*, were identified and characterized. Each sequence possesses at least one conserved late-nodulin domain. Nine putative NCR peptides of *Cicer arietinum* contain single motif, 24 sequences had two motifs and 34 sequences had three motifs. The generated information will help in developing tools for optimizing the symbiotic efficiency under natural farming environment.

QTL mapping for foliar fungal disease resistance: 84 polymorphic SSR markers were used in mapping foliar fungal disease resistance and 70 of them were mapped on 14 linkage groups (LGs). The genotypic and phenotypic data was used for QTL analysis. Two major QTLs (LLSQLT1 and LLSQLT2) were detected for Late Leaf Spot resistance and one major QTL (RustQTL) for rust resistance.

Validation of newly developed markers for LLS and rust diseases: Twenty-four markers were used for validation in 12 groundnut varieties resistant to both late leaf spot and rust diseases and 9 varieties resistant to rust only to find out any alleles other than alleles from GPBD 4 which can be utilized for breeding. All markers differentiated resistant varieties justified by their phenotypes (disease score). After screening with all the markers of targeted genomic region, it was observed that all the 12 groundnut varieties resistant to both LLS and rust diseases, carry resistant alleles. These markers were able to clearly differentiate resistant and susceptible varieties specified by their allelic pattern.

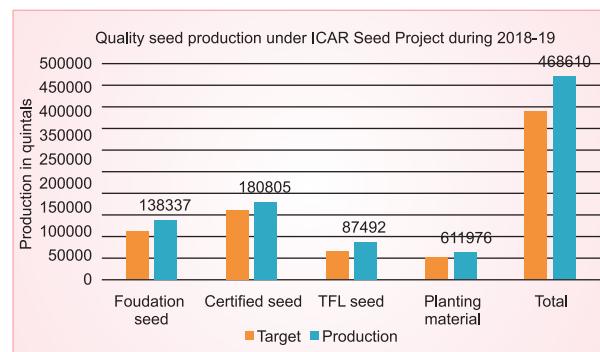
Seed Production

Breeder seed production: The total breeder seed production in field crops was 1,15,293.4 q against the DAC & FW indent of 83,690.1 q. The major share in total breeder seed production belongs to cereal crops, i.e. 61,976.6 q against indent of 36,814.1 q. Under pulse crops a total of 23,530.4 q breeder seed was produced



against the indent of 18,698.4 q. In oilseeds, total breeder seed production was 28,871.7 q against the indent of 27,567.2 q. Breeder seed produced in case of fiber crops was 121.2 q against the indent of 90.4 q and in forage crops, 793.5 q was produced against the indent of 520.1 q.

Quality seed production: Total production of quality seed including all classes was 4,68,610 q against the target of 3,88,137 q. Production comprises 1,38,337 q of foundation seed, 1,80,805 q of certified seeds, 87,492 q of truthfully labelled seed and 61,976 q of planting material of field crops. In addition, 178.1 lakh planting material and 12.2 lakh tissue culture plantlets were



Breeder seed production in Sugarcane

The year was an exemplary period for seed production in sugarcane especially for ICAR-SBI, Coimbatore. A huge indent of about 2,300 tonnes of quality seed has been received from Director of Sugars, Govt of Tamil Nadu. Due to paucity of cultivable land at the Institute, progressive farmers were selected to undertake farmers' participatory seed production from Seyur, Mathampalayam, Veerapandi, Vellamadai and Neelambur, and trained to undertake quality seed production under technical guidance of the scientists. About 21,478.96 q of quality seed were supplied to both cooperative and private sugar factories in Tamil Nadu as per block-wise allotments from the Directorate. Through apical meristem tip culture, the varieties Co 86032, Co 0212, Co 09004, Co 0238, Co 0118, Co 06022, Co V 09356 and new clone Co 11015 were multiplied and were virus indexed against SCYLV, SCMV, SCSMV and GSD. About 90,000 tissue culture plants and 49 virus free mother culture flasks of varieties Co 86032, Co 0212 and Co 09004 were supplied to the sugar mills and private tissue culture laboratories, respectively, for production of quality planting material in sugarcane.





produced against the targets of 193.5 and 5.1 lakh, respectively.

HORTICULTURE

Mango: Arka Suprabhath (H 14) is a double cross hybrid between Amrapali (Dashehari × Neelum) × Arka Anmol (Alphonso × Janardhan Pasand). It bears in bunches with 35–40 kg/tree potential fruit yield (after 4 years of planting). Fruit weight ranges from 250–300 g, deep orange pulp of 70% recovery and 22°B TSS, and 8–10 days shelf life at room temperature.

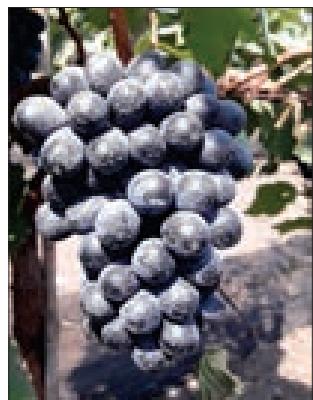
Banana and plantains: One promising cooking banana (plantain) hybrid (NCR 17) for higher yield (25 kg) was developed. Three banana varieties, namely



Kaveri Kanya, Kaveri Haritha and Kaveri Saba were recommended for release and notification by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Horticultural Crops, Government of India. Kaveri Kanya is an introduced accession (FHIA 03) with medium tall (2.4 to 2.7 m) and robust pseudostem (80–95 cm girth) and yields 25 kg bunches. Kaveri Haritha is a clonal selection from Bangrier and released for culinary purpose. It has stable yield in both main and two ratoon crops (25 kg/bunch). Kaveri Saba is a dual purpose variety, tolerant to deficit soil moisture stress and saline sodic soils.

Grapes: Evaluation of Charark (Chardonnay × Arkavati) series of wine hybrids revealed all wines to be

within the category of very dried wines and had higher alcohol. Of the 90 hybrid progenies of grapes, 19 were observed resistant to downy mildew (UPOV rating 1–3). Hybrid progenies H128.23 and H52.23 were observed promising for naturally loose bunches (<2 berries/cm spacing), progeny H95.24 for bold berries (diameter 19 mm) and Hybrid



Grape hybrid Manjari Shyama

H52.23 for rudimentary seeds and rose colour berries. Manjari Shyama is a hybrid (Black Champa × Thompson Seedless) with black, crunchy and bold berries identified for table purpose.

Litchi: Two promising genetic stocks of litchi, viz. NRCL-29 and NRCL-85 were identified. NRCL-29 has precocious bearing (flowering in third year of planting) and fruit pericarp contains high anthocyanins (94.35 mg/100 g). NRCL-85 is a heavy bearer (30–40 fruits/cluster)



NRCL-85

and fruits are tolerant to cracking.

Guava: Arka Kiran, a hybrid (Kamsari, IC395207 × Purple Local, IC 20455), has round and medium size fruits (170–180 g), dark red pulp with medium soft seeds (9–10 kg/cm²) and high lycopene (7 to 7.14 mg/100 g pulp).

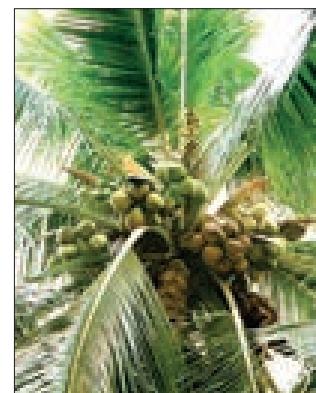
Jamun: CISH Jamwant, an elite and bold (24.05 g), oblong, deep purple jamun was identified. Fruits are 3.9 cm long with 3.03 cm diameter, 92.26% pulp, 16 to 17 brix and more pulp: seed ratio (90–92%). It has relatively high ascorbic acid (49.88 mg/100 g) and total antioxidant value (38.30 mg AEAC/g). At 10 years of age, it yields 80–90 kg fruits/tree.

Wood apple: Thar Gaurav is precocious (bearing in 4th year), large fruit (452.25 g), high yielding (124.36 kg/tree) under rain-fed conditions of western India. Fruits are rich in pectin (1.76%) and protein (pulp 18.13% and seed 24.38%), phosphorus (0.07%), potassium (1.73%), calcium (0.30%) and iron (16.72 mg).



Coconut: A promising coconut hybrid BGR × ADOT (Tall × Tall) with 81.4 nuts/palm/year yield was identified.

Kalpa Ratna is a selection and suitable for tender nut, copra and inflorescence sap production. The variety is relatively tolerant to low moisture stress with a yield of 148 nuts/palm/year with copra out turn of 27.23 kg/palm/year, which is 34.55 and 40.65% higher than the local control (West Coast Tall). It has 34.78% higher inflorescence sap yield than WCT and suitable for cultivation in Kerala, Karnataka and semi-arid regions of Tamil Nadu.



Cocoa: Cocoa hybrids, viz. VTLCP 8 and VTLCP 9, with high yield potential (2.5–3 kg dry beans/tree/year), were found suitable for high density planting under arecanut and coconut plantations.

Oil palm: Three oil palm hybrids for higher yield were identified. Godavari Swarna has 26.87 t/ha/year fresh fruit bunch (FFB) yield and 5.71 t/ha/year mesocarp oil yield; identified for cultivation in Andhra Pradesh. Godavari Ratna has 22.44 t/ha/year FFB yield; 18.31 kg





bunch weight; high mesocarp oil yield (5.36 t/ha/year); suitable for coastal region of Maharashtra and Goa. Godavari Gold has 27.23 t/ha/year FFB yield with more number of bunches/ palm (11.74); high mesocarp oil yield (5.79 t/ha/year); suitable for coastal Tamil Nadu under assured irrigations.

Cashew: Hybrid-130 (NRCC-Sel-2 × Bedasi), highly precocious, and cluster bearing with bold nuts (10–14 g) and large yellow cashew apple (75–120 g). The shelling percentage is 29.5 and kernel grade is W110 to 150 with 47% fat and 26% protein.



Tomato: Plants of Arka Aditya are semi-determinate, fruits medium large (90–100 g), resistant to tomato leaf curl disease (Ty_2+Ty_3), bacterial wilt and early blight. It is suitable for fresh consumption and yields 60–65 t/ha in 140–150 days. It is recommended for cultivation in Karnataka, Tamil Nadu and Kerala by Central Variety Release Committee (CVRC), Government of India.

Brinjal: Kashi Himani (IVBL-26) has shiny white fruits, tolerant to fruit and shoot borer, low soil moisture stress and lodging. It has 400–430 q/ha yield potential.

Chilli: Arka Khyati is a CMS based, cucumber mosaic virus tolerant, F_1 hybrid for fresh market. Fruits measure 12 × 1 cm, light green and turn deep red on maturity. Medium pungent, smooth and wrinkles after drying. Kashi Abha (VR-339) fruits are short, stout with blunt apex. It is tolerant to biotic anthracnose, CLCV, thrips and mites and has 15 t/ha yield potential. Kashi Ratna (CCH-12), is a CMS based F_1 hybrid, suitable for green chilly with semi-erect growth. It is tolerant to anthracnose and thrips with a yield potential of 20–22 t/ha. Kashi Tej (CCH-4) F_1 Hybrid, is CMS based, dual purpose (green and dry chilli) F_1 hybrid, tolerant to anthracnose and thrips. It has 14.2 t/ha potential yield of green chillies.

Dolichos bean: Arka Supriya is a pole type, photo-sensitive variety. Pods are light green, up to 28 t/ha potential yield. This variety has been recommended for cultivation in Madhya Pradesh (excluding eastern area), Maharashtra, Karnataka, Tamil Nadu and Kerala. Kashi Sheetal (VRSEM-11) is semi-pole type, tolerant to dolichos yellow mosaic virus (DYMV). It has 18–19 t/ha yield potential. Kashi Khushal (VRSEM-3) is semi-pole type variety. It is tolerant to high temperature and DYMV.

French bean: Pods of Arka Sharath have no parchment layer. Its pod yield potential is 18.5 t/ha in 70 days. It has been recommended for cultivation in Karnataka in both *kharif* and *rabi*. Kashi Rajhans (VRFBB-2) has fleshy (parchment less) pods. It is field tolerant to French bean golden yellow mosaic virus (GYMV). Kashi Sampunn (VRFBB-1) is tolerant to GYMV.

Yard long bean: Arka Mangala is a pole type, photo insensitive variety with 75 cm long pods, yield up to 25 t/ha, suitable for both *kharif* and *rabi*. It has been

recommended for cultivation in Karnataka.

Bitter gourd: Kashi Mayuri (VRBTG-5) has comparatively less seeds (10–15/fruit) with higher fruit yield (19.56 t/ha). It has fruiting potential during hot summer (>35°C), tolerant to anthracnose, downy mildew and mosaic diseases.

Bottle gourd: Kashi Kirti (VRBOG-63-02) variety is resistant to downy mildew and has high yield potential (375–425 q/ha), suitable for distant market and transportation. Kashi Kundal (VRBOG-16) is suitable for cultivation during *kharif*. Its yield is 47.5 t/ha. It is resistant to downy mildew. Each fruit of Kashi Kiran (VRBG-4) weighs 600–700 g. Its estimated yield is 45 to 48 t/ha. It is tolerant to downy mildew.

Sponge gourd: Kashi Shreya is an open pollinated variety suitable for river bed cultivation. Each fruit weighs 100 to 150 g; yield is 150–200 q/ha. It is resistant to downy mildew, powdery mildew and sponge gourd mosaic virus under field condition. It has been notified for cultivation in Punjab, Uttar Pradesh, Bihar and Jharkhand. Kashi Rakshita, a F_1 hybrid, yields 12–14 fruits/plant. It is resistant to downy mildew and sponge gourd mosaic virus under field condition. It has been notified for cultivation in Punjab, Uttar Pradesh, Bihar and Jharkhand. Thar Tapish is a short duration (110–115 days) variety, tolerant to high temperature (flowering at 36–38°C) and has 142.2–155.8 q/ha potential fruit yield. Kashi Jyoti (VRSG-1-17) has potential yield of 15–18 t/ha. Kashi Saumya (VRSGH-3) is suitable for river bed cultivation. It is resistant to sponge gourd mosaic virus and tolerant to downy and powdery mildew under field conditions. It has high potential yield (185–195 q/h).

Satputia: Kashi Khushi (VRS-1) is most suitable for cultivation during *kharif* and can be also grown during spring season. It has 11–12 t/ha potential yield.

Ivy gourd: Thar Sundari is perennial, and responds to pruning and re-sprouts with the on-set of spring (February) and monsoon rains (June-July) facilitating two crops (2.85–3.48 kg/plant/season) in a year.

Pointed gourd: Kashi Amulya (VRPG-89) fruits contain comparatively less seeds (5–8/fruit) and 20–22 t/ha potential yield. Kashi Suphal (VRPG-2) yields 18–20 t/ha.

Summer squash: Kashi Subhangi (VRSS-06-12) is most suitable for cultivation during autumn but can also be grown during spring with 60–65 t/ha yield potential.

Cucumber: Kashi Nutan (VRCUH-01) F_1 Hybrid has cylindrical, light green fruits with mottling near peduncle. It is suitable for cultivation during *kharif* and *zaid* with 17.85 t/ha yield potential and resistance to downy mildew.

Pumpkin: Kashi Shishir (VRPKH-1) F_1 Hybrid bears round and mottled green, 3–4 fruits/plant (2–2.25 kg) with higher yield potential (38–42 t/ha) during *kharif* but can be grown in *zaid* as well.

Radish: Kashi Mooli-40 (VRRAD-203) is tolerant to high temperature (35–42°C) and suitable for summer cultivation, with 30–35 t/ha yield potential during *rabi* and 20–23 t/ha during *zaid*. Kashi Lohit (VRRAD-131-2) has attractive red roots with 40–45 t/ha yield potential.





Carrot: Kashi Krishna (VRCAR-126) has attractive black roots along with self-colour core with fewer secondary roots/scars. It is tolerant to bolting with 20–22 t/ha yield potential.

Cauliflower: Kashi Gobhi-25 (VRCF-50) is a tropical variety and matures during November (at 25°C). It has 25–28 t/ha estimated yield.

Okra: Kashi Chaman (VRO-109) is resistant to yellow vein mosaic virus (YVMV) and okra enation leaf curl virus (OELCV) under field conditions. It has 150–160 q/ha yield potential and suitable for cultivation both during *zaid* and *kharif*. Kashi Lalima (VROR-157) has reddish purple fruits and is tolerant to YVMV and OELCV with yield of 14–15 t/ha; suitable for cultivation during both summer and *kharif*. Kashi Shristi (VROH-12) F₁ Hybrid, has higher yield potential during *kharif* (18–19 t/ha) but suitable for cultivation during *kharif* and *zaid*. It has field tolerance to YVMV.

Vegetable amaranth: Arka Samraksha is pulling type, high yielding (10.9 t/ha) in 30–35 days duration with high antioxidant activity (499 mg-AEAC units) and low nitrate (27.3 mg) and oxalates (1.34 g/100 g) in fresh leaves. Arka Varna is high yielding (10.6 t/ha in 30–35 days) with high antioxidant (417 mg-AEAC units) activity and low nitrate (37.6 mg) as well as oxalates (1.42 g/100 g) content in fresh leaves. It is a pulling type variety with green leaves and pink stem.

Palak: In Thar Hariparna, fresh leaf yield is 154.72 q/ha.



Amaranth: Kashi Suhaavani (VRAM-42), has high yield potential (30–33 t/ha); suitable for summer and rainy season; tolerant to white rust.

Bathua: Kashi Bathua 2 has 180–195 cm plant height and yields 31.7 t/ha in a crop duration of 160 days. Kashi Bathua 4, has upright growth with purplish-green leaf and petiole colour. It has high yield potential (35 t/ha).

Poi/Indian spinach: Kashi Poi-1 has procumbent growth; tolerant to excess soil moisture stress (4–5 days); first picking starts 40 days after transplanting and continues up to 220–230 days at 20–30 days interval; high yield potential. Kashi Poi-2 is a fast growing variety; first picking starts at 38–40 days after transplanting and continues up to 140–150 days at 20–30 days interval with higher potential yield. Kashi Poi-3 is fast growing; first

picking starts at 40 days after transplanting and continues up to 240–250 days at 20–25 days interval with high yield potential.

Potato: Four new potato varieties were released. Kufri Manik (PS/06-88), a bio-fortified variety with red-skinned, round tubers and yellow flesh, possesses high dry matter (19.2%), and rich in micro-nutrients; yields 25–30 t/ha and moderately resistant to late blight; suitable for all potato growing regions especially in eastern plains. Kufri FryoM (MP/4-578), yields 30–35 t/ha with 20–21% dry matter and is field resistant to late blight and potato virus Y. Kufri Karan (SM/00-42) has multiple resistance to diseases such as, late blight, apical leaf curl virus, potato virus Y, potato virus S, potato leaf roll virus, potato virus A, potato virus M with moderate resistance to potato cyst nematode. It produces 30 t/ha; recommended for cultivation in hills and Plateau regions of the country. Kufri Sahaydri (OS/01-497) is highly resistant to potato cyst nematode and yields 32 t/ha; recommended for Nilgiri hills of Tamil Nadu.

Tropical tuber crops

New varieties of different tropical tuber crops (three cassava, one sweet potato, three greater yam, three aerial yam and four taro) were identified by the ICAR-AICRP on Tuber Crops.

Cassava: TCa13-1(CAU C-1 Nungha) matures in 8–9 months with 24–31 t/ha yield; recommended for release and cultivation in Manipur. TCa13-7(9S 125), a hybrid (CR43-11 × Mankozhunthan), with high (35 t/ha) yield, tolerant to cassava mosaic disease; recommended for cultivation in Kerala, Manipur and Chhattisgarh. TCa13-4 (S4) has 27.33 to 31.2 t/ha fresh tuber yield. It is tolerant to cassava mosaic virus; recommended for cultivation during *kharif* in Chhattisgarh.



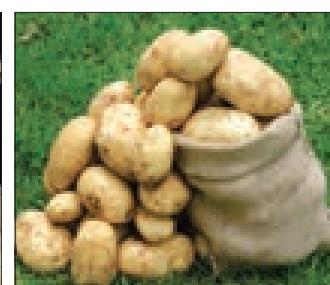
Kufri FryoM



Kufri Manik



Kufri Karan



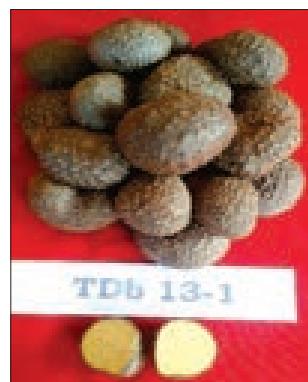
Kufri Sahyadri

Sweet potato: TSp12-6 (BCSP-10) has 20.1 t/ha tuber yield; less affected by sweet potato weevil (0.8 t/ha) damage and it is recommended for cultivation in Bihar.





Greater yam: TGy12-6 was identified for cultivation in Chhattisgarh and Rajasthan during *kharif* with 25 to 35 t/ha tuber yield. TGy12-3 (Da-342) has high yield (35.8 t/ha); identified for Odisha, Kerala and Andhra Pradesh. TGy12-1 (Da-406), a hybrid (Da402) with high yield (57.87 t/ha); identified for release for cultivation in Kerala.



Aerial yam: TDb13-1 (DBSKKV Db-1) has high yield (5.27 t/ha) potential; recommended for Maharashtra and Chhattisgarh. TDb13-5 has underground tuber yield 0.78 t/ha; recommended for release in Jharkhand. TDb13-6(IGDb-1) has 15 to 20 t/ha tuber yield; recommended for cultivation in Chhattisgarh during *kharif*.

Arvi / taro: TTr12-8 (AR Coll-7) has 12.2–16.2 t/ha cormel yield and recommended for cultivation in Bihar, Jharkhand and Andaman & Nicobar Islands. TTr12-4 (BCC-9) has 16–17 t/ha cormel yield and identified for cultivation in West Bengal. TCb1 12-4 (BCC-2) has 16.2 t/ha cormel yield; less susceptible to *Phytophthora* leaf blight (PDI 12.2); recommended for cultivation in Bihar. TCb12-5 (BCC-5) has 11.5–13.5 t/ha cormel yield, highly resistant to taro leaf blight and recommended for cultivation in Maharashtra and Telangana.

Onion

Arka Bheem has bulb yield potential up to 47 t/ha in 130 days. It has been recommended for cultivation in Karnataka. Bhima Shakti (DOGR-1156) has 32–36 t/ha yield in *rabi*; very good bulb storability (up to five months); notified for cultivation in Andhra Pradesh, Chhattisgarh, Karnataka, Madhya Pradesh, Maharashtra and Odisha.



DOGR-HT-1, an advanced breeding line of short day onion with 30 t/ha bulb yield during *rabi*, matures in about 120–125 days after transplanting. It is suitable for dehydration and produces seed under short day conditions. NHRDF Fursungi (L-819) is tolerant to *Stemphylium* blight; 380–400 q/ha yield during *rabi*; notified for cultivation in Delhi, Rajasthan, Haryana, Jammu & Kashmir, Punjab, Gujarat and Maharashtra. JWO-11-5-

7 has 230 q/ha marketable yield and can be stored up to 4 months. It has been notified for cultivation during *rabi* in Gujarat, Jammu, Punjab, Delhi, Haryana, Rajasthan, Madhya Pradesh, Chhattisgarh, West Bengal and Maharashtra.

Garlic: Bulbs of Yamuna Purple (G-404) are light purple; 25–30 cloves/bulb; marketable yield ranges from 165 to 175 q/ha. It has been notified for cultivation during *rabi* in Jammu, Punjab, Delhi, Haryana, Rajasthan, Madhya Pradesh, Chhattisgarh, West Bengal and Maharashtra.



Spices

Black pepper: Hybrid HP 117 × Thommankodi, a promising hybrid with highest fresh yield (8.9 kg/standard) with 32.5% dry recovery was identified.

Ginger: Solan Giriganga gives 19–20 t/ha yield. It has been identified for Himachal Pradesh, Jammu & Kashmir, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Sikkim, Arunachal Pradesh and Assam.

Turmeric: Uttar Rangini (TCP 129) has 5.1% curcumin and 26.51% dry matter in rhizome with 27.17 t/ha yield in 210 to 220 days. It is tolerant to leaf spot and leaf blotch and identified for West Bengal, Tamil Nadu and Bihar.

Nutmeg: Konkan Sanyukta has 9.2 g and 1.07 g nut and mace weight, respectively; yield 500 nuts/plant/year (equivalent to 621 kg nuts and 72.22 kg/ha mace yield) and identified for Konkan region of Maharashtra.

Seed spices

Coriander: Ajmer Coriander-3 (ACr-3) has higher (16.8 q/ha) seed yield; its seed contains 0.55% essential oil and essential oil having 75.42% linalool; notified for cultivation in Rajasthan. Rajendra Dhania-3 is high yielding (14.09 q/ha) with higher oil (0.52%) content and identified for cultivation in Rajasthan, Haryana, Gujarat, Madhya Pradesh, Uttar Pradesh, Bihar, Chhattisgarh and Andhra Pradesh. Sri Chandrahansini Dhania-2, yields 10 to 14 or 15 to 22 q/ha, respectively under rainfed and irrigated conditions in 105–110 days; identified for cultivation in Chhattisgarh, Rajasthan, Haryana, Gujarat, Madhya Pradesh, Uttar Pradesh, Bihar and Andhra Pradesh. JD (SI)-1 is high yielding (14.14 q/ha) with 0.67% oil content and identified for cultivation in Madhya Pradesh, Uttar Pradesh, Chhattisgarh, Uttarakhand, Rajasthan and Haryana. Ajmer Green Corinader-1





(AGCr-1) has 74.32 q/ha green leaf yield; moderately resistant to powdery mildew; recommended for cultivation in Rajasthan.

Ajmer Celery-2 (A-Cel-2): It gives 8.74 q/ha seed yield containing 6.74% essential oil and identified for cultivation in Rajasthan.

Fenugreek: HM 425 is high yielding (20–22 q/ha) and resistant to powdery mildew and downy mildew; identified for cultivation in Rajasthan, Uttarakhand, Madhya Pradesh, Uttar Pradesh and Tamil Nadu. Narendra Richa, dual purpose (seed and leaf) with higher green leaf and seed yield (12–15 q/ha); tolerance to soli alkalinity and moderate resistance to powdery mildew; identified for cultivation in Rajasthan, Uttarakhand, Madhya Pradesh, Uttar Pradesh and Tamil Nadu.

Cumin: Gujarat Cumin-5 is high yielding (5.71 q/ha) with yield potential of 10.28 q/ha (38% > Gujarat Cumin-4) in short duration (92 days) and resistant to wilt; identified for cultivation in Gujarat and Rajasthan.

Fennel: Ajmer Fennel-3 (AF-3) is high yielding (21.43 q/ha seed yield) variety, matures in 175–180 days, moderately resistant to *Ramularia* blight disease; notified for cultivation in Rajasthan, Haryana, Bihar, Madhya Pradesh, Uttar Pradesh, Uttarakhand and Gujarat.

Ornamental crops

Rose: Arka Sinchana is highly floriferous and ever-blooming floribunda rose identified for garden display. Flowers are bright red with small flowers (5.4 cm) borne in bunches.

Gladiolus: Arka Ranjini has attractive purple floret arranged in double rows with short spikes and early flowering (62–68 days). It is suitable for cut flower and bedding purpose.

Crosandra: Arka Chenna has orange petals with 40 kg flower yield per week per 1000 plants.

Gerbera: Flowers of Arka Pink variety are double with pink florets and black disc having 11 cm diameter and 62 cm stalk length. It bears 2 to 3 flowers/plant/month with 7 days vase life.

Marigold: Arka Honey is a photo insensitive French marigold variety with double flowers and flowering throughout the year. It starts flowering at 30–35 days after planting with 6 weeks flowering duration. It yields 10–12 t flowers/ha in three months crop duration.

Mushrooms

Button mushroom: Two improved strains, NBS-5-1084 with 13.34% biological efficiency and NBS-5-1077 with 12.92% biological efficiency as against 12.69% in control were identified.

Oyster mushroom: PSCH-35 is a crossbred strain of *Pleurotus sajor-caju*. The average biological efficiency (BE) of the strain is 58.65%

with 2.71% superiority than check and suitable for culture at 24–28°C.

Shiitake mushroom: DMRO-356 is a selection having 46.7% biological efficiency.

Medicinal plants

Teraploid line of isabgol (*Plantago ovata*): A stable tetraploid ($2n = 4x = 16$) line of isabgol (DTPO6-6) was developed from the variety GI 2 using colchicine (0.1 to 0.5%) seed treatment. The tetraploidy was confirmed through flow cytometry, root anatomy phenotypic observation and cytology. The tetraploids were fertile and stable.

Biotechnology

Banana: The genetically modified and bio-fortified banana cv. Rasthali and Grande Naine with enhanced pro-vitamin-A (range 20 µg/100 g dry weight) were developed. The protocol for large scale micro-propagation of banana Elakki Bale using embryogenic cell suspension (ECS) was developed (1 lakh plants/embryogenic calli). Field evaluation of embryo derived plantlets showed normal phenotype as compared to sucker or shoot tip plants.



Pomegranate: Genome sequencing of cv. Bhagawa with high quality genome (346 Mb) using the sequencing technologies revealed 96.92% of estimated genome size to be 356.98 Mb with 342 scaffolds having average N50 value of 16.1 Mb.

Clonal propagation of coconut: Direct *in vitro* plant regeneration for coconut plantlets was achieved using rachilla bits of immature inflorescence of West Coast Tall variety. Root generation was partially successful, but could be improved with further manipulation of the medium and growth conditions. Clonal fidelity of the plantlets was clearly established with SCoT markers.

Cryo-preservation of coconut tissues: Procedure for V-cryomesh/V-cryoplate method for coconut (plumular tissue) and arecanut (embryogenic callus) cryopreservation was standardized. Use of single-walled carbon nanotubes (SWCNT) enhanced post cryopreservation recovery in coconut zygotic embryos. Cryo-conservation of coconut germplasm in the form of embryos (nine accessions), pollen (six accessions) and DNA (12 accessions) was undertaken at National Cryo Gene Bank, ICAR-NBPG, New Delhi.





Molecular markers for arecanut hybrids: SCAR (Sequence Characterized Amplified Region) molecular markers for identification of arecanut interspecific hybrids were developed and validated.

Testing genetic purity of inter-specific hybrids of cashew: Three SSR markers, viz. CSSR5, CSSR8, and CSSR18 were identified which showed parental polymorphism and could identify the true hybridity of interspecific cashew hybrids such as ISH816 (*Anacardium occidentale* cv. Bhaskara × *A. microcarpum*), ISH706 (*A. occidentale* cv. Ullal-3 × *A. microcarpum*) and ISH794 (*A. microcarpum* × *A. occidentale* cv. Ullal-3).

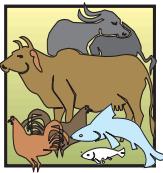
Genome sequence analysis of dihaploid potato C-13: Whole genome of an androgenic potato dihaploid C-13, developed through anther culture of cv. Kufri Chipsona-2, was sequenced with reference assembly. Overall, 30241 genes were identified in C-13 genome, of which 15,538 genes were characterized by the GO terms. A total of 11,22,388 SNPs and 48,145 InDels were identified in C-13 genome.

Genomics approaches to improve nitrogen use efficiency in potato: Precision phenotyping of two contrasting potato varieties (Kufri Gaurav: N efficient, and Kufri Jyoti: N inefficient) was standardized in aeroponics supplied with different N doses. Plant biomass, root traits, total chlorophyll content and plant N increased with increasing N supply, whereas higher NUE parameters namely NUE, agronomic NUE (AgNUE), N uptake efficiency (NUpE), harvest index (HI), and N harvest index (NHI) were observed at low N.

Identification of Indian potato varieties: SSR markers (STIKA and STU6SNRN) with potential roles in varietal identification, genetic fidelity testing, DUS and molecular characterizations were developed.

Genomic SSR markers in *Ocimum sanctum*: Genomic SSR markers for tulsi (*Ocimum sanctum*) were developed using genomic sequence database. Primer pairs were designed based on SSR motifs identified and screened for amplification. These markers showed 100% polymorphism in 23 genotypes.





6. Livestock Improvement

Cattle

Genetic aspects of Holstein-Sahiwal crossbreds:

The total population of Frieswal females as on 31st March 2019 at 13 Military Farms of the country was 8,199 including 451 elite Frieswal cows. During the period, 204 Frieswal bulls were maintained at bull rearing unit. The overall mean age at first calving was 970.65 days (31.92 months). The overall means of 300 days milk yield, total milk yield, peak yield (PY) and lactation length were 3,335.82, 3,346.17, 15.21 kg and 325.90 days, respectively. The least square means of service period (SP), dry period (DP) and calving interval (CI) were 159.95, 115.36 and 441.96 days, respectively.

Improvement through selection: The Indigenous Cattle Breed Improvement programme covers Gir, Kankrej and Sahiwal breeds. Nine each of Gir and Kankrej, and eight Sahiwal bulls of fourth set were inducted for progeny testing. During the period, 2,145, 2,466 and 836 inseminations were carried out with the conception percentages of 47.69, 45.01 and 40.78 in Gir, Kankrej and Sahiwal animals, respectively. During the year, 449 Gir, 423 Kankrej and 141 Sahiwal daughters were born. The average age at first calving in Gir, Kankrej and Sahiwal were 1,420.0, 1,238.42 and 1,326.94 days, respectively. The average first lactation 305 days or less milk yield, first lactation length and first peak yield in germplasm (GP) units were 2,344.4 kg, 504.2 days and 13.5 kg in Gir and 2,258.17 kg, 287.20 days and 10.49 kg in Kankrej cattle. In Sahiwal, the average first lactation 305-day milk yield, peak yield and lactation length were 1,651.62, 10.78 and 258.63 days, respectively. The first set of eight Sahiwal bulls were evaluated based on the first lactation 305-days milk yield of their daughters and the overall expected breeding value was 1,957.76± 51.14 kg with a range of 1,940.92 (-16.84 kg) to 1,989.75 kg (+31.98 kg).

Large scale progeny testing: The project envisages to progeny test Frieswal (HF×Sahiwal) bulls under field conditions at four different agro-climatic locations in India having larger concentration of HF crossbred cows. During the year, 5,376, 5,450, 5,799 and 5,074 inseminations were carried out in GADVASU, Ludhiana; KVASU, Thrissur; BAIF, Uruli-Kanchan; and GBPUAT, Pantnagar, with the conception percentages of 47.0, 45.8, 42.5 and 56.9, respectively, in the adopted field areas. The number of daughters which completed their first lactation during the reporting period in the areas covered at Ludhiana, Thrissur, Uruli-Kanchan and Pantnagar were 433, 139, 152 and 221, respectively. In all the four centres, the first lactation milk production showed an increasing trend of 42.2, 60.1, 6.1 and 31.1% over the

years; while the age at first calving recorded a decrease of 25.7, 13.1, 11.5 and 10.9%, respectively.

Buffalo

Progeny testing in Murrah breed is carried out at six participating institutional/ SVU centres, viz. CIRB, Hisar; NDRI, Karnal; IVRI, Izatnagar; GADVASU, Ludhiana; LUVAS, Hisar; and ICAR Research Complex for Eastern Region, Patna. About 14,000 artificial inseminations were carried out in the reported period at farmers' doorstep in the village to produce daughters. The milk yields of daughters are being recorded for use in sire evaluation.

Breedable buffaloes (1,067) are being maintained at institutional Murrah centres for production of high genetic merit male and female calves to be used for production of future sires. As per technical program for Murrah breed, a set of up to 15 pedigree bulls is selected and it is used for AI in the associated herds and field buffaloes (approximately 14,000 AIs per annum) for test mating over 18 months duration. The XVII set has 16 superior bulls (10 bulls from CIRB, Hisar; 4 bulls from GADVASU, Ludhiana and 2 bulls from NDRI, Karnal). So far, 234 superior bulls have been test mated in 17 sets and 15 bulls of XVIII set are under test mating.



Progeny testing in Murrah breed is carried out at participating institutions

Data of 581 daughters (born from the 13th set of bulls), which completed first lactation were compiled and bulls were evaluated. Bull no. 2234 and 2269 from GADVASU, Ludhiana ranked first and second with sire index value of 2,688 kg and 2,619 kg, respectively. The per cent superiority over their contemporary daughters was 14.80 and 13.86%, respectively.

Elite herds of Jaffarabadi, Surti, Bhadawari and Nili Ravi breeds of buffaloes were established in their respective breeding tracts. Semen freezing laboratories were also established at all the centres. During the reporting period, 260,659 semen doses were produced and 189,530 semen doses were sold/used and the closing balance was 777,709 semen doses of Murrah breed.





Balance stock of frozen semen of buffalo bulls other than Murrah breed is 213,094 doses.

Performance of participating Murrah herds: The herd strength of associated Murrah herds was 2,041, which includes 1,067 breedable buffaloes. During the period under report, 16 bulls of 17th set were used for test mating. The weighted average of 305 days lactation milk yield in Murrah buffalo revealed an overall 58.98% improvement since inception of the project in 1993. The weighted average for age at first calving and service period were 43.37 months and 140.02 days, respectively. The weighted wet average of Murrah buffalo was reported the highest (8.37 kg) since inception of the project and revealed an overall 57.83% improvement since 1992–93.

Goat

Jamunapari goats for better body growth: The average body weight of Jamunapari goats under intensive management at 12 months of age was 38.74 kg and the highest body weight observed was as 45.5 kg. The average daily weight gain (ADG) of the kids under intensive management was 113.38, 167.73 and 114.97 g/day, respectively, during 3–9, 6–9, and 6–12 months.

Requirement of breeding bucks: Multiplier flocks of Barbari goats were developed in Uttar Pradesh, Haryana, Rajasthan, Bihar, Uttarakhand for genetic improvement, conservation and promoting scientific goat farming among educated youths and farmers. Interventions were provided for development of livelihood models.



Multiplier flock at Patna, Bihar

Increasing protein percentage in goat milk: The effects of *CSN1S1* polymorphism on milk production and composition traits were analysed in different breeds. The total casein content of goat milk is positively correlated with these allelic variants of *CSN1S1* and was higher for A, B and C alleles. The goats homozygous for E or F allele produce milk with low protein, fat content, and cheese yield. The tropical goats are producing lesser milk as compared to temperate breeds, however, the milk casein locus carries higher frequency of A and B alleles. The effect of genotype was established with milk composition traits and milk yield in Jamunapari goat population. *CSN1S1* polymorphic pattern provides an opportunity to select and breed goats for producing milk with desired protein content.

Improving goat productivity in farmers' flock

Goat production is facing diverse challenges in different agro climatic conditions and it is necessary to carry out research and development activity to increase farmers' income for better livelihood. AICRP on Goat Improvement is operational at 461 villages covering 2,277 registered farmers. Under this 13 registered breeds and 4 local genotypes (lesser-known goats) were covered. The project has contributed significantly by producing breeding bucks for genetic improvement in their natural habitat. There is a significant increase in income of goat farmers and enhanced food security of all stakeholders. The performance recording was carried out in 62,784 animals during the year. The farm based units namely Jamunapari, Barbari and Sirohi are working as best model for *in situ* conservation in the natural home tract of the breed. Farm units have significantly produced and distributed improved animals to different agencies for breed improvement as well as up-gradation of local germplasm. The field units also distributed improved bucks, provided preventive health care to 169,497 animals, resulting in lower mortality rate ranging from 1.96 to 8.10%. This increased population growth and improved farmers' income by 32%. AICRP on Goat Improvement has bagged Breed Survivor Recognition for Malabari, Jamunapari and Surti goats.

Sheep

Network Project on Sheep Improvement: The aim of this project is genetic evaluation and continuous improvement of indigenous sheep breeds through selection for better growth and wool production. Presently, there are six ongoing cooperating centres with its coordinating unit at ICAR-CSWRI, Avikanagar. Four of these units are farm based units while two are field based units.

Marwari, Muzaffarnagri, Deccani and Nellore sheep are maintained under farm units for improvement through selection and production of superior germplasm. In Marwari sheep average age at first service, age at first lambing and weight at first service were 477 days, 666 days and 29.43 kg, respectively, corresponding values in Muzaffarnagri sheep were 503 days, 655 days and 38.4 kg, in Deccani sheep were 479 days, 627 days, 31.90 kg and in Nellore sheep were 489 days, 616 days and 28.04 kg, respectively.

Mega Sheep Seed Project (MSSP): The project has four cooperating units namely KVAFSU, Bidar for



Deccani flock





Performance of farm flocks

Breed	Av. body weights (kg)				Annual GFY (kg)	Tupping rate (%)	Annual lambing (%)	Overall survivability (%)
	Birth	3 M	6 M	12 M				
Marwari	3.22	17.24	25.26	33.54	1.201	97.87	87.26	97.81
Muzaffarnagri	3.54	16.25	24.93	37.26	1.195	96.00	88.20	96.74
Deccani	3.18	14.35	24.18	29.13	0.955	95.80	94.30	90.49
Nellore	3.29	15.07	22.75	24.56	NA	83.80	96.13	90.34

Performance of field flocks

Breed	Av. body weights (kg)				Lambing rate (%)	No of rams distributed
	Birth	3 M	6 M	12 M		
Madras Red	3.08	10.05	14.17	20.33	73.79	135
Magra	2.99	15.55	21.18	28.23	79.04	38

Performance of farm and field flocks of different breeds

Breed	Flock	Mean body weight (kg)				Lambing (available basis)	Annual GFY (g)
		Birth	3 M	6 M	12 M		
Mandya	Farm	2.21±0.01	11.12±0.05	15.54±0.07	22.04±0.12	97.45	593.53
	Field	2.15±0.005	10.42±0.01	15.12±0.04	21.40±0.10	90.71	—
Mecheri	Farm	2.68±0.02	11.25±0.11	16.49±0.32	25.19±0.61	77.03	—
	Field	2.48±0.02	11.2±0.07	14.25±0.11	21.98±0.19	88.04	—
Sonadi	Farm	3.19±0.04	15.01±0.28	18.96±0.41	26.50±1.94	75.12	748.90
	Field	2.62±0.008	9.67±0.05	14.21±0.09	24.75±0.39	56.78	—
Malpura	Farm	3.39±0.03	17.33±0.18	26.36±0.25	29.77±0.35	88.16	906.00
	Field	3.28±0.01	14.47±0.10	19.96±0.15	28.97±0.71	78.78	514.00

GFY, Greasy fleece yield



Mandya rams

Mandya Sheep; TANUVAS, Chennai for Mecheri Sheep; RAJUVAS, Bikaner for Sonadi Sheep; and ICAR-CSWRI, Avikanagar for Malpura sheep.

Poultry

Improvement of germplasm: Male lines, viz. PD-1 (Vanaraja male line) and PD-6 (Gramapriya male line); female lines, viz. PD-2 (Vanaraja female line) and PD-3 (Brown egg layer line) are maintained for use in developing rural chicken varieties. The analysis indicated that the selection is quite effective with significant genetic gains over the generations for trait under selection. In PD-6 (Gramapriya male line) population, the body weight and shank length at 6 weeks of age were 777.2 g and 85.3 mm, respectively, which were higher than that in

previous generation. The egg production and egg weight at 40 weeks of age were 72.3 eggs and 57.2 g, respectively. In PD-2 population (S-15 generation), the egg production and egg mass at 52 weeks of age were 133.2 eggs and 7,447 g, respectively, which were higher compared to the previous generation. In PD-3 line (S-7), the body weight and shank length at 6 weeks of age were 270 g and 53.6 mm, respectively. The egg production (75.6 eggs) and egg mass (4,157 g) at 40 weeks of age increased considerably from the last generation.

In PD-4 (Vanashree) population, the egg production was 192.5 eggs up to 71 weeks of age. The body weight at 8 weeks was 570.6 g, which showed an increment of 5.2 g over the previous generation. The egg production and egg weight at 40 weeks of age were 74.3 eggs and 48.8 g, respectively. In the Aseel population (G-5 generation), the body weight at 40 and 72 weeks of age was 1,944 and 2,540 g and 2,235 and 3,942 g in females and males, respectively. The egg production and egg weight at 72 weeks were 54.7 eggs and 53.1 g, respectively. In Ghagus breed, the egg production up to 40 weeks was 33.8 eggs, while the egg weight at 40 weeks was 46.9 g. The 8-week body weight in Ghagus increased by 7.1 g compared to previous generation. In Nicobari breed (G-5 generation), the egg production was 63.8 up to 40 weeks of age and the egg weight was 47.7 g. The body weight and shank length at 8 weeks were 401.7 g





and 60.27 mm, respectively. In Kadaknath (base generation), the body weight and shank length at 6 weeks were 259.2 g and 56.86 mm, respectively. The egg production and egg weight at 40 weeks were 65.1 eggs and 44.15 g, respectively. Evaluation of 2-way cross, revealed annual egg production of 185.3 and 140.6 eggs in farm and field conditions, respectively, and the corresponding 72 weeks body weights of hens were 2.7 and 2.2 kg respectively. Economic analysis indicated a net profit of ₹ 800–900 from a pair of birds of this cross.

Two-way chicken cross at farmer's doorstep: Multi-coloured synthetic broiler lines (PB-1, PB-2 and control) were maintained and evaluated. The body weight, shank length and FCR at 5 weeks were 841.6 g, 74.1 mm and 2.2, respectively, in PB-1 line. In broiler control population (G-16), the production traits were similar to those observed in previous generation. In PB-2 population (S-27 generation), the egg production and egg weight at 40 weeks were 65.0 and 59.4 g, respectively. The body weight at 5 weeks of age showed an improvement over the previous generation. The breeding value of the population indicated that the selection was effective for traits under selection. The body weight at 5 weeks was 801.6 and 640.5 g, respectively, in naked neck and dwarf populations. Layer lines (IWH, IWI, IWK, IWD, IWF and control) were maintained and evaluated. The egg production increased in all the selected lines over the previous generation.



Two-way chicken cross at farmer's doorstep

AICRP on poultry breeding: All the 12 centres are working on the development and propagation of location specific chicken varieties; conservation, improvement, characterization and application of local native, elite layer and broiler germplasm; and development of package of practices for village poultry along with development of entrepreneurship in rural, tribal and backyard areas. At Mannuthy centre, egg production up to 40 weeks was 79.2 eggs in native germplasm, recording an increase of 3.24 eggs over the previous generation. The egg production up to 64 weeks increased by 3 eggs in IWN and by 4.9 eggs in IWP lines. At Anand centre, egg production up to 40 weeks in native chicken was 66.4 eggs. The 3-way cross recorded 62 eggs up to 40 weeks under field conditions. At Bengaluru centre, 8-week body weight in native chicken was 464.9 g. The 3-way cross recorded a body weight of 1,255 g in males at 8 weeks. The genetic response of body weight at 5 weeks over the

past 12/13 generations was 30.4 g in PB-1 and 20.4 g in PB-2. At Ludhiana centre, the body weight of native germplasm was 765 g at 8 weeks, while the egg production in the PB-2 × Desi cross was 55.6 eggs in the field. Body weight at 5 weeks was 1,166 and 1,071 g in PB-1 and PB-2, respectively. At CARI centre, body weight of native chicken was 504.6 and 1,140 g at 6 and 12 weeks of age, respectively. Body weight of cross (CSML × Desi) was 1,368 g at 8 weeks. The genetic response for 5-week body weight was 15.1 and 15.0 g in CSML and CSFL, respectively. At Bhubaneswar centre, the body weight of native chicken (Hansli) was 587 g at 8 weeks and the egg production up to 40 weeks was 23.1. In the purelines, the body weight at 5 weeks was 1,025 and 1,129 g in CSFL and CSML lines, respectively, which were higher than in the previous generation. At Tripura centre, the body weight at 8 weeks was 306.5, 495, 1,102 and 512.9 g in Tripura black, Dahlem Red, color broiler dam line and BN cross, respectively. The BND cross chicks weighed 403 g at 8 weeks of age in the field. At Jabalpur centre, the 6 weeks body weight of Kadaknath and Jabalpur Color population (JBC) was 343.3 and 803.7 g, respectively, while the respective egg production up to 40 weeks was 57.3 and 91.9 eggs. The Naramadanidhi variety recorded annual egg production of 176 eggs under field conditions. At Guwahati centre, in Kamrupa variety, 5-week body weight and 52-week egg production were 210.6 g and 73.7 eggs, respectively, under field conditions. At Ranchi centre, the 20-week body weight and egg production up to 40 weeks were 989.2 and 1,218 g and 32.3 and 45.4 eggs in native and Dahlem Red population, respectively. At Palampur centre, the 8-week body weight and egg production up to 52 weeks in native and Dahlem Red were 530.3 and 617.1 g and 84.3 and 148.4 eggs, respectively. The Himsamridhi variety recorded annual egg production of 145.7 eggs under field conditions. At Udaipur centre, the 8-week body weight was 640.9 g and the 52-week egg production was 69.2 eggs in native (Mewari) population. The annual egg production in Pratapdhan variety was 166.1 eggs.

Under Poultry Seed Project, 12 centres located at West Bengal University of Animal and Fishery Sciences, Kolkata; Bihar Agricultural University, Patna; ICAR Research Complex for NEH Region, Nagaland Regional Centre, Jharnapani; ICAR-National Organic Farming Research Institute, Gangtok; ICAR Research Complex for NEH region, Manipur Regional Centre, Imphal; Tamil Nadu Veterinary and Animal Sciences University, Hosur; ICAR-Central Coastal Agricultural Research Institute, Panaji; ICAR-Central Island Agricultural Research Institute, Port Blair; Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar; PVNR Telangana Veterinary University, Warangal; Sri Venkateswara Veterinary University, Tirupati and ICAR Research Complex for NEH Region, Umiam, distributed 647,194 birds of improved chicken varieties to the farmers in their respective regions/states during the reported period.



Improvement in Aseel Peela native chicken: Selective breeding programme for Aseel Peela was completed for second generation. There was slight improvement in 20-week body weight (1517.57 ± 7.7 in first generation to 1660.41 ± 16.5 g in second generation), though ASM, 40-week and 52-week egg production and weight were almost similar.

Improvement in RIR chicken: The age at first egg was improved to 146 days in selected strain as against control (172.2 days) of RIR chicken. Body weights at 20th and 40th week have also improved to 1,521 g and

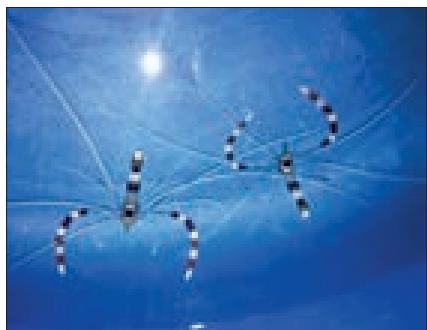
1,681 g, respectively, as against control (1,381 g and 1,614 g, respectively). Similarly, 28th and 40th week egg weight as well as 40 week egg production improved significantly in the new first generation as against 33rd generation selected earlier.

Fish

Breeding and rearing of ornamental shrimps and fishes: Marine ornamental shrimps, *Ancylocaris brevicarpalis*, *Gnathophyllum americanum* and *Stenopus hispidus* collected from the Lakshadweep Islands were



Stenopus hispidus



Gnathophyllum americanum



Dascyllus carneus



Ancylocaris brevicarpalis



Thor hainanensis



Lysmata amboinensis

Three-tier seabass farming

Three-tier seabass farming in mangrove region of Sindhudurg by self-help groups (SHGs) of Maharashtra was undertaken. Six nurseries, a pre-grow-out and 33 grow-out cages were installed. SHGs generated total revenue of ₹ 3.16 lakh through seabass nursery and pre grow-out rearing. Up to grow-out farming (400–500 g) generated a total revenue of ₹ 12 lakh.



Open water cages in brackishwater at Talashil village, Sindhudurg, Maharashtra





bred and larval rearing and juvenile production is in progress. Broodstock development is in progress for *Thor hainanensis* and *Lysmata amboinensis*, the ornamental shrimp species first time reported from Indian waters. Achieved successful breeding and larval rearing of marine ornamental fish, Cloudy Damsel (*Dascyllus carneus*) from wild-caught broodstock. Wild broodstock took four months to spawn and laid 6,500–10,500 eggs/spawning. Hatching rate ranged from 90.6 to 98.81%. Newly hatched larvae (1.95 ± 0.14 mm in total length) were reared using live feed, copepod *Parvocalanus crassirostris*. Yolk was completely absorbed in 72 h of hatching. Preflexion stage was from 4 to 10 dph (day post hatching), flexion stage from 11 to 12 dph and postflexion stage from 13–15 dph. Larvae settled from planktonic stage in 22–23 days and all the larvae metamorphosed into juveniles by 50 dph.

Coldwater ornamental fish species *Garra gotyla* and *Garra annandalei* were successfully bred. *G. gotyla* achieved 70–75% fertilization rate and 85–90% hatching rate. The complete embryonic development took 1,420 min and emerging sac fry were 3 mm in total length. In three months they attained total length of about 38 mm. *G. annandalei* was found to be single spawner having fecundity of around 610–700 eggs/fish (weight 14–16 g) with egg size of 1,150–1,186.91 μm . Fertilization rate was 60% and hatching rate 90%.

Captive breeding of catfishes: Two endemic, rare



F1 progeny of *Clarias dussumieri* matured in captivity

and threatened catfish species from Western Ghats, viz. *Hemibagrus punctatus* and *Clarias dussumieri* were captive bred with wild collected broodstock from River Cauvery. *Hemibagrus punctatus* had fecundity of about 3,000 eggs/female. Fertilization and hatching rates were 80%. In *Clarias dussumieri* F1 progeny were matured in captivity and bred again and F2 generation is being raised in captivity.

Restoration of fisheries diversity in River Ganga: ICAR-CIFRI in its continued effort to restore the



Restoration of fisheries diversity in river Ganga

fisheries diversity of River Ganga, has undertaken on a large-scale ranching of Indian major carp fingerlings produced by induced breeding of wild broodstocks collected from River Ganga. More than 20 lakh fingerlings were released in different stretches of River Ganga. Further, a hilsa ranching station was established at Farakka, West Bengal, and hilsa fish are being ranched in river Ganga above Farakka barrage for restoration and conservation.





7. Crop Management

Crop Production

Technologies for integrated farming system: Indian Agricultural Research Institute (IARI), New Delhi has developed crop and resource management technologies for different farming systems. A horticulture crop-based integrated farming system with a net income of ₹ 2.4 lakh per acre per year has been developed. Green Seeker and Nutrient Expert® (NE) as decision support systems for precision nitrogen application was developed which saves up to 26 kg nitrogen/ha, thus, reducing the cost of cultivation and adverse environmental impact.

Conservation agriculture system in pigeonpea: Conservation agriculture (CA)-based ICM module was developed in pigeonpea with 1.92 t/ha yield and profitability of ₹ 82,776/ha. CA based cotton-wheat system was developed which gave 44.1% higher system productivity than conventional tillage with a saving of 25–30% N and emerged as a superior alternative to rice-wheat system. Nitrogen-nanoclay polymer composites (NCPC) was developed and found most efficient in enhancing yield of maize. Rock-phosphate and waste mica treated with phosphate and potash solubilizing bacteria were found as alternate sources of P and K. In farm machineries, gladiolus corm harvester, low cost storage structure for rural areas, spinach-cum-coriander offset rotary cutter were developed.

Artificial intelligence in crop and resource management: Remote Sensing and GIS approaches have been used to develop methods for crop and resources management in IARI. Drone remote sensing method for field phenotyping was developed with multispectral sensor for monitoring nitrogen and drought stress in wheat. In a collaborative study with ISRO and NASA, ground based spectroradiometer and air borne AVIRIS – NG instrument were used to map eight horticultural crops in Sabour, Bhagalpur region of Bihar. Crop residue burning is a major problem in Punjab and Haryana. The method for real-time monitoring of crop residue burning by using thermal image acquired from seven satellites at the IARI satellite ground station was developed.

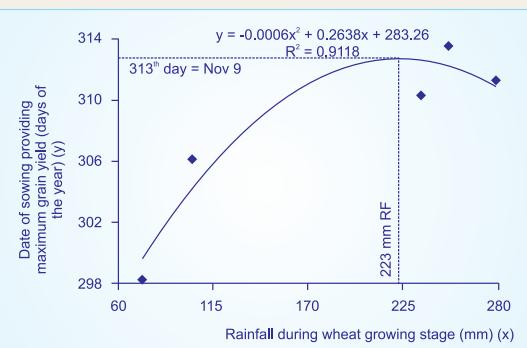
Precising row ratio and time of sowing of relay crop of pigeonpea in groundnut: Groundnut pod yield, haulm yield, pigeonpea grain yield and groundnut pod equivalent yield was found higher with 3:1 ratio in groundnut+pigeonpea relay cropping system in both Spanish and Virginia bunch varieties. Pod yield of groundnut was recorded higher when pigeonpea was relay sown at 30 and 50 days after sowing in Virginia bunch and Spanish varieties, respectively. Pigeonpea grain yield and groundnut pod equivalent yield was found significantly higher with relay sowing of pigeonpea at 30 days after sowing of groundnut in both type of varieties.

Conservation Agriculture in cropping systems: The impact of Conservation Agriculture in groundnut + pigeonpea and groundnut + cotton cropping systems in light black soils was studied. Groundnut pod and haulm yield was found highest with normal tillage, pigeonpea grain yield and stover yield was highest under conventional tillage while seed cotton yield and stalk yield was higher under minimum tillage. Groundnut pod equivalent yield was significantly higher with normal tillage, being at par with minimum tillage. Groundnut + pigeonpea cropping system was found to give significantly higher groundnut pod yield, haulm yield and groundnut pod equivalent yield over groundnut + cotton intercropping system.

Zinc-solubilizing microorganisms for mobilizing Zn in groundnut crop: Twenty-seven potential Zn solubilizing bacteria and six fungal isolates were evaluated *in vitro* for their capacity to solubilize insoluble zinc phosphate. The solubilization index (SI) among the bacterial isolates ranged from 0.07 to 2.28 and that of

Early sowing of irrigated wheat for the potential grain yield

Optimization of sowing date of irrigated wheat for changing climate was assessed by conducting five years' experiment with different sowing dates and four popular varieties in the mid-Himalayas. It is clearly proved that lesser the rainfall during crop growing stage, the earlier was the date of sowing to achieve maximum grain yield and vice versa in the mid-Himalayas. The highest grain yield with seasonal rainfall of 75 mm was recorded under 25 October sowing. The sowing on 25 October during the seasonal rainfall of 75 mm (5,669 kg/ha) provided 12% higher grain yield compared to recommended mid-November sowing. It was estimated that the rainfall of 223 mm during crop growing season was optimum for wheat. November 9 is the optimum sowing time for the optimum rainfall of 223 mm. Yield loss of 28 kg grain/ha/day for sowing during second fortnight of November is estimated in the northern hill zone.



Response of sowing date of irrigated wheat to amount of rainfall during crop growing stage in the mid-Himalayas

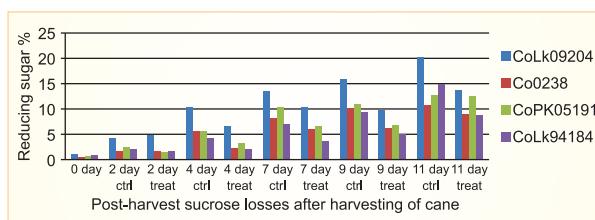


fungal isolates ranged from 0.01 to 0.72. In liquid medium using zinc phosphate as substrate, the solubilizing capability among the bacterial isolates ranged between 11.17 to 13.59 ppm and that of fungal isolates were up to 13.18 ppm. Identified bacterial zinc solubilizers are different species of the genus *Enterobacter*, *Pseudomonas*, *Acinetobacter* and *Microbacterium*.

CAM transition in groundnut for achieving drought tolerance: Crassulacean Acid Metabolism (CAM) transited groundnut genotypes have been identified which can be cultivated with 20–70% less water without any significant loss in yield. These are variants of a popular groundnut variety TG37A. Seven drought-tolerant CAM variants of a popular groundnut variety TG37A such as DGRMB 3, DGRMB 5, DGRMB 13, DGRMB 17, DGRMB 19, DGRMB 29 and DGRMB 31 were evaluated alongside TG37A with only two irrigations after emergence equivalent to 120 mm rainfall. While the pod yield reduction in TG37A was around 49%, it varied between 32–40% in the CAM variants. CAM variants such as DGRMB 19 (4,110 kg/ha), DGRMB 24 (4,040 kg/ha), DGRMB 32 (4,000 kg/ha) and DGRMB 5 (3,920 kg/ha) out-yielded pod yield of TG37A (3,177 kg/ha) under rainfed conditions (around 700 mm of rainfall during crop growth). Two of these CAM variants of TG37A (DGRMB 5 and DGRMB 19) also exhibited salinity tolerance.

The Integrated Farming Systems (IFS) model: The IFS models, viz. Agri (0.8 ha)- horti (0.2), Agri (0.8)-api (0.1) system, Agri (0.8)-mushroom farming (0.1), Agri (0.8)- horti (0.2)- api system, Agri (0.8)- horti (0.1)-mushroom farming (0.05), Agri (0.8)- api- mushroom farming (0.2) were developed. The highest net income was found under Agri (0.8)- horti (0.2)- api system with net income ₹ 5,62,943.

Post-harvest management of sucrose losses in sugarcane: Four promising sugarcane varieties, viz. CoLk 94184, CoLk 09204, CoPK 05191 and Co 0238 were established following normal agronomical practices, and post-harvest sucrose losses and their management using chemical formulation (0.1% SMS + 0.2% BKC) were carried out. Among these varieties, post-harvest deterioration (after 11 days of cane harvest) in terms of reducing sugars (RS) and sucrose % juice was observed maximum in CoLk 09204, an increase of RS from 0.94 to 20.33 and decrease of sucrose % juice from 17.59 to 12.19 in control and 0.94 to 13.67 in RS and 17.59 to 15.78 in sucrose % juice in SMS+BKC treated canes. The least increase in RS was observed in Co 0238 (0.44 to 10.80 in control and 0.44 to 9.10 in treated), whereas most responsive variety to formulation was CoLk 94184 where RS reduction from control to treated cane was from 14.86 to 8.82% (6.04%) after 11 days of post-harvest. Maximum reduction in sucrose % juice due to delayed crushing in comparison to fresh crushing in control condition was observed in CoLk 09204 (17.59 to 12.06 on seventh day) and minimum reduction was observed in CoLk 94184 (17.59 to 16.84 on eleventh day). Based on drop in sucrose % juice and purity due to delayed



Varietal scenario of post-harvest sucrose losses seen in terms of increase in the level of reducing sugar. Application of SMS + BKC formulation checked reducing sugar increase.

crushing, CoLk 94184 was found most tolerant to post-harvest deterioration followed by CoPK 05191 and then Co 0238 and finally CoLk 09204.

Dense planting: A climate resilient strategy for FCV tobacco: Flue-cured tobacco is grown as rainfed crop during *rabi* season in an area of approximately 30,000 ha in Alfisols of south coastal Andhra Pradesh comprising Prakasam and Nellore districts of Andhra Pradesh. Soils are poor in fertility and moisture retention. FCV tobacco crop is normally planted with the onset of North-East monsoon. In recent years, the monsoon are getting delayed because of which the crop is not getting enough time to exhibit its full potential and in turn resulting in low yields. In order to enhance the productivity plant population was increased under delayed monsoon condition.

Experiments were conducted with different plant populations and results found that increasing plant population by 100% (reducing the plant to plant spacing to half) increased the productivity to an extent of 410 kg/ha. On-farm testing of this technology was carried in farmers' fields and found 11–26% increase in yield under low productivity areas or in a situation when planting is delayed due to late onset of monsoon and realized an additional net returns of ₹ 10,200 to 27,000/ha.

Three tier cactus based agroforestry system at Bhuj

Cactus based three tier agroforestry systems with two trees (*Salvadora oleoides* and *Prosopis cineraria*), three cactus pear accessions (CAZRI Botanical garden, Clone 1308 and *Bianca macomer*) and two grass species (*Dichanthium annulatum* and *Sporobolus marginatus*) in 18 different combinations were tested. The combination of *Salvadora oleoides* + CAZRI Botanical garden + *Sporobolus marginatus* based silvi-pasture system produced maximum green and dry fodder yields of 10.0 and 3.04 t/ha, respectively.

Development of pomegranate based production system for transitional plain of luni basin in western Rajasthan: The recorded system production under one-ha pomegranate based production system for clusterbean, mungbean and okra was 259.9 kg, 275.2 kg and 736.8 kg, respectively during *kharif* season. Similarly, the yields recorded in mustard, fenugreek and cabbage was 221.3 kg, 235.5 kg and 4037.7 kg, respectively, during *rabi* season. The total mung bean equivalent yield was about 10 q from one-hectare area of the system, in which highest contribution was from okra (42%) followed by





mungbean (34%) and clusterbean (24%). The total mustard equivalent yield was about 14 q from one-ha area of the system, in which highest contribution was from cabbage (62%) followed by fenugreek (20%) and mustard (18%). In both the seasons, vegetable component (okra and cabbage) recorded highest yield. The EC and pH of the soil after harvest of *kharif* crop was 0.81 dS/m and 7.86 respectively. The EC and pH of irrigation water during *rabi* season was 3.62 dS/m and 7.00, respectively.

Performance of sugarcane grown with resource conservation technique: Sugarcane water requirement is very high (~ 3000 mm) and due to changing climatic scenario inadequate supply of water will result in reduction of yield. Subsurface drip irrigation (SSDI) technique offers many advantages over surface drip irrigation (SDI) such as reduced evaporation, efficient water use, greater water uniformity and thus reduces the water requirement of the crop. However, in case of sugarcane, SSDI is taken up in very less area and mostly advocated with paired row planting technique. Though, paired row planting technique saves the irrigation water and also number of drip laterals and their installation costs but also often have resulted lower cane yield production due to inter-row competition between the paired rows. Thus, standardization of planting geometry of paired rows and spacing of drip laterals for SDI and SSDI under paired row planting systems is needed. In addition to this, surface retention of crop residues in conjunction with micro irrigation techniques would be helpful in improving hydro-thermal regimes and soil health further. Keeping these things in mind, a field experiment was conducted with six main plot treatments. The amount of applied irrigation water was equal to 100 and 80% of the crop evapotranspiration (ETC) under surface and subsurface irrigation methods. The crop was irrigated at 2 days intervals under SDI and SSDI and at 80 mm CPE under surface irrigation method. The maximum cane yield (141.7 t/ha) was recorded under the ZPR-75-225 cm + SSDI treatment which was significantly higher by 5–14% as compared to remaining planting and micro irrigation techniques, except PSR-150 cm + SDI and ZPR-75-225 cm + SDI treatments. While covering of soil surface with live mulch of mungbean followed by retention of mungbean residue and trash in the field improved the cane yield on an average by 11% as compared to without residue retained treatment. This indicated that yield of paired row planted sugarcane could be improved significantly with adoption of zigzag planting, micro irrigation techniques and retaining the crop residues on soil surface.

HORTICULTURE

Fruits

Fertigation in banana: Fertigation of 75% N, P₂O₅, K₂O along with irrigation at 80% ER and polyethylene mulching (100 μ thickness) in combination with 2% micronutrient foliar spray of Banana Shakti/Arka Banana Special at 4th, 5th and 6th MAP and/or bunch spraying

with 2% SOP (1st at male bud removal and 2nd 30 days later) is recommended for enhancing the yield of banana cv. Grand Naine in West Bengal and Gujarat to the tune of 15% (Gujarat) to 51% (West Bengal) with a B:C ratio of 3.15 to 3.82 respectively. The treatment can also significantly advance the harvest by 25 days (Gujarat) to 41 days (West Bengal).

Improved training system for higher productivity in guava: A modified training system of guava on Espalier architecture comprising training on five-tier wires fixed at 50–60 cm vertical interval on the iron angles or cement poles planted at 1.5 m \times 3 m (row \times plant) accommodated 2,222 trees/ha. Orientation of 8–10 branches on four to five wire tiers for emergence of fruiting shoots was achieved, which altered the apical dominance and favoured better fruiting with 35 to 40 fruits weighing 7 to 8 kg/tree (after one year with 14.89 t/ha potential productivity) as compared to 3–4 kg/ tree in traditional system. The potential productivity in third year was 23–25 t/ha.



Bearing in one year old guava on Espalier training system

High density planting in citrus: High density (800 plants/ha at 5 m \times 2.5 m spacing) and ultra-high density (1,600 plants/ha at 2.5 m \times 2.5 m spacing) orchards of acid lime cv. Pramalini produced 12.87 t to 17.81 t/ha as against 6.62 t/ha in conventional planting (400 plants/ha at 5 m \times 5 m spacing). Similarly, Nagpur mandarin on Rangpur lime rootstock grown under high density (555 plants/ha at 6 m \times 3 m spacing) produced 19.46 t/ha as against 6.94 t/ha under conventional (277 plant/ha at 6 m \times 6 m spacing).

High density planting in cashew: Technology on high density (5 m \times 5 m) and ultra high (1,600 plants/ha)



Ultra-high density planting in cashew





density ($2.5\text{ m} \times 2.5\text{ m}$) planting with 12.12 and 24.32 q/ha nut yield at four years after planting, respectively, as compared to normal ($7.5\text{ m} \times 7.5\text{ m}$) planting density (7.23 q/ha) in Hybrid-130 has been standardized and field demonstrated.

Root-stock for new grape varieties: Dogridge was identified as the best root-stock for Fantasy Seedless variety with higher berry diameter (18.34 mm) and yield (10.5 kg/vine). Similarly, Dogridge was identified to be best rootstock for Red Globe variety too with higher berry diameter (22.9 mm), bunch weight (580 g) and yield (18.40 kg/vine).

Plastic cover and anti-hail nets: Thompson Seedless grapes grown under plastic cover showed better yield (18.42 t/ha) as compared to anti-hail net (16.8 t/ha) and open conditions (13.09 t/ha). Bunches produced under plastic and anti-hail net had PLW below 5% even on 10th day as compared to 5% physiological loss of weight (PLW) at 7 days in bunches produced under open conditions.

High density planting: Technology of high density planting ($8\text{ m} \times 4\text{ m}$) under hedge row planting with higher fruit yield (20.11 t/ha) in 10 year old litchi cv. Shahi was standardized.

Minimizing fruit decay during storage: Pre-harvest prophylactic spray (2 days before anticipated harvest) of salicylic acid (2 mM) significantly reduced browning and fruit decay during post-harvest storage of litchi under refrigerated conditions ($5\text{--}8^\circ\text{C}$ and $80\pm 5\%$ RH) up to 18 days.

Protected cultivation: Papaya crop grown under net house recorded higher yield and quality attributes at Anantharajupet, Coimbatore and Gandevi for number of fruits (63.63, 77.20 and 46.38 respectively), fruit weight, marketable fruits, total yield (151.03, 236.71 and 77.79 t/ha respectively), TSS (12.13, 12.90 and 14.64 °B respectively) as compared to crop grown in open condition. Net house significantly protected the plants from PRSV incidence in the three test locations.

Pomegranate special micronutrient formulation: Three new amino acid based micronutrient formulations were developed for nutrient management at different stages of fruit development in pomegranate. The foliar application of amino acid based formulation I and II resulted in 41.23% increase in fruit yield, with highest (46.57%) exportable grade fruits as against 9.75 kg/tree in control.

Integrated nutrient management: An integrated nutrient management package (50 kg FYM + 100% NPK + 200 g each of *Azotobacter* and PSB) for commercial cultivation of bael under eastern UP conditions with 127.93 kg/tree fruit yield, was standardized.

Multiplication rate in apple clonal rootstocks: A technology for enhanced multiplication rate in apple clonal rootstocks was standardized; with this method, 5–8 graftable size (4.5–5.5 mm thick at grafting height), rooted plants with well developed root system could be obtained from the first year in stool beds in polyhouse.

Pruning in custard apple: Pruning schedule for

custard apple cv. Balanagar with removal of 75% of previous seasons growth at 90 days after final harvest of fruit was standardized (fruit yield 9.76 kg/tree or 3.9 t/ha) for semi-arid and arid conditions.

Tender coconut harvesting: Continuous harvesting of tender nut throughout the year recorded significantly higher yield (187/palm) as compared to harvesting mature nuts (97/palm) with better return (₹ 2,64,768) to farmers.

Coconut husk composting technology: A two-stage composting strategy involving initial aerobic composting using earthworm gut microbiota with organic amendments followed by coconut leaf vermin-composting earthworms effectively recycled the recalcitrant wastes to useful manure rich in organic carbon and plant-beneficial microbiota. The simple composting technology can help in producing quality organic manure for improving soil and plant health with reduced chances for mosquito multiplication which is a severe health hazard in urban and rural environment.

Oil palm site suitability evaluator software: A decision support system with software for evaluating site suitability to cultivate oil palm under irrigated or rainfed conditions was developed and test validated.

Pollen storage of date palm: In date palm cv. Halawy, 70% fruits set through pollination with pollen stored under refrigerated conditions ($4\text{--}5^\circ\text{C}$) was achieved as compared to 53% under pollen stored at room temperature and 89% fruits set with fresh pollen.

Vegetable

Root-stock in tomato: Inter-species grafting was successfully exploited in production of tomato on brinjal root-stock (IC-354557) with 6.13 kg/plant yield in cv. Kashi Aman and 5.6 kg/plant in cv. Kashi Chayan.



Cultivating long melon in low tunnel in arid zones: The technology for cultivation of long melon under low tunnel with polythene covering for early and off-season production was standardized with sowing on 20th December.

Enhancing fruit set in polyhouse grown cucurbits: Introduction of Indian honey bee (*Apis cerana*) through hives with two side openings helped in orienting honey bees towards cucurbit flowers in poly-house and assisted pollination resulted in 88.5% fruit set compared to zero fruit set in bagged flowers.

Seed germination of moringa: The method of seed germination for shahjan (*Moringa oleifera*) var. Thar





Harsha was standardized. Seeds without wing kept in between paper (rolled towel method-BP) produced healthy and vigorous seedling with maximum germination (66%) as against seed with wing-BP (48%), seed with wing-TP (42%) or seed without wing-TP (22%) with poor seedling growth.

Potato

A site specific decision support system NRPPP (Nutrient Recommendation for Potato Production in Punjab) was developed as per the output derived from QUEFTS Model. A document on GAP for production of potato in India was developed for the benefit of different stakeholders. It includes control points and their compliances for GAP certification developed by Quality Council of India (QCI).

Spices

Drip fertigation in black pepper: Drip irrigation in black pepper (8 l water/day) in combination of 50% RDF (recommended dose of fertilizer as 19:19:19-NPK liquid mixture) in 3-equal splits at weekly interval during June, September and February gave highest benefit cost ratio (2.07) and ₹ 187,500/ha, which is equal to ₹ 150/vine/year as compared to the conventional method of irrigation and basal application of fertilizers.

Fertigation in cardamom: Highest gross (₹ 252,928) and net returns (₹ 177,928) were recorded with drip irrigation (9 l/clump/day) in combination of 100% RDF through drip with B:C ratio 3.37.

Drip fertigation in coriander: The drip fertigation in coriander at 0.8 IW/CPE ratio recorded significantly higher plant height (112.17 cm), umbels/plant (28.22), umbellets/umbel (5.68), seeds/umbel (46.50), test weight (12.84 g), 45% increased seed yield (20.86 q/ha), net returns (₹ 135,946/ha) and B:C ratio (3.62) with 18.7% water saving as compared to conventional practice.

Drip fertigation in fennel: A package of practices comprising drip irrigation (0.8 IW/CPE ratio) at 2 to 3 days interval coupled with fertigation (75% RDF through soluble fertilizers at 20, 40, 60, 80 and 100 days after sowing) in fennel for light textured soils was standardized. It recorded significantly higher plant height, umbels/plant (29.22), seed yield (24.78 q/ha), net returns (₹ 163,176/ha) and B:C ratio (3.73) along with 18.9% saving of water.

Organic farming: An organic cultivation package comprising monthly application of Jeevamrutha (20 l/clump) +*Azospirillum* (10 g/clump) + phosphorus solubilizing bacteria (10 g/clump) + *Trichoderma viride* (10 g/clump) which improved the yield of cardamom (479.66 kg/ha), net return (₹ 385,117/ha) and BC ratio of 2.15, was standardized and recommended for cultivation of cardamom in Reserve Hill regions of Kerala.

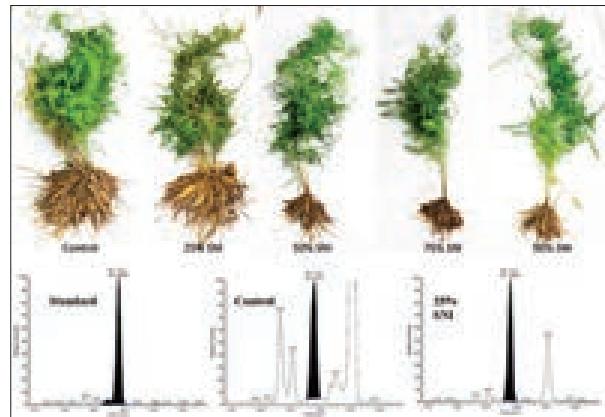
Bio-fertilizers: A package of practices comprising soil application of phosphate solubilizing bacteria (PSB @15 kg/ha) or *Azospirillum* (15 kg/ha) along with NPK (60:40:30 kg/ha) was standardized. It was recommended for improving the productivity of coriander with

enhanced yield (47.6%), BC ratio (2.2) and net profit (₹ 98,750/ha).

Climate analogue sites for cardamom: Based on relative yield and spread index, 236 taluks in 104 districts for small cardamom and 234 taluks in 112 districts for large cardamom were identified as climate analogues sites using CCAFS climate analogues tool considering the future climate (2050) under changing climate scenario.

Medicinal and aromatic plants

Shade-net intensity for satavari: Shatavari could be cultivated as an intercrop (25% shade net intensity) for fetching higher shatavarin IV content without causing significant root yield loss at 12-month harvest after transplanting at 45 cm × 45 cm spacing as compared to 6- and 18-month harvest.



Performance of herbage and root yield and LC-MS/MS chromatograms of *Asperagus racemosus* under different shade-net intensities.

Mushrooms

Culture technique of mushroom *Lentinus strigosus* with 24% biological efficiency in 2 flushes was standardized.



Cultivation of *Lentinus strigosus*

CROP PROTECTION

Biological control for biotic and abiotic stress management: Bio-prospecting rhizospheric and endophytic cyanobacterial diversity led to identification of 25 strains belonging to *Plectonema* sp., *Phormidium* sp., *Nostoc* sp. and *Anabaena* sp. Inoculation with osmotolerant bacteria (*Bacillus casamancensis* MKS6 and





Bacillus sp. MRD17) were found to boost drought tolerance of mustard crop at IARI. Novel methods for diagnostics and integrated pest management were developed.

Protocol for detection of diseases and nematodes: A rapid loop mediated isothermal amplification based protocol was developed for detection of Karnal bunt pathogen in wheat and bakane pathogen of rice. Synthetic compounds active against *Sclerotium rolfsii*, *Alternaria solani* and root knot nematode (*M. incognita*) were identified. A nano emulsion with significant antifungal activity effective against both *R. solani* and *S. rolfsii* was identified. In addition, five potent antifungal halogen substituted benzylidene aryl amines were identified and synthesized for their formulation development. In nematodes, RNAi silencing was used to discover the roles of *ama-1* and *mad-2* genes of *M. incognita* on infection, development and reproduction of the nematode in tomato. Tomato leaf curl New Delhi virus-derived AC4 protein was found to suppress host RNA silencing mechanism and auxin biosynthesis.

Use of nanoparticles for disease resistance and quality enhancement: Combination of copper and silver nanoparticles were shown to have better impact against the bacterial blight of rice after two applications than using individual copper or silver nanoparticles. Results on *Xanthomonas oryzae* pv. *oryzae* using ZnO nanoparticles suggested the possibility of enhancing Zn content in seed.

Identification of germplasm lines resistant to rice blast: Molecular screening of 62 putative rice blast resistant rice germplasm lines, showed three lines, viz. IIABR-265, SD-80 and SD-82 possessing 11 blast resistance genes, 14 lines such as IIBR-374, IIABR-418, IIABR-139, IIABR-422, SD-103, IIABR-286, IIABR-312, IIABR-262, SK-1, JD-35, JD-82, IIABR-397, IIABR-277 and JD-57 possessing 10 blast resistance genes.

Virulence analysis of *Magnaporthe oryzae* isolates from Uttarakhand: Virulence analysis of 16 *M. oryzae* isolates using 26 rice blast monogenic lines carrying blast *R*-genes, viz. *Pia*, *Pib*, *Pii*, *Pik*, *Pik-h*, *Pik-m*, *Pik-p*, *Pik-s*, *Pish*, *Pit*, *Pita*, *Pita-CP1*, *Pita2-PI*, *Pita2-Re*, *Piz*, *Piz-t*, *Pi1*, *Piz-5*, *Pi3*, *Pi5(t)*, *Pi7(t)*, *Pi9*, *Pil2(t)*, *Pi11(t)*, *Pi19*, and *Pi20* in the genetic background of a japonica rice variety Lijiangxintuanheigu (LTH) along with a susceptible check LTH and a resistant check VL 8657 was carried out. The virulence ranged from 23 to 92% and the least virulent isolate was Mo-nhz-09 collected from Raulsera, Almora, Uttarakhand and highly virulent isolate was Mo-nhz-04 collected from Mukteshwar, Nainital. Among the *R*-genes tested, *Piz5*, *Pita2*, *Pi9* and *Pizt* showed high degree of resistance and *Pikp*, *Pish*, *Pikm* and *Pi19* showed low degree of resistance. A total of 16 races were classified and the predominant race was U42-i7-k177-z17-ta513 which showed compatibility with maximum *R*-genes. These findings will be helpful in deploying identified *R*-genes for effective management of blast disease.

Management module for soil borne diseases of groundnut: Maximum 32% inhibition of stem rot disease and 43% higher pod yield and 36% higher fodder yield was achieved by the module for soil borne diseases of groundnut -M 17A, i.e. Deep summer ploughing with mould board plough + seed of variety GG 20 + seed treatment with tebuconazole @ 1.5 g/ kg of seed + soil application of *Trichoderma harzianum* S1 @ 4 kg/ha enriched in FYM first at the time of sowing, second at 35 days after sowing (DAS) and third at 80 DAS.

Efficacy of sweet flag rhizome in managing bruchid beetles: Sweet flag (*Acorus calamus*) rhizome powder has been found effective in managing bruchid beetle (*Caryedon serratus*), a serious storage pest of groundnut. The powder at one, two, five, ten, fifteen and 20% concentration was tested for its efficacy in managing bruchid beetle along with untreated control. Observations were taken on egg laying and pod damage. Pods treated with 20% sweet flag rhizome powder recorded lowest number of eggs. Sweet flag rhizome powder of 10% and above concentration was found significantly superior and recorded 18% pod damage as compared to 64.2% damage in untreated control.

Toxicity of nanosilica on hairy caterpillar: Six different concentrations of nanosilica, viz. 10 ppm, 1 ppm, 0.1 ppm, 0.01 ppm, 10^{-3} ppm and 10^{-4} ppm were prepared. Uniform third instar larvae of hairy caterpillar (HC) (*Spilosoma obliqua*) were used for determining the toxicity of nano silica on them. Ten larvae were exposed on fresh jute leaves as feed in petriplates that were sprayed with different concentrations of nano silica @ 5 ml/plate by an atomizer. After 24 h, fresh leaves were provided for feeding. After 48 h of spray the weight of nanosilica treated larvae of HC showed considerable reduction as compared to the untreated larvae. The highest body weight reduction of 64.41% was noticed in case of nanosilica spray @ 10 ppm followed by 1 ppm (62.93%) and 0.1 ppm (37.31%). The lowest body weight reduction (4.55%) was recorded in case of 10^{-4} ppm nanosilica. After 72 h of spray, the highest mortality of 75% was recorded in case of 10 ppm followed by 73.33% in case of 1 ppm. Even in case of 10^{-4} ppm nanosilica spray application there was 16.67% mortality.

The LC₅₀ of nanosilica was as low as 0.0000097% of a.i. It was lower than most of the commonly used insecticides such as indoxacarb, cypermethrin, emamectin benzoate etc.

Widespread practice of IPM: Horizontal spread of IPM in Basmati rice in 488 ha by participation of 450 farmers in six villages in Gautam Budh Nagar, Uttar Pradesh resulted in reduction of chemical pesticide application from a.i. 791.2 g/ha in farmers' practices (FP) to a.i. 60.1 g/ha in IPM, and enhanced paddy yield and B/C ratio by 19.7% and 47.7% respectively over FP. Validation of IPM in basmati rice (Pusa 1509) at Uttarakhand in 16 ha resulted in 25% reduction in chemical pesticide application, and 35.8% and 40.6% increase in paddy yield and B/C ratio, respectively, over FP. IPM interventions resulted in significant reduction





Unravelled soil microbiome of Valley of Flowers, Uttarakhand

The Valley of Flowers National Park – a UNESCO national heritage site is situated in representing a virgin and pristine habitat for more than 500 flowering species grow year after year without addition of any fertilizer. The study revealed a high population density of $\sim 2.0 \times 10^9$ cfu/g which mainly comprised active microflora as is evident from high activity of soil enzymes like alkaline phosphatase, FDA hydrolase, β -glucosidase, aryl sulfatase etc. Using different media, 72 bacterial morphotypes were retrieved while no fungi could be isolated. The cultivable bacterial diversity was also active for production of hydrolytic enzymes like cellulase (21%), amylase (34%), β -glucosidase (35%), laccase (25%) etc. The cultivable microflora was also endowed with plant growth promoting traits like production of ammonia (68%) and siderophore (41%), solubilization of Zn (25%) and K (11%). Whole metagenome sequencing revealed that the soil microbiome of Valley of Flowers was dominated by bacteria (~99%) while populations of eukaryotes (0.6%) and archaea (0.2%) were very low. Taxonomic analyses revealed that *Bradyrhizobium* (8%), *Pseudomonas* (4%), *Streptomyces* (3%), *Mycobacterium* (3%), *Pseudonocardia* (1%), *Frankia* (1%), *Solirubrobacter* (1%) were among the most predominant genera. High abundance of the members of order Rhizobiales (15%) indicated that symbiotic nitrogen fixation must be a major means of available nitrogen. Functional analyses of soil microbiome showed abundance of genes encoding diverse carbohydrate degrading and binding modules indicating them as key player in carbon cycle. The microbiome was rich in genes coding for phosphatases indicating the predominant role of P mineralizers in phosphorus cycle. Genes encoding nitrogen, potassium and sulfur metabolism were also abundant in the soil.

in BPH incidence and chemical pesticide use in DSR in Koppel district, Karnataka. None of the rice pests crossed ETL and based on this, 826 advisories and 68,670 SMS were sent under ICT based project in Tripura.

Large scale integrated pest management validation conducted in 10 ha in Perambalur (Tamil Nadu) resulted in higher yield of 1,650 kg/ha and 2.87 CBR in IPM as against yield of 902 kg/ha and CBR of 1.62, respectively, in farmers' practice. IPM implementation in cotton in whitefly hot spot of Fazilka, Punjab resulted in significant reduction in chemical pesticides from nine sprays (5.625 kg a.i./ha) in FP to 3 sprays in IPM (0.537 kg a.i./ha) with higher yield. IPM validation also resulted in conservation of natural enemies.

IPM technology validated in bulb onion in Pune district, Maharashtra resulted in reduced chemical pesticide sprays to 3 from 10 in FP, and higher CBR of 1:2.1 in IPM from 1:1.71 in FP. Low but clean and better quality onion of 300 q/ha was recorded in the organic trial. Adoption of IPM technology in cucumber crop resulted in reduced pesticide usage to five sprays from nine sprays in farmers' practices in Karnal, Haryana. FP fields recorded only 29.6 t/ha compared to 32.1 t/ha in IPM fields.

High arsenic tolerant bacteria from arsenic polluted soils of Ballia: Arsenic polluted regions of Ballia district in Eastern UP were found to contain arsenic at the concentration of 400 mg/kg of soil. Bacterial diversity from soil were cultured and 25 distinct bacterial isolates obtained were characterized for tolerance to different concentrations of arsenate and arsenite (source sodium arsenate and sodium (Meta) arsenite, respectively) through minimum inhibitory concentration (MIC) test.

Five very potential isolates, viz. PH-N4, PH-N5, PH-N6, PH-N7 and PH-N9 exhibited very high degree of tolerance up to 40,000 ppm against sodium arsenate, whereas EK1-N4 could withstand 2,000 ppm of sodium (meta) arsenite on NA plates.

Fruits

Banana: Spraying with *Beauveria bassiana* (1×10^7 spores/ml) at 5th, 6th and 7th month after planting controlled banana stem weevil (*Odoiporus longicollis*). The identity of the banana fruit scarring beetle was conclusively established as *Basilepta subcostata* for phytosanitary purposes while the presence of *Basilepta viridipennis* as a pest of banana from India could not be established. Serious infestation of the invasive Jack Beardsley mealy bug was observed on the fruits of many banana cultivars and effective natural enemies of the mealy bug were identified. Two species of thrips, *Pseudodendrothrips mori* and *Anascirtothrips arorai*, were observed as banana feeders for the first time.



a-c, Colour forms of banana scarring beetle; d-e, *Asprothrips navsariensis*, a new pest of banana foliage in South India.

Guava: For the control of guava tea mosquito bug, *Beauveria bassiana* (IIHR formulation) in talc formulation (10 g/l) or wettable formulation (1 g/l) effectively reduced the fruit damage percentage (15%) with a benefit cost ratio of 2.35 compared to the standard check (Lamda cyhalothrin-0.05%) recording 25.60% of fruit damage at Tinsukia.

Litchi: An integrated mite management package in litchi comprising two sprays of chlorfenapyr 10 EC (0.03%) or Spiromesifen 22.9 SC (0.034%) at 15 days interval during July and pruning of affected twigs (in October) was standardized. For successfully managing



the litchi nut borers with higher yield, two sprays of flubendiamide 39.35 SC @ 0.2 ml/l or spinosad 45 SC @ 0.32 ml/l or novaluron 10 EC @ 1.5 ml/l water at an interval of 7 days starting from the colour break stage of the fruit were recommended.

Plantation crops

Coconut: Bio-suppression of rugose spiralling whitefly (RSW) by conservation biological control using *Encarsia guadeloupae*, *in situ* preservation of sooty mould scavenger beetle *Leiochrinus nilgirianus* and adoption of palm health management strategies (nutrition and water) were developed. More than 50% of the hard scales were found parasitized by the aphelinid parasitoid, *Aphytis* sp. and the population of the parasitoid was considerably higher in the coconut scale insect inflicted garden. Besides, *Chilocorus nigritus*, *Sasajiscymnus* sp., and *Pharoscymnus horni* and their grubs were recorded feeding voraciously on scales at Kayamkulam, Alappuzha, Kerala.

A simple nylon net covering in the entry points of the pest, viz. spear leaf base and adjoining axils proved effective in reducing the rhinoceros beetle damage to seedling of coconut. Leaf damage was reduced from 62.18 to 25.49%. The use of nylon netting could thus become an important component of integrated management of rhinoceros beetle in plantation crops.

Oil palm: Application of *Isaria fumosorosea* fungus strain was effective in managing rugose spiralling whitefly (RSW) *Aleurodicus rugioperculatus* when applied at a spore concentration of 130×10^4 . Liquid culture preparation of *Isaria* fungus was standardized using PDB and starch. The protocols for mass multiplication and mother culture multiplication were standardized using starch and jaggery.

Vegetables

Pumpkin: An integrated pest management module for pumpkin (cv. Kashi Harit) comprising spraying of DDVP 76% EC @ 0.75 ml/litre at 20 and 30 days after sowing (DAS), *Bacillus thuringiensis* var. Kurstaki @ 2 g/litre at 40 DAS, imidacloprid 17.8 SL @ 1 ml/3 litre at 50 DAS, *Lecanicillium lecanii* @ 5 g/litre at 60 DAS and Azadirachtin 300 ppm @ 5 ml/litre at 70 DAS was standardized. It was most effective in reducing the red pumpkin beetle, white fly; and mirid bug population on leaves with significant increase in the yield (320 q/ha) over chemical (307 q/ha) or untreated control (195 q/ha).

Bio-pesticides: Thar Jaivik 41 EC is an organic bio-pesticide developed from local wild plants and cow product. It is effective against *Helicoverpa armigera*, *Spodoptera litura*, white fly and aphid with safe to natural enemies.

Bio-management of nematode induced disease complex: In chillies cv. Arka Meghana, seed treatment with talc formulations of bacterial bio-agent, *Bacillus pumilus* 1% WP at 20 g/kg seed, substrate treatment at 10 g/kg coco-peat and soil application of 5 t/ha FYM

enriched with bio-agents recorded significantly 27.3% higher yield and 72.2 to 74.1% lower nematode population in soil and roots with low gall index (1.8).

Spices

Cumin: An eco-friendly, integrated nematode (root-lesion nematode; *Pratylenchus thornei*) management technology in cumin comprising soil application (5 kg/ha) of bio agents was standardized. It resulted in 81.5% reduced plant mortality of cumin. The chemical management technique comprising soil sterilization by application of dazomet (@ 30 g/m²) and metham sodium (60 ml/m²) resulted in 98% reduction of plant mortality in cumin.

Transcriptomics of *Radopholus similis*: The transcriptome of burrowing nematode (*Radopholus similis*), a serious pest of tropical plants, was sequenced. A total of 62,312 unigenes (73.09%), ranging from 201–10,747 bp with a mean contig size of 1046 bp were obtained. The assembled contigs were functionally annotated and protein domains were predicted. Out of these, 1116 Excretory/Secretory (ES) proteins were predicted and functionally annotated. Potential targets for gene silencing were identified, cloned and sequenced.

Diseases and their management

Fusarium wilt (Panama disease) disease: In June 2017, there was a severe loss to banana due to *Fusarium* wilt at Sohawal block of Ayodhya, Eastern Uttar Pradesh. The pathogen for the disease was identified to be *Fusarium oxysporum* f. sp. *cubense* Tropical Race 4 (Foc TR-4). Subsequent transect survey confirmed the presence of *Fusarium oxysporum* f. sp. *cubense* Tropical Race 4 (Foc TR-4) in Katihar and Muzaffarpur districts of Bihar. Molecular characterization of the Foc isolates from 7 locations confirmed the presence of TR-4 pathogen. VCG testing established that the fungal isolates obtained from isolated samples were compatible with VCG 01213/16 confirming the presence of TR-4 in India.

Field evaluation of the formulation at 40 sick fields

Integrated disease management

A modified integrated disease management (IDM) schedule was tested in a bacterial blight affected pomegranate orchard with 40% incidence. The modified IDM schedule, gave 100% blight free yield of 11.45 kg/plant. The incidence of fungal spots/rots was below 2%.



Plot with modified schedule in flowering (front) in comparison to plot without modified components (rear)





of adopters and non-adopters from Bihar and Uttar Pradesh indicated that the bio-formulation ICAR-FUSICONT was effective in controlling the disease to about 93.92%. This suggested the commercial potential of formulation in management of the disease.

An extensive survey conducted during 2019 in Uttar Pradesh, Madhya Pradesh, Maharashtra, Gujarat and West Bengal and laboratory studies confirmed the presence of *Fusarium* wilt Tropical Race-4 (Foc-TR4), a lethal strain has been identified in Katihar and Purnia districts of Bihar in Cavendish group of banana and the incidence 2–45% in cv. Grand Naine up to 23%. Samples of infected banana cv. Grand Naine from Surat (Gujarat) and Burhanpur (Madhya Pradesh) also confirmed the presence of *Fusarium* wilt caused due to *Fusarium oxysporum* f.sp. *cubense* Tropical Race-4.

Ready-to-use kit for detection of viruses in banana: For on-site field detection, LFIA dipstick kit was developed for banana bract mosaic (BBrMV) and cucumber mosaic virus (CMV). It gives results within 5–10 minutes in the field itself. The kit contains 5 or 10 immunostrips and costs ₹50/kit. In addition, a qualitative, recombinant antiserum based ready-to-use indirect ELISA kit for both the viruses was also developed. This kit is highly sensitive and very specific in detection and the results are available within 6–7 h. The kit can test 90 samples.

Diagnostics in citrus fruits: An iodine solution-based starch test with simple, less expensive and rapid method for on-the-spot diagnosis of citrus greening disease was standardized with 78% accuracy when compared with PCR test.

Anthracnose management in mango: Three sprays of hexaconazole (0.1%) followed by hot water treatment (52°C for 10 min) were most effective in controlling post-harvest anthracnose of mango (PDI of 7.43% as against 46% in control).

Emerging disease of cocoa: A disease symptom similar to die-back was observed in cocoa plantations in West Godavari, Andhra Pradesh and also in Kasaragod, Kerala. Molecular identification using ITS region, actin and beta-tuberculin loci confirmed it as *Lasiodiplodia theobromae*. Pathogenicity tests confirmed the disease causing ability of the fungus against cocoa.

Plantation crops

Alternative for Bordeaux mixture: Mandipropamid, a semi-systemic fungicide of carboxylic acid amide group was equally effective in comparison with Bordeaux mixture (1%) for management of fruit rot of arecanut.

Spices

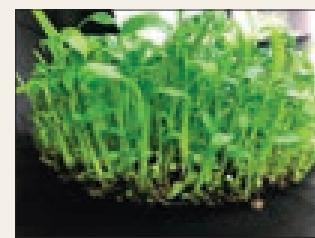
Managing foot rot and slow decline diseases: Application of a consortium of two endophytic bacteria, *Pseudomonas putida* BP25 and *Bacillus megaterium* Bp17 along with 1% Bordeaux mixture spray successfully protected black pepper vines against *Phytophthora* foot rot and slow decline diseases consecutively for the third year at farmers' plots in Kozhikode district of Kerala.

Somatic embryo regeneration vessel for next generation tissue culture



Somatic Embryo Regeneration Vessel (SERV)

A vessel with capacity for higher throughput of banana plantlets from somatic embryo regeneration vessel (SERV) in 90 days at 75% reduced cost of production was developed. This has potential for facilitating saving of space and capital investment on infrastructure for establishing banana tissue culture lab/facilities. Patent has been filed for '**Somatic embryo regeneration vessel**'—Application Number-201841005897.



Production of 500–700 plantlets per vessel in 90 days

Ginger: Based on sRNA sequencing and subsequent verification of the same through RT-PCR, cloning and sequencing, the association of two distinct viruses with chlorotic fleck disease affecting ginger was established. Of these two, one belongs to the genus, *Ampelovirus* (Family Closteroviridae) and the other to a non-descript, new genus of the Family Tombusviridae.

Ornamentals

Bio-management of nematode: In gerbera (cv. Arka Ashwa), soil application of FYM enriched with bio-control bacteria, *Bacillus amyloliquefaciens* at 5 t/ha before planting and further soil drenching of neem cake enriched with bio-agents at 2 l/m² at three-month intervals reduced *Meloidogyne incognita* population in soil by 66.26% with increased spike yield of 26.26%.

Food safety

Grapes: The pesticide degrading ability of *Bacillus subtilis* DR-39 was successfully demonstrated. Two sprays of DR 39 at berry ripening after five spray application of fungicide difenoconazole 25EC (0.50 ml/l) could degrade fungicide residue below quantification limit.

Seed spices: Pre-harvest intervals (PHI) for application of difenoconazole (19 to 22 days), hexaconazole (21 to 23 days), propiconazole (23 to 27 days), thiamethoxam (24 to 27 days) and acetamiprid (10 to 12 days) in cumin, coriander and fenugreek were standardized.

Detection of *Phytophthora capsici* and *P. tropicalis*: *Phytophthora*, viz. *P. capsici* and *P. tropicalis*, are associated with foot rot disease in black pepper. A recombinase polymerase amplification (RPA) assay was



developed for differentiating *P. capsici* and *P. tropicalis* infecting black pepper. The assay is 10 times more sensitive than PCR and could detect *Phytophthora* from infected black pepper leaf, stem and root using both purified DNA and crude extracts.

Mushrooms

Wet bubble disease: Spray application of Thiophanate methyl (0.05%) was effective preventive measure with maximum control of wet bubble disease (89.54%) with highest mushroom yield (17.91%) followed by a botanical [*Pongamia glabra/Pongamia pinnata* (Karanj)] pesticide. Under curative action, thiophanate methyl (0.05%) registered highest mushroom

yield (21.61%) with 96.04% control of wet bubble disease followed by a botanical (*Opuntia* sp + *Oryza sativa*) pesticide-Prabal @ 0.1% with 18.51% yield and 99.55% disease control.

Orchids

Tissue culture protocol: An efficient procedure for rapid and mass *in vitro* propagation of *Cymbidium whiteae* through *in vitro* culture of thin cross-sections (TCSs) derived from young protocorms on modified Murashige and Skoog (MS) medium was standardized. Protocorm-like bodies (PLBs) were directly induced from the TCS explants and developed completely into shoots within 8–10 weeks of culture.





8. Livestock Management

Nutrition

Carnitine chelated trace minerals: A method was developed for production of carnitine chelated trace minerals (Cu-carnitine, Zn-carnitine, Mn-carnitine and Cr-carnitine) for improving bioavailability and tissue utilization of trace minerals and tissue carnitine concentration and thereby improving production performance in ruminants. Cu, Zn, Mn and Cr in the chelated products were 13.0, 15.5, 13.5 and 10.3%, respectively. Both the Cu-carnitine and Zn-carnitine chelated products are completely soluble in abomasal and intestinal pH solution.

Improving fodder quality: Experiments were conducted to evaluate effect of correction of zinc deficiency in soils on yield and quality of fodder jowar crop (variety: Co FS-31) and impact of feeding zinc-fortified fodder in improving the zinc status in sheep. The results indicated that correction of zinc deficiency in soil improved zinc content in jowar fodder by over 16 ppm. Its feeding to sheep for four months enhanced their growth rate by over 40% and mean serum zinc content by 0.24 ppm.

Buffalo

Water productivity: On an average 280–300 litre of water is utilized with traditional hose pipe on cleaning of floor of one bull pen daily. However, using trigger shut off on hose, 75–100 litre water was saved daily in comparison to traditional cleaning method of floor cleaning of one Frieswal bull pen.

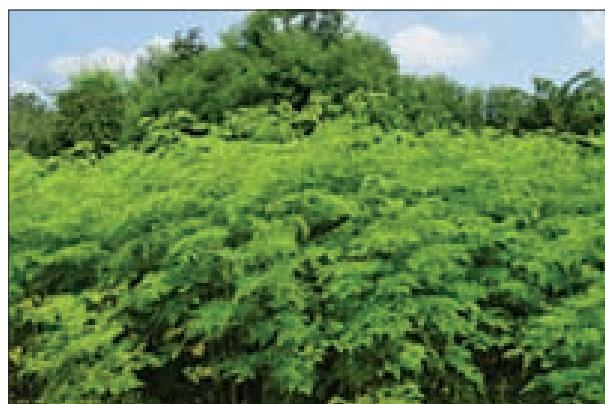
Modulating *in vitro* methanogenesis and rumen fermentation: An *in vitro* study was conducted to examine the plant bioactive compounds individually and in synergy for modulation of rumen fermentation in buffalo to develop phytopreventive feed additive for enteric methane mitigation from ruminants. Extracts of *Sapindus mukorossi* (SMF) fruits (aqueous and ethanolic) as a source of saponins, *Ficus bengalensis* (FBL) leaves (aqueous and acetonic) as a source of tannins and *Eucalyptus globulus* oils (ECO) as a source of essential oils, were prepared and evaluated individually and in association for their effect on feed fermentation and methanogenesis. Both aqueous or ethanol extracts of SMF, acetonic extract of FBL, and ECO showed linear decrease in methane production with increasing concentrations of plant compound. Blend having ECO, 125 µL; SMF aqueous extract and FBL acetonic extract, 6.25 mL each/ litre rumen fluid, reduced methane production without negatively affecting rumen fermentation at much lower individual doses, representing positive associative effect. It is implied that the extracts from *Sapindus mukorossi* fruits, *Ficus bengalensis* leaves and *Eucalyptus globulus* essential oils

and their blends have the potential to act as anti-methanogenic agents.

Sheep

Appropriate feeding modules for different stages of growth to maximize the meat production potential in Avishaan sheep were developed. Higher growth rate during post weaning phase coupled with higher prolificacy in the Avishaan ewes were encouraging. It may prove to be a good choice for intensively fed broiler sheep for meat production in peri-urban and urban areas.

Moringa based complete feed: Complete feed was formulated by using dry moringa biomass (80%) and barley grain (20%) with encouraging results. This feed improved growth rate, body weight gain and DM intake in sheep, in comparison to other conventional complete feed pellet. Carcass characteristics of slaughtered sheep indicated higher empty body weight and carcass weight in moringa based feed than gram straw concentrate based feed. The fat per cent of the meat significantly reduced under treatment. The protein content of the moringa fed animals also increased.



Moringa based complete feed improved the growth rate, body weight gain and DM intake in sheep

Goat

Dietary boron effect on semen: Study conducted to investigate the influence of dietary boron on semen production, semen quality, immunity and molecular changes in the testis, blood and seminal plasma in goats revealed that it significantly increased average sperm concentration and total sperm production. Boron level in blood plasma and seminal plasma showed a positive correlation with sperm progressive motility. The blood and seminal plasma metabolic biomarkers, viz. aspartate aminotransferase and alanine aminotransferase were significantly lower and seminal plasma glutathione reductase was significantly higher in the boron supplemented group. There was a significant increase in





the mRNA expression of serine proteinase inhibitor and interferon in the testis of boron supplemented group. Boron supplementation also upregulated the immune-regulatory gene interleukin 2 and antioxidant gene catalase in the PBMC. On the contrary, toll-like receptor 2 mRNA expression was significantly downregulated in the boron supplemented group.

Camel

Functional metagenomics of camel rumen microbiome: The rumen samples from camels of Leh and Nubra valley, and Kharai camels were collected under natural grazing conditions. These samples were processed for proximate analysis and metagenomic study was done. The serum biochemical profiles of camel calves reared under maize, bajra and jowar based complete rations were also estimated.

Veterinary type culture collection (VTCC)

Four new anaerobic bacteria, viz. *Paraclostridium benzoelyticum*, *Clostridium butyricum*, *Clostridium paraputreficum* and *Paraclostridium benzoelyticum* were isolated, characterized and submitted to VTCC-RM repository. These novel microorganisms have several probiotic properties as evident from their genomic analysis and are now available for further research.

Nutritional and physiological interventions: The research efforts yielded successful pregnancy at the age of 2 years, which is probably the first report of its kind. The camel heifers of >1-year-old, were selected and maintained in two different camel corrals. The control group was fed completely on fodder and treatment group was given concentrate at pre-decided composition and quantity. The results reaffirmed that body weight is more crucial than age for puberty in female camels and heifers with 2 years and > 360 kg body weight can be mated and conceived successfully. To the best of our knowledge this is the first report of successful pregnancy at the age of 2 years. Further, feeding concentrate in addition to regular dry fodder is beneficial for gaining desired body weight.

Poultry

Nutritional manipulations for optimising performance in chicken: Various nutritional strategies for mitigating adverse effects of heat stress were evaluated. Safflower protein hydrolysate and protein concentrate at 0.1 and 0.2% in diet, respectively, reduced lipid peroxidation, whereas the latter increased body weight and activity of super oxide dismutase. Body weight gain and feed efficiency improved progressively with increase in digestible lysine concentration from 1.03–1.23%. Inclusion of vegetable oil (1% in diet) on isocaloric basis in diet during summer improved egg production and antioxidant status in laying chicken. Supplementation of *Chebula* fruit extract and grape seed extract significantly reduced lipid peroxidation in broilers. Improvement in body weight gain and feed

conversion ratio (FCR) of broilers was observed with 255 meq/kg dietary electrolyte balance. In a field study involving rural type chickens, Oxycure supplementation (500 g/t) increased body weight gain. Supplementation of agents like mycotoxin binder, phytase and NSP degrading enzymes could not counter the toxic effects of rice distiller's dried grains with soluble (DDGS) when included at higher levels (12–15%) in the diet of Vanaraja chicks. On the contrary, inclusion of total sulphur containing amino acids at 10% higher level in diet significantly increased body weight of Srinidhi chicks fed DDGS.

Various organic acids and essential oils were screened *in vitro* at graded doses for their effects on growth of *E. coli* and *Lactobacillus plantarum*. A combination of 2 organic acids and 3 essential oils was found optimum. Detailed structural and functional diversity analysis of caecal bacteria in Aseel birds was carried out. Nutritional evaluation of crop and gizzard contents from free-range chickens across 4 different agro-climatic regions of the country indicated wide variation in the nutritional profile of scavenging food base among the regions and seasons. Organic selenium supplementation (0.15 ppm) showed beneficial effects on antioxidant status in broiler chickens. Quality protein maize replacing normal maize (75–100%) with less or no lysine supplementation improved performance of Vanaraja chicks. Supplementation of inorganic or organic Fe (100–300 ppm) significantly increased egg Fe content up to 35.3 and 42.4%, respectively, without affecting feed intake and egg quality traits.

Broilers: Dietary level of 0.25 ppm of selenium or 16 mg/kg copper was optimum during summer, and nano selenium or nano copper (NS or NC either commercial or green) proved to be better than inorganic or organic sources for improved performance, immunity, cost of production and welfare of broiler chickens. Dietary supplementation of tamarind seed powder @ 250 mg/kg diet improved immunity, antioxidant properties of meat and guts microbiota, and decreased fat and cholesterol contents in meat of broiler chicken. Dietary inclusion of symbiotic (Mannan oligosaccharides-MOS @ 0.1% or 0.2% with probiotic *Lactobacillus acidophilus* @ 10⁶ or 10⁷ CFU/g) along with 0.05% glycerol butyrate improved production performance, immune response, blood biochemical parameters and carcass characteristics of broiler chickens. Inclusion of a formulation containing *Kappaphycus alvarezii* seaweed powder and *Gracilaria salicornia* seaweed powder (50:50) @ 1.50% in basal diet improved production performance, immunoresponsiveness, gut health (both microbial and structural), breast and thigh yields (percentage of live weight) in broiler chickens. Supplementation of protease enzyme increased the effective safe inclusion level of rice based dried distillers' grain with solubles (DDGS) from 12.5 to 15% in diet of broiler chickens.

Pig

Vegetable waste/fruit waste based silages: Nutritive





evaluation of locally available fruit and vegetable waste, revealed that it contains a very good level of energy and low to moderate level of protein. Silage was prepared using fruit and vegetable waste. Crossbred (HS × Ghungroo) grower pigs fed on waste silage supplemented basal diet showed no significant difference on nutrient digestibility except crude fibre digestibility which reduced with increase in silage level in diet. There was no significant difference on average daily gain (g/day), feed intake per kg gain (FCR) and feed cost per kg gain. However, FCR and feed cost per kg gain was better at 10% supplementation of vegetable silage in the diet.

Yak

Post-weaning performance of calves: Weaning is an important management tool of a dairy farm management for optimum production performance of dam and calf. Yak calves and dams gave better performance after partial weaning at an age of 3 to 4 months without supplementation of calf starter and also showed enhanced milk production in their dams.

Physiology

Cattle

Effect of seminal plasma prostasomes on spermatozoa: Prostasomes were isolated from seminal plasma of KF and Sahiwal cows to study its effect on semen quality. The prostasomes interacted with spermatozoa in semen and enhanced motility, ATP production, viability, mitochondrial membrane potential of spermatozoa and maintenance of acrosome integrity to improve the semen quality. Leptin concentration, matrix metalloproteinase activity in the spermatozoa also increased with prostasome incubation. Prostasomes enhanced the calcium signalling approximately 3-fold

Performance of Hisar-Gaurav and Sach-Gaurav cloned bulls

- Hisar-Gaurav attained 780 kg body weight and growing normal with good health. All the parameters of a breeding bull such as reaction time (39.5 sec), mean semen volume (2.73 ml), mean sperm concentration (1,023 million/ml), mean mass motility (3.38) and other semen variables were found normal.
- Hisar-Gaurav cloned bull produced 12 progenies.
- Frozen semen doses (9,200) from Hisar-Gaurav are available in stock.
- Sach-Gaurav, Assamese buffalo clone is growing well and has attained weight of 387 kg and this clone was shifted to institute farm after weaning at the age of 12 months.

in cryopreserved semen spermatozoa and 5-fold in fresh spermatozoa.

Semen collection and freezing: Frozen semen doses of Gir (19,240), Kankrej (6,955) and Sahiwal bulls (7,680) were produced at respective Germplasm units. Frozen semen doses (46,628) of Friesian bulls were produced, and 40,169 were distributed to Military Farms, 15,706 doses to Field Progeny Testing Project, and 41,327 doses sold to paravets, State Animal Husbandry Departments, Livestock Development Boards, State Agriculture Universities. The number of semen doses available for Gir, Kankrej and Sahiwal were 160,708, 71,436 and 88,642, respectively.

Sahiwal ETT calf produced at farmer's doorstep: Indigenous (2 Sahiwal, 1 each of Rathi and Gir) cows were subjected to super-ovulatory treatment (PG with 5th FSH-P injection). Six embryos were recovered from two donors. Five embryos were transferred in 4 recipients and which ultimately resulted in pregnancy in one animal. A total of two calves one each of male and female born through ETT.

Udder health management

The infrared thermography (IRT) is effective, non-invasive, on-site diagnostic technology for assessment of physiological-pathological status and offers unique opportunity to investigate temperature variations in udder tissue for udder health assessment, detection of subclinical mastitis and effectiveness of therapeutics adopted. An eight-month pregnant Murrah buffalo heifer with development of one abnormal teat, appearing shrunken with lesser growth was studied. Few drops of milk were squeezed out which tested positive for commensal Coagulase Negative *Staphylococcus* (CNS) species indicating subclinical mastitis. IRT imaging after therapeutic intervention revealed growth in the quarter with arrested growth with significantly high temperature differences (2–3°C) between affected and normal quarters. Thermogram of affected quarter had a high-density red spot area indicating severe inflammation (temperatures above 39°C).



(a) Normal image of udder during onset of subclinical mastitis in buffalo heifer; (b) Normal image of buffalo heifer presented with development of inflammatory signs (later stage); (c) Thermogram (all temperatures indicated); (d) Thermograms with hot spots only (above 39°C).





A thermo-comfortable model shed for dairy cows

Livestock housing plays an important role in buffering the effects of external environment on animals' body. A thermo-comfortable model shed was established at Eastern Regional Station, Kalyani for amelioration of thermal stress and to provide better housing comfort to cows. Thermo-comfortable shed was made up of thatched roof with ridge ventilation roofing design. The main axis orientation of the shed was East-West direction. Owing to changes in roofing material, design and axis orientation, the micro environment of presently developed cow-shed became cooler, more ventilated, thermal radiation protective and comfortable than the existing traditional asbestos roofed cow-shed. The microclimatic conditions of the experimental shed were compared to existing shed having asbestos roof. Over all floor surface temperature of thermo-comfortable shed was 0.68 to 2.33°C lesser in morning and 1.33 to 4.05°C in afternoon. The ceiling surface temperature was 6.10 to 12.28°C lesser than that of existing shed in morning and 3.87° to 10.53°C in afternoon. The average respective daily environmental temperature and humidity in the morning were 0.80° to 1.52°C and 0.4 to 2.29% lesser in experimental shed compared to existing shed. The corresponding values in the afternoon were 1.34 to 2.03°C and 1.00 to 2.23%.



Thermo-comfortable thatched roof influences cow-shed's micro-environment

The study revealed that cow-shed designs and comfort influenced milk production and expression of cows' behaviour in milking parlour. Dairy cows kept in thermo-comfortable sheds were more docile and exhibited less temperament score as compared to those kept in existing shed. Milk flow rate, milking durations and milk parlour exit score were also higher, though the differences were nonsignificant. Use of paddy straw as roofing material and changes in roof design and axis orientation of cow-shed favourably changed the micro-environment of shed, augmented the milk yield, enhanced comfort indices and positively modulated the expression of milking behaviours of dairy crossbred Jersey cows.

Buffalo

Cryopreserving buffalo semen: A new buffalo specific semen extender to improve post-thaw motility of cryopreserved buffalo semen, was developed. Concentrations of several metabolites are significantly

low in seminal plasma of buffaloes than that of cattle. Selected metabolites (35) were quantified. Several of the selected metabolites were in lower concentrations in buffaloes compared to cattle. The new extender was developed incorporating these deficient metabolites and it significantly improved post-thaw sperm motility and viability of cryopreserved buffalo semen.

Mastitis pathogens and somatic cell counts: In milk samples of Murrah buffaloes, the major agents involved in bacterial intra-mammary infection (IMI) are *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Staphylococcus saprophyticus*, *Streptococcus agalactiae* and *Streptococcus uberis*. The culturally examined and characterized samples revealed *S. aureus* (35.29%) as the predominant bacteria followed by *S. agalactiae* with an isolation rate of 25.49%. Coliform bacteria were not detected. Milk SCC ranged between $1.28\text{--}1.48 \times 10^5$ cells/ml in normal milk samples as compared to $3.85\text{--}6.21 \times 10^5$ cells/ml in mastitis milk samples.

Buffalo cloning for production of multiple copies of elite bulls: The aim of the project on 'Production of multiple copies of elite buffalo bulls using animal cloning technology', is to produce multiple clones of elite buffalo bulls, improve production efficiency of clones and evaluate clones for health and reproductive performance. Buffalo oocytes were collected from abattoir ovaries and subsequently *in vitro* matured. These oocytes were subjected to pronase treatment for removal of zona pellucidae. Zona free oocyte was placed at right angle to cut the portion having nucleus. The enucleated cytoplasm from oocytes was used for reprogramming of donor cell nuclear material for development of cloned embryo. Activation of oocytes with chemicals electro-fusion is required to produce cloned embryos.

Goat

Cryopreservation of semen: Semen was extended with tris-egg yolk-egg yolk 7.5% (v/v) and glycerol 5.4% (v/v) was added in fructose diluent as extracellular and intracellular cryoprotectant. Semen samples having mass motility >4 and progressive motility >70% were used. Sperm concentrations were adjusted to $1 \times 10^8/\text{ml}$ and diluted semen was equilibrated at 5°C for 4 h before being frozen. Post thaw motility in Jamunapari, Barbari, Jakhrana and Sirohi were 55.26 ± 3.54 , 55.74 ± 2.84 , 50.16 ± 3.12 , $50.62 \pm 2.32\%$, respectively by AI. About 10,000 doses of semen of different breed were preserved for further use.

Neonatal colibacillosis in goat-kids: A therapeutic phage preparation containing three phages with highest lytic ranges (53, 48 and 46%) was formulated for the treatment of diarrhoeic neonatal goat-kids, caused by *E. coli*. The treatment was effective in 50% of diarrhoeic kids. Developed therapeutic phage preparation could be used with other alternatives such as herbal therapy for the enhanced efficacy to combat antibiotic resistant *E. coli* infections.





Mithun

Growth performance under semi-intensive system:

Average age at first heat (AFH), age at first calving (AFC) and gestation period were recorded as 940, 1215 and 285 days respectively. Calves born during autumn showed higher birth weight than in summer (20.03 ± 0.33 vs. 19.60 ± 0.55 kg). Average daily weight gain (ADG) for calves (up to 12 months), grower (1–3 years), adults (4–5 years) and above 5 years was 176 ± 11.21 , 197.72 ± 11.24 , 142.28 ± 15.02 and 98.63 ± 25.01 g/day.

Estrus behavior and AI: Estrus behavior along with visual, physiological and gynecological changes was observed and recorded in mithun cows to predict the proper timing of AI in mithun. Reproductive behavior of mithun bull was also recorded in response to estrus cows. Physico-chemical properties of cervical mucus (pH, consistency, viscosity, rheological properties and spinbarkeit value) were also studied. Based on all parameters, a score card was developed for prediction of estrus in mithun and proper timing of AI. During the reporting period 18 calves were born from estrus synchronized and timed AI mithun cows.

Poultry

Semen cryopreservation: The protocol of cryopreservation of semen of PD-6 chicken line was optimized using 4% dimethyl sulfoxide, and a fertility of 65% was obtained after AI in PD-3 females.

Heatstress study and waste management: Heat stress decreased concentration of plasma leptin, ghrelin and growth hormone in Nicobari chickens, and supplementation of fermented yeast culture reversed it and showed beneficial effects on body weight and egg production. Poultry waste management protocol is being standardized. Suitability of various raw materials for composting poultry manure, the C: N ratio, P and K were analysed.

In ovo administration of GnRH during embryogenesis advanced the desired body weight of post hatch broiler chicken by one week with optimum physiological functioning and production, while maintaining high level of body growth with high quality meat protein.

Housing management: Floor space of 540 sq cm/laying bird was sufficient to have better production and welfare in laying birds. Further increasing the floor space beyond 540 sq cm did not provide additional benefits/welfare to the birds.

Livestock protection

Disease informatics: The National Animal Disease Referral Expert System (NADRES) is a system that builds on the added value of coordinating the alert and response mechanisms for the stakeholders to assist in prediction, prevention and control of animal disease threats, including zoonoses. This is done through sharing of information, epidemiological analysis and joint field missions to assess and control the outbreak, whenever needed. The monthly disease outbreaks occurrence in various states at district level are predicted two months

in advance. The prediction results, risk maps, bulletins and post prediction maps were updated on NADRES web application (NADRES version 2).

A forecasting bulletin is sent to all the State Animal Husbandry Departments and DAHD, Government of India for initiating preventive action. Further, animal disease prediction for Karnataka at the block level was pilot tested and the predicted results were communicated through auto messaging to field veterinarians to undertake preventive measures in the villages under their jurisdiction. An epidemiological alert for African swine fever was formulated for preparedness to prevent possible necessary transboundary transmission.

Artificial intelligence systems were applied for prediction of Anthrax disease incidence pattern, risk and clustering in Karnataka, and spatial mapping and prediction of classical swine fever disease in India. Nation-wide sampling plan for FMD sero-surveillance and sero-monitoring in India was framed. Remote sensing and meteorological parameters at block level were prepared. Updated aquatic disease maps were uploaded in National Surveillance Program for Aquatic Animal Diseases (NSPAAD) web application. Mobile Apps were designed to give details on haemonchosis disease in Rajasthan, and also on leptospirosis covering veterinary public health aspects.

Epidemiology

Screening of small ruminant serum samples for bluetongue virus antibodies revealed 58% and 43% seroprevalence in goats and sheep, respectively. The highest population for PPR immunity was observed in Maharashtra (74%) followed by Gujarat (67.2%), Rajasthan (63.7%) and Chhattisgarh (51.6%). For brucellosis, highest seroprevalence was recorded in sheep (12.4%) from Jammu & Kashmir and goat samples (5.2%) from Tamil Nadu. Seronegativity was observed for both sheep and goat samples from Chhattisgarh. Pig serum samples showed that 38.9% samples were positive for classical swine fever (CSF) antibodies.

Japanese encephalitis virus and mosquitoes in Assam: Japanese encephalitis virus (JEV) infection in mosquitoes was screened based on seasonal distribution. Mosquito samples were collected from Jorhat, Lakhimpur and Kamrup districts of Assam. The most prevalent vectors identified were *Culex tritaeniorhynchus*, *Cx. gelidus* and *Mansonia* spp. and found significantly higher during summer (April-September). *Cx. tritaeniorhynchus* and *Mansonia* were the most dominant mosquito species followed by *Cx. gelidus*. Phylogenetic analysis of JEV

Reversion to susceptibility in *Haemonchus contortus*

At ICAR-CSWRI farm, implementation of different worm management strategies like strategic drench during mid to late monsoon, community dilution through introduction of susceptible worms and breeding for disease resistance resulted in reversion to efficacy of benzimidazole anthelmintic against *H. contortus*.





positive samples was performed for the envelope protein gene. The sequence analysis of PCR positive JEV samples revealed 100% identity with JEV envelope protein of human and equine from West Bengal, Vellore, Haryana and Lucknow, which also truly reflects on the phylogenetic tree.

Vaccines developed

- Cell culture classical swine fever (CSF) vaccine by adapting indigenous virulent CSF virus in cell culture system was developed. This new CSF vaccine provided 100% protection. Vaccine induces protective immunity from day 14 of the vaccination till 18 months as per the testing trials.



Indigenous Classical Swine Fever (CSF) cell culture vaccine

- An inactivated experimental vaccine was developed using a field isolate of *Pasteurella multocida* A:1 which provided equivalent protection as that of commercial vaccine upon challenge infection.

Identification of individuals, breeds and diseases

An image based system for identification of individuals, breeds and diseases of pigs was developed. This system allows individual animal identification, which in turn allows producers to keep records of animal's parentage, birth, production records, health history, and is also useful for precision farming system and implementation of different Governmental plans and policies to animal farming. The database of indigenous population of 6 breeds of pig along with other potential exotic and crossbred pig germplasm was documented. In pigs, auricular vein pattern and muzzle have promising potential for individual identification. An algorithm was developed to amplify certain hidden features in the muzzle by constructing a gradient significance map and the corresponding patch statistic profile. The gradient significance map extracted from the muzzle images of pigs tends to amplify the pore and ciliary arrangement on the muzzle surface, which may be expected to be distinct for each pig. This pattern can be used as a bio-identifier for segregating individual pigs not within the same breed but also across breeds. As offshoot activities of the programme, two unique mobile applications namely *SwineApp*, *SwineAppHindi*; standalone data recording software for pig farm namely *SwinePro* were developed.

Diagnostics developed

- A highly sensitive multispecies mAb-based blocking ELISA for the detection of FMD NSP antibodies
- Sandwich ELISA kit for detection of bluetongue virus antigen
- Loop mediated isothermal amplification (LAMP) and Real time (TaqMan) assays for food-borne pathogens
- SYBR green dye based real time Polymerase chain reaction (PCR) assay for detection of *Mannheimia haemolytica*
- Pen-side diagnostic kits for detection of porcine circovirus and porcine parvovirus from biological samples of pig. The kits can detect the virus of interest (PCV and PPV) within 1 hour.
- Multiplex RTqPCR assays in the form of kit for Avian Influenza diagnosis in field samples.
- Monoclonal antibody based rapid test for detection of H5 Avian influenza virus in poultry.
- A label-free peptide nucleic acid (PNA) biosensor for visual detection of multiple strains of Influenza A virus suitable for field applications.
- Indirect ELISA kit for avian influenza antibody detection in chickens and Indirect ELISA kit for Porcine Reproductive and Respiratory Syndrome antibody detection in pigs.



The Avian Influenza laboratory of ICAR-NIHSAD have been accredited by National Accreditation Board for testing and calibration Laboratory (NABL) for ISO:17025:2017.

Equines

Sero-surveillance: Total number of positive and seropositive percentage for various diseases were 556 (47.25%) for *Theileria equi*, 208 (17.77%) for EHV-1, 51 (4.35%) for *Trypanosoma evansi*, and 73 (6.23%) for JEV, out of 1,170 equine serum samples tested. None of the equines were found positive for equine influenza, equine infectious anemia, brucellosis and *Salmonella Abortus equi*.

Under disease investigation, 338 samples were found positive for glanders. Glanders cases were from Uttar Pradesh (243), Rajasthan (3), Maharashtra (8), Uttarakhand (7), Gujarat (20), Haryana (9), Jammu and Kashmir (4), Himachal Pradesh (3), Madhya Pradesh (30), Delhi (9) and Tamil Nadu (2). With public health point of view, 198 human serum samples from in contact/ equine handlers were tested, and found negative for glanders. In addition, results of testing of samples for equine influenza, EIA, AHS, and EHV-1 were found negative.

Fabrication of polymeric nanocomposites and evaluation on equine fibroblasts: ICAR-NRC Equines has described a simple and rapid method to synthesize





metal oxide nanoparticles providing an assortment of nanoparticles resembling flower like structure. The novel method of synthesis of polymeric metal oxides demonstrated a much higher yield as compared to conventional methods. It was observed that all cultures treated nanoformulations proliferated well with 70 to 85% confluence except that for DMSO suggesting biocompatibility and non-cytotoxicity of the nanoformulations, whereas DMSO (known for its toxicity) treated cells exhibited 15% confluence indicating detrimental effects on cells.

Cholesterol-loaded cyclodextrins (CLC) on sperm motility: Cryopreservation process induces alteration in the temperature and causes membrane alteration by lipid loss and lipid/protein rearrangements within the sperm membrane. Addition of CLC (1 to 2 mg/120×10⁶ spermatozoa) significantly improved cholesterol: phospholipid ratio of cryopreserved spermatozoa by reducing the total antioxidant capacity and oxidative stress thus resulting in better semen freezability as revealed by higher progressive motility, HOS response, livability, acrosomal integrity and DNA integrity of spermatozoa.

Pulling capacity and biochemical indices of Halari donkeys

The study showed that Halari donkeys may pull draught of 33 kg for 3 hr; 44, 55, 66 kg for 2 hr; 77, 88 kg for 1 hr without much stress to donkeys as fatigue score was less than 7. The fatigue symptoms (tongue protrusion and frothing) were not present in donkeys as heat loss in donkeys is by sweating and not by panting. Halari donkeys could be used in pulling the load till the animal is tired means when the fatigue score is less than 14. However, for using the donkeys in continuous and regular type work, the fatigue score should be less than 7 for keeping the animal healthy and productive.

Bacteriophages against *Staphylococcus* spp: The experiments revealed that the synergistic effect of bacteriophages and antibiotics may provide a better alternative to kill virulent bacteria than either treatment given individually in mastitic bovines.

Characterization of bacteriophages against *Klebsiella pneumonia*: A new bacteriophage (VTCCBPA119) was isolated against *Klebsiella pneumonia*. The phage is temperature tolerant in the range of 4°C to 55°C and within a narrow pH range of 6 - 9. The biological activity assessment of the phage showed it to be strongly lytic against only two (2/10) of *K. pneumonia* tested. A new phage against a laboratory induced resistant mutant was obtained. The resistant mutant of *Staphylococcus* spp (RM Fop 171A) was generated.

Diagnosis of glanders and equine infectious anaemia (EIA): ICAR-NRCE developed a recombinant Hep1 antigen ELISA. It has been duly validated in India and the OIE Reference Laboratory, Germany and showed excellent sensitivity (97.2%) and specificity (99.6%). This technology was transferred to 8 State Disease

Diagnostic Laboratories and commercialized for transformation into ready to use kit. NRCE developed recombinant p26 protein-based ELISA. This technology will provide sustainable and homogeneous source of antigen and harmonized protocol for ensuring regular surveillance of EIA. The kit is highly economical as compared to imported kit.

Recombinant-protein-based iELISA for JEV antibodies: Indirect ELISA was developed using JEV-E protein immunodominant epitope of 444 bp expressed in *E. coli* (BL 21 (DE3)) cells using pET 32a vector, for detection of JEV specific antibodies in horse and pig. The recombinant protein was found to be stable for one year at -2°C. The ELISA was transformed to a diagnostic kit for detection of JEV antibodies in equines.

Poultry

Complete genome analysis of chicken astroviruses:

The genome analysis revealed that the complete genome is 7.5 kb in length and both the isolates were closely related to an isolate previously reported from India (CAstV/INDIA/ANAND/2016). These isolates have a nucleotide identity ranging from 97.1 to 97.3% with CAstV reported from Anand, Gujarat and 86.1 to 92.0% with CAstV isolates reported from other countries. The high sequence similarity of the present isolates with CAstV previously reported from the country indicated the limited sequence divergence of CAstV in the country. Hence, development of a vaccine using a CAstV strain currently circulating in the country may give protection to birds against CAstV infection and both genetically characterized isolates have the potential to be developed as candidate vaccine virus.

Foot and Mouth Disease

Epidemiology: Almost 56% of the outbreaks (391) of FMD, recorded in the country during the period, were in the southern region of the country. There were no outbreaks in Andhra Pradesh, Mizoram and Arunachal Pradesh. The serotype O continued to be the most predominant one and was responsible for 99% of the outbreaks. The serotype Asia1 was recorded in West Bengal and Assam. After a period of almost three years, serotype A was recorded in the country in Maharashtra. Phylogenetic analysis of serotype O virus revealed extended and exclusive dominance of lineage Ind2001 strains. The lineage Ind2001 is dominating the scenario since 2008 with emergence of sub-lineage Ind2001d in 2008 and sub-lineage Ind2001e in 2016. At present the National FMD virus Repository holds 2,278 isolates (O-1574, A-323, C-15 and Asia 1-366). Under National FMD Serosurveillance, overall seropositivity in 20.02% samples/animals was observed, which is comparatively lesser than the previous year's average of 21.2%. To assess the effectiveness of vaccination under FMDCP seromonitoring program, 231,983 serum samples were tested. The results were communicated to DAHD.

Vaccine candidate strain: A total of 34 serotype O were antigenically characterized. The field situation





suggested that majority of the isolates were antigenically homologous to currently used vaccine strain INDR2/1975. The isolates of serotype Asia1 were also antigenically covered by currently used vaccine strain IND63/1972. To circumvent emergence of antigenically divergent VP359-deletion group strains in serotype A, an alternate vaccine candidate strain (A IND 27/2011) was identified for replacement of the existing vaccine strain A IND 40/2000 to maintain the vaccine efficacy and is ready for inclusion in vaccine formulation.

Exotic and emerging diseases

Genetic diversity in H5N1 avian influenza viruses:

Complete genome sequence of six H5N1 highly pathogenic avian influenza viruses (Bihar-4 and Odisha-2) isolated from chickens, ducks, crows and peacocks in different epicenters, was determined. Phylogenetic analysis of the hemagglutinin (HA) gene revealed that the viruses grouped separately (>5% divergence between the viruses isolated in Odisha and Bihar) within the HA clade 2.3.2.1a of H5N1 viruses. The phylogeny indicated that the outbreaks of H5N1 viruses in Bihar and Odisha epidemiologically distinct, were caused by independent introduction events. The persistence and cross border movement of the H5N1 viruses circulating in South Asia indicated that there is a need for continuous active surveillance.

Molecular characterization of H5N8 avian influenza viruses: Molecular characterization of 20 H5N8 viruses revealed presence of multibasic cleavage site in HA gene indicating high pathogenicity to poultry, which correlated with the pathogenic characterization (IVPI of 2.96–3.00/3.00). The PB1-F2 protein was truncated because of nucleotide mutation C35A. Except the polymerase acidic (PA) and NP genes, all other gene segments of H5N8 viruses shared high nucleotide identity ranging from 99.2 to 99.5%. The nucleotide identity of the PA and NP gene was 95.8 and 94.8%, respectively, suggesting involvement of 2 gene pools of H5N8 virus

Viral metagenome profiling of Antarctic animals, birds and environment

Metavirome profiling of fecal samples of Weddell Seal, Adelie penguin and South Polar Skua as well as from Ornithogenic Soil of Penguin rookery from Antarctica collected during the 37th Indian Scientific Expedition to Antarctica was done. Diversity and abundance analysis revealed the presence of 416, 584, 550 and 727 different viruses across 41, 57, 55 and 60 different virus families in fecal metavirome of Adelie penguins, Weddell seal, South polar skua and ornithogenic soil, respectively. Apart from this, each sample had huge numbers of bacteriophages of several families indicative of the bacterial loads harbored in them. New Castle Disease virus genome (58% of whole genome) was also detected in the metavirome of ornithogenic soil. Phylogenetic analysis of the F gene indicated it as genotype VII of class II viruses. The presence of cleavage site RRQKRFI indicated that it is a highly pathogenic virus.

in the outbreaks. In HA gene phylogeny, the Indian isolates clustered within group B (intercontinental group B) of clade 2.3.4.4 viruses. The phylogenetic analysis of various genes of isolated H5N8 viruses suggested that they are 7:1 reassortant of the Tyva and Uvs-Nuur lake H5N8 viruses. The MJ network analysis indicated that the contemporary H5N8 viruses isolated from wild birds in UvsNuur Lake (located at Mongolia-Russia border), Qinghai Lake (China) and Tyva Republic are not the direct ancestors and closely related precursor gene pools are the source of the H5N8 viruses that caused the outbreaks in India.

Genetic characterization of Indian PRRS viruses:

Two porcine reproductive and respiratory syndrome viruses (Ind-30141086/MZ-KLK2/2018 and Ind-30141076/MZ-SL1/2018) isolated from the disease outbreak in Mizoram in 2018 were genetically characterized. Nucleotide sequence analysis of the nsp-2 coding region showed that they belong to highly pathogenic variant of PRRSV genotype-2. Phylogenetic analysis of the ORF-5 and ORF-7 regions showed that the 2018 isolates grouped together with Chinese and Myanmar PRRSV isolated in 2010 and 2011. In the ORF-7 region, the nucleotide sequence identity between the two Indian 2018-isolates was 99.7%, while it was 97.0 to 97.5% with the earlier Indian PRRSV isolate – Ind-297221/2013 and Myanmar isolates; 93.5% with classical genotype 2 isolate VR-2332 and 69% with genotype 1 virus LV. The genetic analysis of ORF-5 and ORF-7 revealed that the Indian PRRS viruses could have evolved from the Myanmar viruses.

Fisheries

Nano system for intracellular delivery of biomolecules:

Delivery of gene into fish cells is a challenging task as fish generally have a lower body temperature than mammals. A hybrid peptide nano system (RR28) was designed from infectious pancreatic necrosis (IPN) and betanoda viral proteins using bioinformatics tools. RR28 interacted with the plasmid DNA (pDNA) and formed non covalent complexes with it. The peptide based nano system may be an alternate DNA delivery vector for fish cells and can also provide insights into transfection of fish cells with peptide. In recent years, cell-penetrating peptides (CPPs) have shown its potential to deliver various cargos that includes protein, DNA, RNA and antisense molecules into live cells in a non-toxic manner. Seven cell-penetrating peptides (CPPs) were designed/ identified from fish viral proteins. These peptides can be modified to make suitable peptide based delivery vectors for various biological applications.

Vaccine against *Flavobacterium columnare* infection: *Flavobacterium columnare*, a Gram negative bacteria, is ubiquitous in various freshwater aquatic environments and causes columnaris disease in fishes. It is associated with stressful conditions like rapid fluctuation of temperatures, elevated organic loads, high stocking density and excessive handling. *F. columnare* causes acute to chronic infections and affects gills, skin



**CarryCap – Aquaculture planning tool**

Assessing the carrying capacity of natural water bodies is essential for planning expansion of aquaculture. ICAR-CIBA developed a conceptual model and methodology for assessment of carrying capacity of water bodies in relation to aquaculture and translated it into an online tool called "CarryCap". This model will provide information necessary for the formulation of strategies to integrate shrimp farming into coastal zone management.

**Functional aquarium feed Kalor fish^{Plus}**

Developed a cost effective aquarium feed "Kalor fish^{Plus}" for ornamental fishes with optimum nutrients and functional properties such as colour enhancement. Feed contains added level of beta carotene and astaxanthin. The feed possesses highly digestible ingredients to reduce waste generation in aquariums. Feed is available in particle sizes ranging from 0.3 mm to 3 mm to promote healthy fish growth and reproduction.

Indigenous functional aquarium feed Kalor fish^{Plus}

and fins, and in particular, dorsal fin and surrounding skin are often exaggerated, causing saddleback lesions. Its outbreak may result in 50–80% mortality in fishes. An inactivated vaccine against *F. columnare* was developed to induce specific immunity in *Labeo rohita* fingerlings and offer protection. Besides an efficient protective vaccine, an efficient and stress-free delivery method for administering the vaccine to fish was also developed. Vaccine showed 81.18% protection to fish under field conditions. The use of vaccine for disease prevention will minimize the antibiotic use in farms, which has adverse environmental effects.

Multi-parameter water analysis kit: Onsite estimation and monitoring of water quality parameters is crucial for successful aquafarming. A cost effective, indigenous and handy multi-parameter water analysis kit was developed for estimation of dissolved oxygen,

ammonia (0.1 to 2 ppm), nitrite (0.05 to 1 ppm), calcium and magnesium ions, and total hardness.

Trademark registration: ICAR-Central Inland Fisheries Research Institute has successfully registered trademarks of four technologies namely CAGEGROW® (Trademark No. 3625921), CIFRI GI CAGE® (Trademark No. 3852537) CIFRI PEN HDPE® (Trademark No. 3852538) and CIFLIN® (Trademark No. 3852539) in the name of 'Indian Council of Agricultural Research' in the Trade Marks Registry of Government of India, Mumbai.





9.

Mechanization and Energy Management

Farm mechanization

Multi-crop thresher: Hill farming needs machineries which should be lightweight for transportation, and portable for easy assembly and dismantling. The developed lightweight multi-crop power thresher is suitable for threshing of wheat, paddy, amaranth and millets to suit requirements of Uttarakhand hills. Its threshing capacity for wheat, paddy, barnyard millet, finger millet and amaranth is 34, 75, 58, 54, and 30 kg/h, respectively. Threshing efficiencies for these crops are greater than or equal to 98%. The multi-crop thresher would benefit hill farmers by saving of time and labour, and also reduce the drudgery involved in the manual threshing operations.

Garlic weeder for raised bed cultivation: Weeding with the hand tools involves one-fourth of the total cost of cultivation in garlic production. Manual weeding generally requires about 50–60 man-days/ha. A tractor drawn garlic weeder was developed for weeding in garlic crop sown on broad beds. The equipment gave effective field capacity and weeding efficiency of 0.13 ha/h and 63%, respectively, at forward speed of 1.14 km/h at 20–25% (db) soil moisture content.



Tractor drawn garlic weeder for raised bed cultivation

Hydraulically operated two-row pigeon pea harvester: Harvesting of pigeon pea is time consuming, labour intensive and drudgerous operation when done manually with sickle. The developed tractor front mounted hydraulic operated two-row pigeon pea harvester consists of two cutting blades mounted over front hydraulic platform and a row divider fitted between these two blades for dividing crop rows during harvesting. The hydraulic system issued for operating blades at high speed and setting the cutting height with the help of hydraulic platform over which blades can move up and down. The oil sump is attached to the rear of the tractor for stability, which balances front load of the machine during operation. The cutting blades rotate in the opposite direction so that cut crop falls outside the

operating zone. The developed harvester can cut the pigeon pea crop at 10–15 cm above the ground level. Its field capacity varied from 0.5–0.6 ha/h with field efficiency of 83%; approximate cost is ₹ 40,000 and operational cost is ₹ 1,800–2,000/ha. The saving in labour is about 96% compared to traditional method of harvesting.

Cassava harvester cum lifter: The cassava harvester consists of a main frame, digging unit, conveying unit, transmission system and cluster breaking system. The equipment when in operation attached to a 50 hp tractor, digs a single ridge and lifts the tubers from the ground and convey to surface for manual collection. The cost of the prototype is ₹ 80,000. The actual field capacity of the planter is 0.22 ha/h. The operational cost of the cassava planter is ₹ 2,265/ha, and saves 82.0% in cost when compared to manual harvesting.



Tractor operated cassava harvester-cum-lifter

Fertilizer applicator for top dressing: A self-propelled site-specific fertilizer applicator was developed for top dressing in wide spaced field crops. It consists of sweep for weeding, 5 hp diesel engine, two fertilizer boxes (8 kg capacities each), fluted roller metering



Site-specific fertilizer applicator for top dressing in wide spaced crops





Model farm machinery package for different agro-climatic zones of India

As per National Agricultural Research Project, the country has 127 agro-climatic zones. Every zone is suitable for a certain range of crops and cultivars, which requires suitable machinery. To create awareness and make better use of available machinery, a model farm machinery package for different agro-climatic zones of India was developed, and is available as web based and mobile app. The developed model farm machinery package is able to provide details of state wise, agro-climatic zone wise, district wise, cropping pattern wise and power source wise model machinery package. It also includes economic parameters such as machine cost, per hour operating cost, hiring rate, the total annual cost and net return, break-even analysis, payback period, machine specifications and available manufacturers for different agro-climatic zones of India. The developed package is very useful in calculating various technical and economic parameters leading to decision making for establishment of technically feasible and economically viable model farm machinery for custom hiring at various agro-climatic zones/districts in India.



Pneumatic precision planter for pigeon pea

Automated control system for tractor implements:

At present, the draught control system of tractors is inefficient to keep draught in line with slip so that the operator has to control lever frequently for achieving the optimum draught. A microcontroller based automatic slip and draught control system was developed for 2WD tractors to maintain the wheel slip and implement draught in a pre-specified range of slip and draught, respectively, by automatically adjusting the depth of operation. The system continuously measures the wheel slip and draught in the field and communicates to the hydraulic system for depth adjustment if the wheel slip and draught of implement falls outside the desired range. The wheel slip is calculated using the actual and theoretical speeds of the tractor, computed by measuring the output pulse from the radar sensor and revolution per minute of rear wheels respectively. The draught requirement is measured by especially designed load pins. This system can be installed on any make and model of 2WD tractor. Measuring efficiency of the developed system is 99%. The developed automatic draught control and slip control system can reduce the fuel consumption up to 14% and increase the field capacity up to 36% in vertisol.

Package of machinery for banana crop: A package of machinery was developed for ease of doing different operations in banana cultivation.

Banana sucker trimmer equipment: The banana sucker to be trimmed is held against the rotating grating blade (300 mm) and adjusted as per the area and the depth of the banana sucker to be trimmed. The grates are arranged in set of three rows of grates (22 grates, 5 mm size). Similarly, there are six sets of grates around the circumference of the blade. A variable speed motor is attached to the unit, to adjust the operating speed. The blade can be rotated in any direction. The overall size of the equipment is 750 mm × 500 mm × 850 mm. The model is very handy as the exact area of the sucker to be trimmed can be targeted, thus the final product obtained is of a better finish. The



mechanism, triggering mechanism to detect plant and delivery system to apply fertilizer at the target plant. The application rate of urea can be varied simply by changing the exposure length of fluted roller. The field trials revealed that the field capacity is 0.10 ha/h, field efficiency 78%, weeding efficiency 80.2% and fertilizer application efficiency 93%, at a forward speed of 1.5 km/h. The fertilizer is released at a distance of 86.5 ± 17 mm from the plant.

Cotton stalk puller: Uprooting and disposal of deep rooted crops such as cotton after the harvesting is a serious problem in crop residue management. Two-row tractor operated rear offset cotton stalk puller-cum-conveyor was developed. It consists of two cotton stalk pulling units and conveying units. The uprooted crop conveys towards the rear of machine by means of chain type conveyor. The actual field capacity of machine is 0.18 ha/h at an average forward speed of 1.2 km/h with a field efficiency of 80%. The uprooting efficiency and conveying efficiency ranged from 86–94% and 85–91%, respectively. The developed machine can uproot 54 plants/minute. The labour requirement for uprooting operation with the developed machine is about 5.7 man-h/ha as against 77 man-h/ha in the conventional method, and its cost of operation is about ₹ 625/h.

Pneumatic precision planter: A tractor drawn battery operated two-row drum type pneumatic precision dibbler/planter was developed for sowing pigeon pea. It can sow one or two seeds per hill and the row to row spacing can be adjusted with 75 and 90 cm and plant spacing of 10 to 90 cm. It could be operated at forward speed of 4–6 km/h at operating pressure of 2–3 kPa. The field capacity is 0.5–0.6 ha/h and field efficiency 80%. The approximate cost of the developed equipment is ₹ 50,000, and operational cost ₹ 1,000–1,200/ha.





capacity of the equipment is about 80–90 banana suckers/h.

Banana pseudo stem injector: The developed banana pseudo stem injector consists of chemical tank, peristaltic pump, control unit with non-return valve and injector. The injector is made of SS 304 Grade of 7.5 cm length. The chemical tank is made of plastic with storing capacity of 16 litre. The peristaltic pump is attached to pump the liquid from chemical tank to injection system. The control unit is integrated with embedded system to control chemical quantity and depth of injection by 8 mm I/P and O/P screw variable valve. The non-return valve ($\frac{1}{4}$ thread, one way valve) is attached with control unit to restrict the chemical reentry to the injector after injection. Preliminary trials have been conducted and extensive trials are in progress. The quantity of liquid injected is 2 to 4 ml/tree and coverage is around 140–150 trees/h. The spillage percentage is 2% and injector efficiency 95%.

Banana bunch harvester: The newly developed banana bunch harvester is used for harvesting banana bunches from the tree of var. Grand Naine and other traditional varieties. Its height of reach is 1.1 to 2.7 m, weight of bunch handled is about 14–17 kg and the coverage of harvester is 25–30 trees/h.

Auger plough for green manuring and straw incorporation: The green manuring and straw incorporation involve high labour and cost in traditional practice. To address the problem, a tractor operated two bottom auger plough was developed which consists of cutting unit, truncated/shortened mould board and vertical rotating clod-crusher/soil-ripper. Field trials were carried out to incorporate green manure crop Dhaincha (*Sesbania bispinosa*) at two stages of crop growth, viz. 36 days and 50 days with biomass density of 15.4 and 22.5 tonnes/ha, respectively. Its actual field capacity is 0.25–0.28 ha/h and fuel consumption 6.7–8.2 litre/h, at a forward speed of 3.5 km/h with 175–179 mm depth of operation. The soil pulverization and mixing index with the developed machine varied from 5.6 to 10.4 mm and 93.7 to 96.2%, respectively.

Irrigation channel former: Traditionally the irrigation channel for orchards is formed manually using hand tools, which is a drudgerous and pain taking activity.



Tractor operated irrigation channel former

A tractor operated irrigation channel former for making irrigation channels in orchards was developed. The developed equipment was evaluated at forward speed ranging from 2.1 to 2.8 km/h for making irrigation channels. The channel formed is of trapezoidal shape with 610 mm and 390 mm of top and base width, respectively. The depth and outer width of channel formed is 244 mm and 1,080 mm, respectively. The average fuel consumption for making irrigation channels is about 6.1 l/h. The labour requirement with developed equipment is 0.05 man-h/m, whereas it was 0.16 man-h/m with manual method. The savings in labour and cost of operation is about 68.7% and 61.2%, respectively, compared to manual method. The machine can form 1,760–1,875 m long channel in 1 h.

Vegetable transplanter for cell feed nursery: The high missing index, labour requirement and mortality rate of seedlings are hindrance in promotion of existing transplanters developed in India. To overcome these lacunas, a two-row semi-automatic vegetable transplanter



Vertical cup-type vegetable transplanter for cell feed nursery

having cup-type metering mechanism for cell feed nursery was developed. The metering unit consists of 5 vertical cups mounted over a disc of 500 mm diameter. The developed transplanter could transplant seedlings with plant missing of less than 4%. The effective field capacity of the machine for transplanting tomato, brinjal and chilli seedlings is 0.11, 0.12, and 0.15 ha/h at a forward speed of 1.0, 1.25 and 1.5 km/h, respectively. The saving in labour with developed transplanter over manual transplanting of tomato, brinjal and chilli seedlings is 85, 86 and 86%, respectively, whereas saving in cost is about 24, 31 and 29%, respectively.

Sprayer to control whitefly in cotton crop: The cotton crop is cultivated in an area of 0.67 million ha in Haryana with production of 1.63 million bales but damages due to whitefly attack causes reduction of plant growth and crop yield in Haryana. A prototype of sprayer equipped with electro-pneumatic system was developed. It consists of suction unit, electric unit and prime mover for pneumatic unit. The pneumatic unit creates turbulence dislodging the whitefly from cotton plants, using suction and forward thrust of air pressure to trap insects. The



electric unit kills trapped insects. Its field testing indicated 42, 40 and 38% reduction in whitefly at 860, 760 and 550 PTO rpm, respectively.

Intra-cum-inter row weeder for orchards: The tractor operated intra-cum-inter row costly weeders are imported in India and are used by a few grape and pomegranate growers. A low hp tractor operated intra-cum-inter row weeder was developed. The overall dimension of the machine is $1070 \times 700 \times 800$ mm. It is easy to extend and retract the rotary unit by swiveling action of hydro-mechanically controlled sensor. It was tested in farmers' orchard (2 ha) of pomegranate in Ahmednagar district and grapes orchard (1.5 ha) in Nashik district. The effective field capacity of the machine is 0.17 ha/h with 89% field efficiency in pomegranate orchard and 0.15 ha/h with 81% field efficiency in grape vineyard. The weeding efficiency of the machine is about 95%. There is net saving of ₹ 1,775/ha and ₹ 1,480/ha in pomegranate and grape vineyard, respectively, over traditional method.

Ginger harvester-cum-elevator: Ginger is cultivated in an area of 29,300 ha with total production of 109,300 tonnes in Karnataka. The conventional method of harvesting ginger rhizome is labour intensive (240 man-h/ha), which increases total harvesting cost due to higher wages during peak season. A tractor operated ginger harvester-cum-elevator was developed. The overall dimension of machine is $1.88 \times 1.55 \times 1.15$ m. It consists of digging blade, ground wheel and elevator. The conveying system is provided with arrangement for removal of soil clods in between mild steel rods. The maximum soil separation index was found at 20° angle of elevator. The maximum conveying efficiency of 99.7% is observed at 1.25 speed ratio of elevator and 20° angle of elevator. The effective field capacity and field efficiency of the harvester is 0.18 ha/h and 82%, respectively. The cost of operation using developed equipment is ₹ 910/ha as compared to ₹ 2,205/ha in manual digging. The saving in cost and time of digging by developed equipment is 59% and 86%, respectively, as compared to manual digging excluding collection and transportation. Its cost is approximately Rs 80,000.

Low heat grinding machine: A low rpm grinding machine (60–70 rpm) was developed that can be operated by a pair of bullock or single camel through rotary transmission system. It consists of main frame made of MS channel, beam and ring gear with 72 teeth, pinion with 8 teeth, driving shaft and grinding unit. Driving shaft is connected to the beam for supplying the animal power. The grinding machine is installed in a circular pit and grouted with foundation bolts. A camel is hitched to the beam to supply the power to the driving shaft and studies were conducted by using a camel weighing 505 kg for grinding wheat. The draught requirement is in the range of 600 to 680 N. The temperature of the wheat flour ranged from 21 to 24°C while the temperature of wheat flour from electric grinding machine varies from 52 to 56°C .

Alert system for chaff cutters: A sensor based

warning system, which alerts as soon as human limbs approach a dangerous area of chaff cutter or moving blade of the chaff cutter, was developed. The system helps in generating alert once human fingers/ hand is detected beyond danger zone. PIR Sensor is fixed on the frame in such a way that it faces the feeding chute area. The PIR sensor was tested for its efficacy and effectiveness with different subjects S1, S2 and S3 and the output in terms of digital value (ADC – analog to digital conversion) 77, 83, 80 and signal in milli volt (mV) 377.59, 408.54, 393.90 was recorded.



PIR sensor based alert system for chaff cutters

Finger millet thresher: Threshing of finger millet is one of the critical operations. Traditionally, the threshing of finger millet is performed by three different methods, manually beating with sticks, bullock drawn stone roller and tractor drawn stone roller. These methods are labour intensive with low output, uneconomical resulting low quality products. Based upon requirement of threshing and pearling action, a thresher has been designed and developed by BSKKV Dapoli Centre. The equipment was tested at different throughput capacity, concave clearance and cylinder peripheral speed. The optimum values of the feed rate, concave clearance and cylinder peripheral

Improvement of visibility of tractor cabin for operators

The tractor cabins provide weather protection to operator against sunshine, rainfall and other harsh conditions. It also protects operator with higher noise level especially if tractor driver is working for long working hours. A tractor cabin using the criteria of optimum space layout, was developed and fabricated with the help of a local manufacturer. The cabin was evaluated for its benefit as a safeguard against health hazards like noise, dust, ambient temperature, relative humidity, etc. for which its benefits were quantified. It was found that owing to its design the visible area to operator was lower as compared to normal tractor (without cabin). Area not visible to tractor operator was found to be 159.79 m^2 . The modifications in existing design resulted in increase of transparent area by 29.71, 59.41 and 38.76% in the modified tractor cabin towards front, rear and left and right side, respectively. An overall improvement of 40.48% was achieved in the transparent area after making all the design changes in the existing tractor cabin. Area not visible to tractor operator improved from 159.79 m^2 to 102.89 m^2 with modifications in tractor cabin.





speed was found to be 36 kg/h, 5 mm and 7.12 m/s. The cleaning parameters, viz. sieve slope, stroke length and stroke frequency were also optimized. The sieve slope 3.50°, stroke length 20 mm and frequency 400strokes/min was found to be optimum. The developed thresher was tested with Dapoli1 variety of finger millet crop having moisture content and grain straw ratio as 11% (db) and 3:1, respectively. The threshing efficiency, pearling efficiency, grain damage, cleaning efficiency, total grain loss and energy consumption were recorded as 99.5%, 99%, 0.7%, 97.5%, 1.6% and 0.7 kWh, respectively.

Development of two row disc type ratoon management device: The cultural operations, ratoon initiation operations, were performed in the field free from sugarcane trash. Now-a-days, sugarcane trash is left in the field after harvesting. For carrying out ratoon initiation operations, prototype of a new machine, tractor operated two row disc ratoon management device, was developed. Main feature of the machine was its off barring discs which perform efficiently even in the field having leftover surface trash. Field capacity of the machine was 0.30 to 0.35 ha/h.

Animal draught power

Weeder-cum-fertilizer applicator: The developed, animal drawn weeder-cum-fertilizer applicator is suitable for top dressing of granular urea in widely spaced crops, such as cotton crop planted at spacing of 900 mm × 600 mm. There is provision to vary application rate of urea by changing exposure length of fluted roller as per requirement. It applies fertilizer at a distance of 78±9 mm from plant, whereas average length of fertilizer band was 9.5±1.3 mm. The field capacity, field efficiency and draught of implement at forward speed of 1.8 km/h are 0.12 ha/h, 74.9% and 450–600 N, respectively. Also, the fertilizer application efficiency is 91% and weeding efficiency is 84.5%.

Production and post-harvest operation of maize: A package of bullock drawn implements comprising MB plough, stubble collector, seed drill, fertilizer applicator-cum-ridger and maize dehusker-cum-sheller were



Bullock drawn implements for production and post-harvest operation of maize

developed for hilly terrain. The field capacity of MB plough is 0.02 ha/h with 65.8% field efficiency. The field capacity of stubble collector, used to remove the stubbles and weeds from the field prior to the sowing operation, is 0.17 ha/h with 72.0% field efficiency. The field capacity of the seed drill is 0.13 ha/h with 62.4% field efficiency. The bullock drawn fertilizer applicator-cum-ridger is operated for simultaneous application of fertilizer and ridging in two rows which have the actual field capacity of 0.04 ha/h with 61.5% field efficiency. A bullock operated (rotary system) maize dehusker-cum-sheller was developed with an output of 150 kg/h and shelling efficiency of 95%. This package of animal drawn implements was demonstrated to tribal farmers. They used implements and found that the saving in time of sowing is about 15–20% and in labour cost of weeding 25–30% as compared to traditional practice.

Multi-crop planter for intercropping: Animal drawn multi-crop planter for inter-crop of selected crops namely soybean and pigeon pea, wheat and mustard, wheat and black gram and linseed and coriander was developed. It was tested for 4 sets of intercropping, viz. soybean and pigeon pea, wheat and mustard, wheat and black gram and linseed and coriander. The row to row spacing is adjustable and can be kept as 200, 300, 400, 450 and 500 mm. The draught requirement and power output to pull the implement is about 410 N and 0.22 kW, respectively. Field capacity of the planter is 0.28 ha/h with field efficiency of 84.7% at an operating speed of 1.89 km/h. The unit cost of the developed planter is about ₹ 12,500, and its cost of operation is ₹ 270/ha. The operational energy requirement is 50 MJ/ha.

Fish dressing platform: Women workers carry out fish dressing and peeling in sitting postures. They use

Postural support system to reduce load in bending posture

The acute lower back disorder occurs due to awkward and continuous bending in manual agricultural activities such as weeding, rice transplanting, uprooting of crops, plucking of fruits, etc. A study was undertaken to observe physiological and postural parameters at different work place heights. The twisting velocity of spinal cord values ranged between 2 degrees/sec and 6 degrees/sec in standing posture and 9 and 36 degrees/sec and maximum lateral velocity ranged from minimum of 18 degrees/sec (straight) to maximum of 50 degrees/sec at severe bending posture. This increase in heart rate from 88 to 110 beats/min and energy expenditure varied from 1.30 kcal/min to 2.78 kcal/min when working height reduced from 100 cm to 10 cm. A postural support system with plastic belts and plastic mould system was developed, which gives back support as well as transfers some of the load on back to legs of the worker. This reduces the overall discomfort to the operators.





crates as desk and work in squatting posture, which causes discomfort. Also their sitting posture during fish dressing operation causes leg pain, back pain etc. problems thereby reducing the work efficiency, capacity and aggravate their health issues. Therefore, a fish dressing platform was developed. The optimum hand reach envelope and relevant anthropometric body dimensions were considered for proper workplace layout (placement of raw material, finished product and cutting blade) in fish dressing operation. Based on hand reach envelope, the fish dressing platform was developed. It is 1,100 mm long and 660 mm wide, and selected on the basis of reach envelope. The height was kept adjustable between 630 mm and 700 mm and the cutting blade was kept at 405 mm from SRP.

Muffler for a 45 hp tractor to achieve low noise level: New mufflers with 4 and 6 mm hole diameter were developed and tested based on the parametric studies. Pipes of all chamber have the same diameter. Perforations on the pipe introduce multiple path for acoustic waves to propagate. The large diameter of perforations provided more open area ratio, which enables in reducing exhaust back pressure. Designed muffler produced 2.45 kPa and 4.9 kPa exhaust back pressure with sound pressure level of 98.11 dBA and 96.97 dBA, respectively. These both designs reduced sound pressure level and exhaust back pressure well, compared to existing muffler. Designed new muffler having 4 mm perforation diameter showed 1.05% noise reduction compared to the existing muffler with 33.78% less exhaust back pressure. A new muffler with an absorptive muffler resonator was also developed to achieve reduced noise level. Test result of the designed muffler showed that it is able to reduce noise by 2.4 dB, which is 2.45% as compared to existing muffler. The testing of mufflers of 6 mm perforated diameter improved transmission loss in lower frequency zone and reduced exhaust back pressure as well.

Air blast sprayer for tall palms: A prototype of an air blast sprayer mounted on a 20 BHP mini garden tractor which delivered up to a height of 25 m was developed.

Solar energy integrated mobile mushroom cropping chamber: A solar energy integrated mobile mushroom cropping chamber which can hold 80 RTF

A guidance system for agricultural tractor

The conventional practices of tractor manoeuvring pattern and turning methods are widely used in our country because these practices are very convenient for the operator to follow. An RTK-GNSS navigation system and an android-based application system were developed to show the real-time tracking of the tractor. An algorithm for finding alternate fieldwork patterns was developed, which is also simulated for different implement widths and different field sizes. The simulation results indicated that the conventional fieldwork patterns are economical for implements having a width of less than 0.8 m, whereas alternate fieldwork patterns are economical to the implements having a width of more than 0.8 m.

Automatic irrigation system for rice

Rice, a water intensive crop, is commonly cultivated under submerged condition and remains under ponding water for 80% of crop duration. The existing automated irrigation systems are based on soil moisture measurement, which fail to recognize the moisture level beyond the 100% saturation level. The automatic irrigation system, designed for alternate wetting and drying (AWD) method of irrigation, detects ponding water in rice fields. It can detect water level and transmit signal to the controller wirelessly. The controller unit is programmed to operate the pump based on the desired water level in the field at different crop growth stages. Manual colour based system for water level (above and below soil surface) indicator in rice field was also developed. Farmers can operate their pump after seeing the status of water in the rice field. Both the systems were evaluated and the results were compared with the farmers' practice of rice cultivation. The irrigation water productivity of 6.15, 5.71 and 3.06 kg/ha.mm, and the total water productivity of 4.80, 4.49 and 2.63 kg/ha.mm were recorded for automated, manual and control (farmers' practice) system, respectively. Rice yields of 4.8, 4.6 and 4.1 tonnes/ha were obtained for automatic, manual and control system, respectively.

bags and produce 15–20 kg of fresh mushrooms in 20 days cropping period was developed. The average monthly mushroom yield is up to 25–28 kg. The technology has been licensed.

Automated fumigation chamber for treatment of grapes with SO₂ and CO₂

Indian exporters of grapes are facing problems in

Annular core biochar reactor

The annular core biochar reactor with a capacity of 50 litre is an excellent instrument for making biochar in pilot scale. It is heated by an electrical heater of 8 kW. The concept of two side radial convective heating was invented to heat biomaterial placed in an annular core cassette to gain the uniform temperature distribution across the biomaterial bed. It can be customized for reactor capacity of 20 to 100 litre and for heating capacity of 4 kW to 12 kW. The electrical wiring is given in such a manner that in case of malfunctioning/ non-operation of one heating element the system will not stop and biochar experiment will be continued using the heat from other working elements. Electrical load is distributed in such a manner that full load can be put on single phase supply. Panel precisely controlled the system temperature ($\pm 2^\circ\text{C}$) accurately to the desired set temperature, nullifying the effect of thermal inertia. The system was tested at different temperature levels and for different crop residues. The average recovery of biochar ranged from 30–40%. Developed unit has the merits for dominant convective heating mode, precise thermal regulation, two side heating of the biomaterial bed for uniformity, radial heating, easy replacement of heating elements, current leakage protection and outflow gas control.





Performance of rice and wheat crops under different micro irrigation systems

Studies on the effect of different micro irrigation systems on rice (Pusa 1121) and wheat crop production were continued in the consecutive third year (2018–19). The experimental treatments are conventional irrigation, drip irrigation, rain hose, portable sprinkler and drip irrigation plus plastic mulching. In case of rice, under conventional irrigation, all conventional cultural practices were followed, whereas in remaining treatments, cultivation practises of System of Rice Intensification (SRI) were adopted till transplanting of the crop. After transplanting, irrigation treatments were imposed.

Rice: Analysis of data on rice crop performance under different micro irrigation systems stated highest yield of 4.70 tonnes/ha under drip irrigation. However, highest water productivity of 1.04 kg/m³ was obtained under the drip irrigation treatment plus plastic mulched rice crop. The different crop growth and yield parameters under various irrigation methods are as follows:

Wheat crop: Analysis of data on growth and yield parameters of wheat crop have stated highest plant height (96.50 cm) and effective tillers (492) under drip with mulch, followed by drip irrigation and lowest under flood irrigation (86.26 cm and 380 cm). The yield attributes, viz. ear head length, ear head weight, no of grains/ear, and 1,000 grain weight were recorded the highest in drip with mulch. The highest yield and water productivity of 6.05 tonnes/ha and 2.20 kg/m³, respectively, were observed under drip irrigation with mulch whereas the lowest were recorded under flood irrigation (4.62 tonnes/ha and 0.66 kg/m³). The findings indicated improvement in grain yield and water productivity of rice and wheat under micro irrigation systems over conventional methods of cultivation.

Growth and yield parameters of rice under different irrigation systems

Parameter	Conventional	Drip	Portable sprinkler	Rain hose	Drip + mulch
Plant height at maturity (cm)	88.5	94.5	90.2	92.3	95.0
No. of effective tillers/m ²	21.1	42.3	20.5	26.5	41.2
Number of seeds/panicle	98	133	95	111	124
Yield (tonnes/ha)	3.58	4.70	3.50	3.90	4.54
Straw yield (tonnes/ha)	4.16	4.59	4.02	4.30	4.48
Water productivity, 0.39 kg/m ³	0.75	0.45	0.52	1.04	

Growth and yield parameters of wheat under different irrigation systems

Parameter	Flood Irrigation	Drip Irrigation	Sprinkler Irrigation	Rain hose Irrigation	Drip + mulch
Plant height at maturity (cm)	86.26	95.42	86.30	92.50	96.50
No of effective tillers	380	478	445	471	492
Ear head weight (g)	3.24	3.36	3.19	3.50	3.62
No of grains/ear	62	75	66	79	81
Yield (tonnes/ha)	4.62	5.15	4.79	5.67	6.06
Water productivity (kg/m ³)	0.66	1.78	1.49	1.67	2.20

exporting grapes due to phytosanitary requirements. New Zealand and Australia are the major importers of Indian grapes. As per phytosanitary requirements formulated by New Zealand, *Drosophila suzukii* is considered as an invasion insect, which causes severe qualitative and quantitative losses. Fumigation is one of the most effective ways to manage pests in stored grapes. In this regards, fumigation chamber and standardization of protocol for fumigation of grapes is needed. Keeping in view, a fumigation chamber was designed, fabricated and established. The fumigation chamber has capacity of 1.50 tonnes grapes (one pellet) at a time. The chamber is divided into two parts namely, fumigation chamber and Ante room (small room for placing the gas cylinders and gas release system), which are connected by an electronically controlled door. All the operations of the fumigation system are controlled from an electronic control panel, which is fitted outside the chamber. The parameters are displayed through LED display and controlled by a BMCS (building management and control system) program specifically prepared for this fumigation

system. The chamber was tested at full load using CO₂ and SO₂. It was found effective by achieving complete mortality of insects. A model fumigation chamber has been established at M/s Sahyadri Farmers Producer Company Limited, A/P Mohadi, Nashik (Maharashtra). The chamber is ready for commercial exploitation, which will be useful for grape exporters.

Micro algae harvesting system: Harvesting of micro-

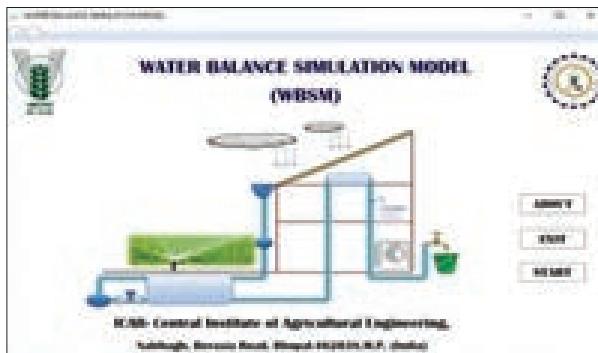


Micro algae harvesting system



algae is a difficult task as it is hard to separate from water. Electro-chemical flocculation method was used to harvest micro-algae. A system was developed, which includes a 2.5 m³ transparent rectangular tank, voltage excitation arrangements and electrodes. The electrical current was supplied through 6 aluminium electrodes for electro-chemical flocculation. The current initiated the neutralization of algal cells by Al³⁺ cations and caused flocculation of algal cells which floated on top. Harvesting efficiency of 93% was observed using this method with an energy consumption of 2.71 kWh/kg.

Assessment of reliability of rainwater harvesting system: The rooftop rainwater harvesting (RWH) is an effective strategy to meet the increasing demand of



freshwater in water scarce regions. A Water Balance Simulation Model (WBSM) was developed to simulate the performance of RWH system under different climatic regions. The model considers daily rainfall, losses due to leakage/spillage, roof area and daily water demand as input parameters. The model determines the optimum tank size and analyses the liability and water saving

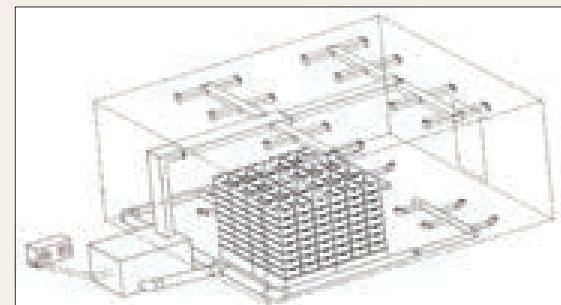
Low cost farm level milk cooling system

In the first phase of the study, environment test chamber was designed so as to allow for testing of refrigeration system round the year without having a significant effect of seasons. The purpose of the test chamber was to evaluate the refrigeration system of low cost farm level milk cooling system. The testing chamber has provision for venting to enable complete exposure to the external environment, if required. The temperature of the system can be elevated up to 48–50°C to simulate severe hot weather conditions. An automatic temperature controller, monitors and regulates the temperature. Refrigeration system was designed and installed in the test chamber of milk cooling system. The cooling tank was installed outside the test chamber. A multiple channel data logger was installed to record temperature of test chamber.



Controlled storage structure for onion

A controlled storage structure ($27 \pm 2^\circ\text{C}$ and RH of 60–65% with air circulation system) of 2 tonnes capacity for onions was designed and developed under Public Private Partnership mode. The total losses were 7.14% in controlled storage structure as compared to 54% losses in ventilated storage structure without any control of temperature and relative humidity.



Design of controlled storage structure

efficiency of rainwater harvesting system. It also estimated various parameters such as inflow volume, storage, release, spillage (tank overflow), deficit, cumulative deficit, cumulative demand and deficit rate. The developed model analyzes the combination of different roof sizes, demand and tank sizes for planning, design and implementation of RWH system in a different climatic region.

Solar energy for FCV tobacco curing: A polycarbonate chamber on roof-top of tobacco curing barn (24'×16'×10.6') was designed and developed to make use of solar energy through greenhouse effect for reducing the wood consumption in curing FCV tobacco. Polycarbonated roof chamber, increased the leaf temperature in all the layers, especially in top layers of the barn. Fuelwood to an extent of 22.0–25.0% could be saved with polycarbonate roof barn when compared to traditional barn.

Frying oil quality management: A test rig was developed and fabricated to carry out study on quality of ghee during frying. During trials of frying oil test rig, it was observed that the operating environment was smoky. The test rig was upgraded with a smoke removal mechanism. Electrical properties measurement unit was developed using parallel plate system, two wire system and two rod system. The purpose of this unit was to select and optimize the sensor for measuring properties of oil. The fryer can be cleaned by rinsing with any alkali to remove any tar buildup on the surface.



10.

Post-harvest Management and Value-addition



Manually operated small onion grader: Grading of small onion or multiplier onion (*Allium cepa* var. *aggregatum*), one of the most important commercial vegetables grown mainly in southern India according to their sizes adds value to the product and economic gain to the farmer while marketing them. The optimum operating parameters of the developed grader are—rotational speed of drum, 15 rpm; slope, 4° and feed rate, 200 kg/h. The grading efficiency was 93.1% and there was no damage of onions at the optimized operating conditions. Grading to uniform sizes will increase the market value both in domestic and export markets.



Manually operated small onion grader

Onion de-scaler: Individual onion is cleaned with removal of its dry peel and infected onions during storage and marketing of onions. The manual operation is labour intensive and time consuming. The newly developed descaler mechanizes this operation, reduces drudgery and cleans onions effectively. The machine has facility to sort out infected/rotten onion bulbs during its de-scaling operation with one labour employed for inspecting. The machine works successfully with removal of dry peel effectively without any damage to onions. Its capacity is about 350–400 kg/h of onions and requires 1.5 hp electric motor. The roller speed of 300–350 rpm and slope of 3° is suitable for better operation of the machine. The de-scaling efficiency is more than 90%.

Modular system for onion storage: Storage of onions especially during rainy season leads to great losses due to fungal rot, sprouting and physiological weight loss. Losses to the tune of 30 to 40% during a period of 4 months were reported. A modular storage system having capacity of 1 tonne and consisting of a storage structure,

sensor controlled aeration unit and fumigation unit was developed. The structure was evaluated for storage of *rabi* onion harvested in April. The storage study was conducted up to harvesting of *kharif* season onion, i.e. till second week of October. The results indicated 9.97% weight loss, 1.73% rotting and 0.16% sprouting in the stored lot of onion at 120 days storage. This is much less than 18.75% weight loss, 13.22% rotting and 1.92% sprouting as reported by other studies for same storage period. Further, over a period of 180 days, the losses were recorded as 20.30% weight loss, 5.07% rotting and 0.67% sprouting. The storage structure is rust proof and hence expected to have long life and durability. Since the aeration and fumigation units are required intermittently for one storage unit, the same can be used to serve multiple storage units of similar capacity. Approximate cost of the structure with sensor network (excluding blower) is about ₹ 16,000. Moreover, time required for filling up and emptying the storage bin is about 0.83 man-h/t and 0.4 man-h/t, respectively, as compared to 1 man-h/t and 3 man-h/t in case of conventional structures.

Abrasives pre-treatment machine for grape berries: A novel abrasive pre-treatment system was developed for grape berries for the production of chemical free (organic) raisins. The protrusions of abrasion provide superficial abrasion with removal of waxy (cuticle) layer of grape berries that obstructs drying. The machine has a capacity of about 150 kg/h. The drying time for different varieties reduced from 4 to 7 days in solar tunnel dryer and 2 to 3 days in hot air drying (temperature 50°C) compared to existing method that requires around 15 to 20 days for preparation of good quality raisins. Nowadays consumers are more conscious about health and demanding safe and organic food, and the developed machine has potential applications for the preparation of organic raisins.

Infrared pre-treatment system for pulse milling: Removal of husk from cotyledon is the foremost requirement to utilize legumes as dals. The husk is tightly bound with cotyledon. Therefore, pre-treatment is necessary for loosening of the bond prior to milling. Hydro-thermal treatment, one of the commercially used treatments, is time consuming, resource intensive process and also requires space and energy for drying. A controlled heat based infrared pre-treatment system was developed, which is a more cost-effective option. The equipment has provisions for controlling exposure time and power density/heat flux of the treatment. The same prototype could be used for infrared treatment of multiple





Infrared pre-treatment system for pulse milling

grains at desired experimental conditions. The machine has output capacity of about 200 kg/h.

Production of soy chaap: Soy chaap was prepared in 27 combinations using Mixture Simplex-Lattice design. The amount of gluten was fixed. Soy nuggets, defatted soy flour and wheat flour were in different combination so that the ratio of gluten and other ingredients was 1.7:1. The soy chaap, which spoiled within 1 day at room temperature, after 3 days under refrigerated condition, remained in good condition till 24 days in freezer. Soy chaap kept under sterilized condition is in good condition till 30 days. Soy chaap prepared with a combination of soy nugget, DSF and wheat flour in the ratio of 40:40:30 has better acceptability than other combinations.

Classification of maize kernels: Presence of aflatoxins in maize is a serious threat to food safety. Currently acceptable methods for detection of aflatoxin concentration in food products are laboratory based and require high time, skilled personnel and hence expensive. A rapid and easy method of aflatoxin detection was developed in which Vis-NIR hyperspectral imaging system with wavelength between 400–1000 nm was successfully used to classify the maize kernels based on

Detection of pesticide residues in milk and other food products

Paper strip assay for pesticide residues in milk was developed. The approach is unique and has been attempted for first time. Paper strip assay can detect different group of pesticides, i.e. organo-phosphorous, carbamate, fungicide and herbicide within regulatory limits. Extraction protocol was optimized using novel alternatives. Assay is cost effective, robust, reproducible, sensitive, selective and giving result in real time compared to chromatographic techniques.

The test can detect pesticide residues at trace levels in food matrices. The technology can be applied successfully to screen water, raw, pasteurized, dried milk, processed fruit juices, cereal based foods, feed, fodder, fermented feed, soil, in dairy farm for different pesticide groups (OP, OC, carbamates, fungicides, herbicides) complying codex/ FSSAI regulatory limits. The technology has been commercialized for regulatory compliance of dairy products.

the concentration of aflatoxin. At 508 nm and 580 nm, maize kernels could be distinguished into healthy and infected. Application of defined protocol could enable detection of aflatoxin infected maize kernels within a few seconds.

Post-harvest handling and value-addition

Low glycemic flour: A process for extraction of starch from cooking bananas such as Nendran with 90% purity and methodology for low glycemic products like pasta, bread, doughnut, etc. was developed. The product is suitable for making baby food and health improving fortified powders also.

Nagpur mandarin: An optimized process for ready-to-serve beverage and spray-dried powder from Nagpur mandarin juice was standardized.

Spray dried avocado powder: The process for spray drying of avocado pulp was standardized. The finished product is stable for more than three months at room temperature. The cost : benefit ratio is 1:1.78.

Aonla: The process for preparation of 'Aonla Prash', an aonla based formulation with therapeutic uses was standardized. The process for sugarcane juice blended with aonla and flavoured with lemon, ginger and cumin was standardized.

Post-harvest handling-cum-storage box for ber

A handling cum storage box (23 cm × 23 cm × 4 cm) using three ply corrugated fibre board (CFB) with 1% ventilation was designed for improving the consumer appeal and acceptability of ber fruits. The designed box could hold 750–800 g of fresh ber fruits. Freshly harvested mature green ber fruits (Kaithli) could be stored for four days under ambient conditions. The top cover of the box has a transparent window slit (10 × 8 cm) showcasing the freshly packed ber fruits.

Mango: The process for preparation of instant raw mango peel based soup powder containing 52.6 mg vitamin-C and 944 mg phenolics/100 g powder formulation was standardized. The process for raw mango candy of commercial varieties, viz. Dasheheri, Totapuri and Mallika with TSS ranging from 66.5 to 73.5 °B was standardized.

Cashew: The process for cashew apple crisp, an extruded product prepared from cashew apple pomace powder for diversified uses during off season, was standardized. The optimum quantity of cashew apple powder in cashew apple crisp ranges from 5–25% along with corn flour and rice flour. Process for preparation of cashew apple chew and cashew apple fig were also standardized.

Brahmi and ashwagandha squash: The process for preparation of brahmi (*Bacopa monnieri*) and ashwagandha (*Withania somnifera*) squash, brahmi enriched aonla and dill flavoured squash with 6 months storage life were standardized.

Quince candy: A process for preparation of candy from quince with shelf life of nine months with respect to colour, texture and taste was standardized.





Bean to bar chocolate making: A complete processing protocol from cocoa bean fermentation to chocolate bar making using coconut sugar was developed for chocolate making at home scale. Using response surface analysis optimized combination of cocoa liquor and cocoa butter at 30% coconut sugar was found ideal for bean to bar chocolate making.

Coconut: A prototype for tender coconut trimming was developed. Preservation protocol for trimmed tender coconut was optimized, and the technology commercialised. Frozen coconut delicacy, a vegan based coconut product, was developed. A pilot level plant for frozen coconut delicacy production was installed at ICAR-CPCRI, Kasaragod.

Commercialization of technology: An MoU was signed with M/s Hadapsar Bakery, Pune to commercialize the technology for the preparation of cookies using pomace of Manjari Medika grapes.

Synthesis of nano curcumin: A sonication based protocol for nano-curcumin having 2.5 fold increased solubility in both water as well as in virgin coconut oil was standardized. It exhibits 20% improved antioxidant activity and could be used as an enhanced bio-available formulation of curcumin.

Mushroom: A technology for mushroom fortified mushroom chutney powder, from dry oyster mushroom was developed and licensed. It contains traditional healing herbs like brahmi and drumstick leaves and flax seeds, sesame seeds, groundnut and coconut. It has 3 months shelf-life in airtight containers/pouches at ambient temperature. A process for mushroom soup mix was developed with 30% oyster mushroom powder, 30% corn flour, 25% milk powder, 8% salt, 3% sugar, 2% black pepper, and 2% oregano. A process for mushroom multigrain bread was also developed with 5% oyster mushroom powder, 85% refined wheatflour, 6% whole wheat flour, 2% ragi flour, 2% oatmeal, and 1% flaxseeds. The process for value added, mushroom fortified health drink powder was developed containing 10% oyster mushroom powder, 10% malted ragi, 20% whey-protein, 30% milk powder, 20% sugar and 10% cocoa with overall 8.17 acceptability score.

Post-harvest handling of mushrooms: Chemical treatments (0.3% citric acid and 0.3% ascorbic acid) were found optimum for shelf-life extension of white button (*Agaricus bisporus*) and oyster mushrooms (*Pleurotus* spp.) during storage. In packaging, 200 and 400 g capacity bags with 0.5% vents was observed better for retention of quality of white button mushroom.

Milk

Detection of vegetable fat in milk fat/ghee: Droplet Digital PCR (ddPCR) assay, a method for performing digital PCR, is based on water-oil emulsion droplet technology. The massive sample partitioning is a key aspect of the ddPCR technique. Mitochondrial cytochrome b gene was used for cattle and buffalo DNA detection and chloroplast trnL gene for vegetable (plant) DNA in the ddPCR assay. This sensitive technique was

Technologies Transferred

1. Strip based test for detection of urea in milk.
2. New colour based test for rapid detection of detergent in milk.
3. Strip based test for detection of glucose in milk.
4. A new strip based test for detection of sucrose in milk.
5. Anionic mineral mixture for reducing post-partum problems in cattle and buffaloes.
6. Spore based kit for detection of antibiotic residues in milk at dairy farm.
7. Technology of sour dahi using prolific acidifying lactic cultures.
8. Process technology for palada payasam mix preparation by dry crystallization method in a mechanical unit.

exploited to detect few copies of the buffalo fat DNA and vegetable fat DNA in cow milk fat.

Gluten-free pasta: Durum wheat semolina flour containing gluten is the ideal source for preparation of pasta. It is difficult to find a perfect alternative to replace techno-functional role of gluten in the pasta. An attempt was made to develop gluten free pasta from depigmented pearl millet flour in combination with milk proteins, hydrocolloids and transglutaminase (TG) enzyme. The rennet casein added pasta samples had superior quality than sodium caseinate added pasta samples. Inclusion of whey protein concentrate (WPC) further improved the cooking and textural properties of pasta, but not sensory properties. Addition of hydrocolloids and TG affected the properties and were useful in development of gluten-free pasta. The selected formulations were subjected to different drying temperatures to improve the quality of gluten-free pasta. The gluten-free pasta packed in metallized polyethylene and stored at 38°C/90% RH was acceptable till 45 days of storage. The cost of production of 1 kg of TG- and hydrocolloids-added gluten-free pasta ₹ 269.93 and ₹ 268.00, respectively.

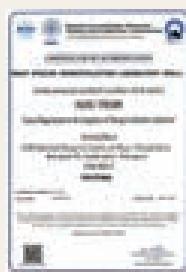
Buffalo milk protein concentrate 60 (BMPC60): milk protein Concentrate 60 (MPC60) powder was manufactured from pasteurized buffalo skim milk (PBSM) followed by its characterization for physico-chemical, functional and reconstitution properties. The standardized UF retentates obtained after salt addition or from carbonation of milk/UF retentate were spray dried to obtain treated MPC powders with improved functional properties. The applied interventions, i.e. salt addition and carbonation significantly improved the solubility (by 15–20%) of resultant fresh powders over control powder. Rheological modelling and micro-structure of all MPC powders were also studied. It was observed that after 12 month of storage, solubility of control and optimized MPC60 powders decreased, but rate of decrease was drastic in control powder. During storage, solubility, dispersibility, flowability, foaming, oil and water binding properties of control and optimized powders showed a decreasing trend while noticeable increase was observed in their hydroxy methyl furfural (HMF) contents.





NABL Accreditation of Meat Speciation Laboratory

The Meat speciation laboratory of ICAR-NRC on Meat, Hyderabad, was accredited by National Accreditation Board for Testing and Calibration Laboratories and awarded with "ISO/IEC 17025: 2005 certificate".



Camel milk products

In order to promote use of camel milk, different consumer friendly value added products were prepared. The protocol for production of good quality paneer from blends of camel and goat milk was standardized.

Meat

Detection and quantification of tissues in meat products: Unique, common and differentially expressed miRNAs were identified to develop tissue specific diagnostic assays. A complete panel of 22 miRNAs was selected for downstream applications and were classified as Reference miRNAs and Rank I, Rank II and Rank III based on the suitability for using in meat (skeletal muscle) and organ (liver, heart, gizzard) mixtures. All Rank 1 primers along with reference miRNAs were validated for differential expressions using RT-qPCR. Promising results in terms of miRNA tissue specificity were observed from the experiment to develop tissue specific diagnostic platform that detect the presence of organ meat/tissue in skeletal meat. Further, validation of miRNA platform in commercial meat products is in progress.

Bioactive peptides: Use ginger as a natural source of protease in comparison with other commercially available enzymes to extract and characterize antioxidant and antihypertensive hydrolysates from water buffalo liver, a protein rich offal was attempted. Hydrolysis of sarcoplasmic protein extracts from buffalo liver using proteinase-K, pronase-E and ginger protease significantly increased the % degree of hydrolysis and generated low-molecular weight peptides. Enzyme treated hydrolysates exhibited significantly higher DPPH radical scavenging activity and ACE inhibitory activity. Mass spectrometric analysis (MALDI-TOF MS) of selected gel-filtered fractions identified the proteins that possess strong antioxidant activity.

Meat products in retort processing: Standardized

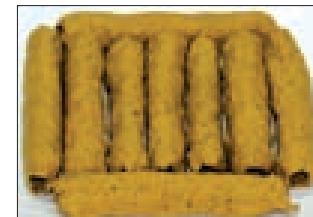
Cultured meat

Cultured meat is the meat produced by *in vitro* cultivation of animal cells rather than slaughtering of the meat animals. This technology allows meat to be cultured from cells in a fermentor or a bioreactor rather than harvested from livestock on a farm. A research project was conceptualized and implemented in collaboration with CSIR - Centre for Cellular and Molecular Biology, Hyderabad. This is the first research project in the country in the area of cultured meat production.

the retort processed goat meat curry, goat milk paneer curry, goat meat biryani and goat meat nugget, which can be kept on room temperature in retort pouch packaging for one year without affecting much nutritive quality at room temperature.

Poultry

Chicken seekh kebabs: For standardization of processing techniques in development of chicken seekh kebabs—a formulation was developed, processing conditions (particle size, mixing time and cooking time-temperature) were optimized, and selected natural preservatives for shelf-life enhancement were added. Added fat level of 8%, meat particle size of 4 mm, mixing time of 8 min and cooking time-temperature of 170°C for 10 min were best for processing of good quality seekh kebabs with desirable physicochemical quality and better sensory acceptability. Use of curcumin, eugenol and vitamin E @ 0.025, 0.02 and 0.04% levels was found most suitable. The product has shelf-life up to 20 days at 4±1°C.



Functional chicken seekh kebabs

Bone-in chicken pickle: In processing technology of bone-in chicken pickle brine, dipping method was used. During storage different physico-chemical parameters, microbiological quality and sensory evaluation were studied. The product has shelf-life up to 6 months at 27±2°C.

Wool

Lightweight quilt from coarse wool: Lightweight, soft and warm quilts were prepared from coarse wool. The protocol and mechanical device were developed to make uniform web from the raw and coarse wool fibres. The coarse wool and fine wool were mixed in the ratio of 75:25 to improve web quality. The delivery system of the semi-worsted card was modified to obtain a consistent and uniform web. The web of the desired thickness was converted into the quilt. The firmness to the quilt was imparted using a combination of different web layers, controlled felting of the web and stitching with a fine quality woven fabric. The subjective analysis of the quilt showed high rating (> 3.6 out of 5) for softness, warmth, breathability and comfort

Integrating production with processing and converting waste into wealth

A success story of a dairy start-up by Shri V. K. Narasimha Rao, Kulla Mallavaram village, East Godavari district of Andhra Pradesh, with total 375 dairy animals including 70 cows and 85 buffaloes in milk and milk processing plant of 2,800 litre/day capacity was documented. Apart from own dairy farm daily milk production of 1,200 litre, the company also procures 1,800 litre of milk daily from farmers. The main products processed on regular basis are pasteurised milk (1,800





litre/day), curd (300 litre/day) and butter milk (100 litre/day). Further, the products processed on demand/order basis include full cream milk, ghee, paneer and khoa. The integrated dairy farm encompasses Dairy Farm, Milk Processing Unit, Feed Mixing Plant, Bio Gas Unit, Bio Gas based Power Generation Plant, Vermi Compost Farm, *Azolla* Farm and Organic Vegetable Farm.

The by-products of the dairy farm such as dung and urine are collected systematically and used to produce biogas that is utilized to further generate electricity and cooking gas. The biogas plant has 6 digesters and generates biogas of volume 510 m³/day. It is partly used for power generation (600–800 units a day), while the remaining gas is processed to produce green cooking gas. The power generation plant is one of the biggest biogas based power generating plants in Andhra Pradesh. He has designed a system to flow a part of the digested slurry to feed his in-house agriculture farm as organic fertilizer and the remaining is converted to solid organic fertilizer. The liquid residue separated from the slurry is utilized to grow *Azolla* crop that acts as a good nutrient feed for the cattle. A part of the slurry is also used to feed the in-house vermi-compost facility. The annual vermi compost production is 180 MT and the annual organic compost, i.e. the slurry and dairy farm waste produced is 320 MT. In order to reduce the cost of milk production, the company started preparing self-formulated alternative cattle feed at farm by procuring good quality of all ingredients like maize, rice bran, groundnut husk, bengal gram husk, tapioca skin, wheat husk, palm oil, etc., in bulk from across the country. The success of the company in dairying has been possible only by integrating production with processing and selling products directly to consumers in the market and by proper utilization of dairy farm by-products like dung, urine, etc.

Shree Narsimha Rao has proved that dairying is profitable and sustainable with his “Integrated Dairy Farm, a complete cycle-a zero waste initiative” model. Apart from developing dairy farm, the company has also trained selective rural youth free of cost. He has provided Internship Training Programme to 17 students of Veterinary College, Tirupati. Government of India honoured him with “National Dairy Farmer Award” during Krishi Vasant in February 2014.

Fish

Antihypertensive extract (Cadalmin™AHe) from seaweeds: An antihypertensive nutraceutical (Cadalmin™ AHe) was developed from seaweed. It contains 100% natural bioactive ingredients extracted from selected seaweeds to combat pathophysiology related to hypertension. It effectively inhibits mediators responsible for causing hypertension. Cadalmin™AHe

is encapsulated in 100% vegetarian based hydroxypropyl methylcellulose capsules.

Biodegradable packaging materials: Incorporation of different types of clays namely, montmorillonite, halloysite and bentonite at 1–2% levels to polylactic acid (PLA) films enhanced its barrier properties. Blown films were suitable for packaging and chilled storage of different fish products and showed 100% reduction of *Staphylococcus aureus* at 72 h. PLA trays of 500 ml capacities with 0.65 mm thickness were developed by injection moulding. Trays stored at frozen temperature (−18°C) were acceptable only up to four months, after which they turned brittle and disintegrated. PLA trays were suitable for chill storage (2–4°C) and were superior to those of HDPE and bagasse. Further, PLA coated, palm sheath trays were superior compared to non-coated. By polymer coating water absorptiveness from inner and outer surface is reduced and durability for storage at low temperatures is enhanced.

Biodegradable films developed from fish myofibrillar protein extract along with sodium alginate, glycerol and microbial transglutaminase were suitable as edible packaging material or edible wrappers. These edible wrappers had better shelf life and were acceptable for packaging fish products.

Determination of contaminants in fishery products: For determination of contaminants in fish and fishery products, developed analytical methods, validated and accredited as per ISO: 17025 requirements for heavy metals and trace elements, methyl mercury, multi-class and multi-residue detection of antibiotic residues, multi-class and multi-residue detection of pesticide residues, formaldehyde, sodium benzoate, ammonia, total volatile base nitrogen, and ciguatoxin.

Species authentication: Developed a high-throughput method based on fourier transform infrared spectroscopy (FTIR) spectral fingerprinting and predictive chemometric modelling for species authentication of commercially important shrimps. The method was aimed at detecting economically motivated mislabelling of low value shrimp as high value shrimp species. Globally shrimp fraud is an issue of socio-economic importance and the method developed is towards tackling such fraudulent activity in seafood supply chain.

Portable fish freshness sensor: Developed a prototype of portable fish freshness sensor for mackerel. It analyses colour variations of eye during storage. Images were captured and processing was done. Hough transform circle detection, drawing contours, converting RGB to HSV (hue, saturation, value) and defining pupil region were executed. Simultaneously cross validation was done by analysing K-value, TPC and TFC during storage.



11.



Agricultural Human Resource Development

The generation and diffusion of technology and management capabilities for more intensive and modernized agriculture and supporting services have become imperative. This can only be achieved by upgrading by the quality of human resources employed in agriculture. To produce quality and competitive human resource, Agricultural Education Division implemented plan scheme titled “Strengthening and Development of Higher Agricultural Education in India”. This helps maintain, upgrade and ensure quality and relevance of higher agricultural education through partnership with State Agricultural Universities (63 SAUs), Deemed-to-be-Universities (4 DUs) and Central Universities (4 CUs) with Agricultural faculties under the National Agricultural Research and Education System (NARS). The council assists the AUs to plan and coordinate higher agricultural education in the country.

The scheme aims at enabling the 74 Agricultural Universities (AUs) to maintain quality of higher agricultural education through accreditation, periodic revision of courses, and helps attract talented students by providing support for various scholarships/fellowships, capacity building of faculty in challenging areas through Centre for Advanced Faculty training, Niche Area of Excellence, as well as through promotion of holistic higher education, viz. experiential learning modules, emphasis on improving and modernizing teaching and learning, infrastructure and student amenities, including those pertaining to sports and personality development.

Governance and quality assurance

Accreditation of agricultural universities: The National Agricultural Education Accreditation Board (NAEAB) started accreditation of agricultural universities. Total number of SAUs accredited till date are 59, faculties/ schools in central/state universities 8, and faculties/schools/ programmes accredited in private universities 7. The agricultural universities accredited during the year are: BUAT, Banda; CCSHAU, Hisar; MPKV, Rahuri; TNAU, Coimbatore; GADVASU, Ludhiana; CSK HPKV, Palampur; VNMKV, Parbhani; School of Agriculture, Lovely Professional University, Phagwara, Punjab; MAFSU, Nagpur; UBKVV, Coochbehar; Dr PDKV, Akola; AU, Jodhpur; IGKV, Raipur; Dr PVNRTVU, Hyderabad; KVAFSU, Bidar; DBSKKV, Dapoli; AMU, Aligarh; B.Sc.(Ag.) Programme in University College of Agriculture, Guru Kashi University, Bhatinda; M.S. Swaminathan School

of Agriculture, Centurion University of Technology and Management, Odisha; College of Agricultural Technology, Kullapuram, Theni, (affiliated to TNAU); University of Agricultural Sciences, Raichur; University of Agricultural Sciences, Dharwad; Punjab Agricultural University, Ludhiana; Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry (affiliated to Pondicherry University); Palli-Siksha Bhavana, Visva-Bharti, Sriniketan; College of Agriculture, Lembucherra, Tripura (affiliated to Tripura University); Faculty of Agriculture, Annamalai University, Annamalainagar; Faculty of Agricultural Sciences, Siksha ‘O’ Anusandhan (Deemed to be University), Bhubaneshwar, Odisha; and School of Agriculture, ITM University, Gwalior.

Ranking of agricultural universities: Ranking of agricultural universities was initiated to improve ranking of Indian universities in World University Rankings. Considering the unique position of agricultural education both excellence and relevance were taken into account for evaluation. The emphasis on parameters such as research product, research impact, research excellence, technologies transferred to farmers, spread/adoption of technologies and increase in agricultural growth in the area of jurisdiction of the university, etc. were also considered while evaluating the agricultural universities. It is expected that the process of ranking would help agricultural universities to self-assess themselves on the quality and enhance their abilities. The ranking process is done annually and top 3 universities are honoured on ICAR Foundation Day. Based on the evaluation, 60 agricultural universities were ranked and top three universities, viz. First ICAR- National Dairy Research Institute, Karnal; Second- ICAR Indian Agricultural Research Institute, New-Delhi; Third-G.B. Pant University of Agriculture and Technology, Pantnagar, were honoured on ICAR Foundation Day Award Ceremony held on 16 July 2019.

Student READY: The Fifth Dean’s Committee recommended Student READY (*Rural Entrepreneurship Awareness Development Yojana*) programme in the agricultural universities of the country. The programme is to reorient graduates of agriculture and allied subjects for ensuring and assuring employability and develop entrepreneurs for emerging knowledge intensive agriculture by articulating knowledge, skill, ability and experiences. Student READY programme is introduced as an integral part for one complete year in the last year of the degree programme for undergraduate education





Practical exposure of students—banana ripening during RAWE Programme AAU, Anand

in the disciplines of Agriculture, Agriculture Engineering, Biotechnology, Community Science (Home Science), Dairy Technology, Food Technology, Forestry, Fisheries, Horticulture and Sericulture. The Student READY programme consists of—Experiential learning (Business Mode); Hands on training (Skill Development Mode); Rural Awareness Work Experience (RAWE); In Plant Training/ Industrial attachment; and students projects. For building self-confidence in the agricultural graduates by honouring their professional skills is the key objective of introducing RAWE at the undergraduate level by ICAR. Under this component of student READY the students are exposed to the rural settings and work with the farmers, help them solve their problems and become aware of the challenges faced by those involved in agriculture and allied areas. Students are exposed to the opportunities and challenges in agricultural development. The UG students across AUs are exposed to farm planning, watershed programme, agro-clinics, KVKS, NGOs during their village stays and hence exposed to hands-on experience of these strategic areas and excellent opportunity to rediscover and connect with the farmers. They also help in analyzing the soil samples and make farmers aware of the latest agricultural implements and technologies. They also impart knowledge about latest crop protection methods as well as organic farming. The students visit the farms of highly progressive farmers and gain experience on managing commercial horticultural farms. This exposure of students helps them gain competence and confidence for solving problems related to agriculture and allied sciences. The students are also exposed to agri-industry in the region and even outside the region. Under RAWE 24,244 students were trained through council's support.

Experiential learning: Experiential Learning (EL) is another major components of Student READY programme, to promote entrepreneurship, and to train students to be 'job creators' through practical end-to-end approach in product development. Till date 465 modules have been developed/supported by the council in profitable areas. These modules were supported in the disciplines of agricultural engineering, agriculture, biotechnology, fisheries, forestry, horticulture etc.

The EL units were sanctioned to ANGARU, Guntur;



Students involved in fabrication of greenhouse, SKUAST-Srinagar

BCKV, Mohanpur; BUAT, Banda; CSAUAT, Kanpur; MPKV, Rahuri; NAU, Navsari; OUAT, Bhubaneshwar; PAU, Ludhiana; RAU, Pusa, Samastipur; RLBCAU, Jhansi; RVSKV, Gwalior; SKUAST, Jammu; UAS, Dharwad; and UHS, Bagalkot. The Experiential Learning units were supported in agri bio-inputs, mushroom spawn production, agricultural waste management through vermicompost, animal feed formulation and production, bee-keeping and honey production, breeder seed production of groundnut, plant tissue culture, organic farming, post harvest processing, nursery raising, seed production of carps, etc.

Human Resource Development

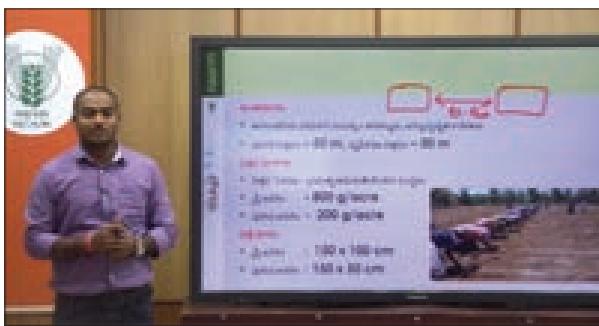
Teaching, research and capacity building

Niche Area of Excellence: Since inception 70 programmes have been supported out of which 55 programmes have been concluded and 15 are ongoing.

Significant achievements

- Digital courses are packaged with interactivity in compact format. Course on 'Veterinary Entomology and Acarology' was launched. E-learning website registered 3 lakh hits with highest monthly hit rate of 1,60,921. Two certificate programmes completed by the centre at NAARM, Hyderabad.
- National Reference Standard for rabies vaccine was developed. The calibrated inactivated rabies vaccine will be used as a standard vaccine for potency determination of the inactivated rabies vaccine. Developed antiserum against IBDV for potency testing of inactivated IBD vaccines. This antiserum will be supplied to other QC labs for testing of IBDV vaccines.
- Products based on canine-specific probiotic (*Lactobacillus johnsonii* CPN23) and polyphenols from Jerusalem artichoke- (JAE) and pomegranate peel-extract (PPE) were developed (Probiotic-PPE, Probiotic-JAE and Probiotic-PPE-JAE) and tested for shelf-life. The viability of the probiotic could be maintained up to 45 days under room temperature and refrigerated conditions. Probiotic-





Digital teaching on hybrid seed production in local language

PPE-JAE could be used as a potential supplement for gut health promotion of dogs with inflammatory conditions of the intestine.

- Two immunogenic outer membrane proteins (OMPs) of *Dichelobacter nodosus*, viz. Pil-Q and Por in, were cloned, expressed and purified. These proteins are being evaluated as vaccine candidates against virulent footrot.
- Whole Genome Sequence of *D. nodosus* serogroup B isolate was deposited in GenBank (Acc. No. NZ_SRJB00000000). The genome content of serogroup B of *D. nodosus* is 44.38% and a total of 1,272 protein-coding genes, 44 tRNA genes, 4 ncRNAs, 9 pseudogenes and 7 rRNAs genes were identified. Genome sequence of *D. Nodosus* serogroup B revealed presence of 21 genes which are unique to *D nodosus*, serogroup B and were not found in the reference strain.
- Refinement of the strip based sensor to identify pesticide residues in other food matrix, viz. pesticides legally recommended for cattle feed and fodder were evaluated and found well within MRL set by FSSAI/Codex. Extraction protocol from cattle feed and fodder used in organized dairy farms was optimized.
- Sour orange exhibited higher tolerance to soil salinity than 4 other tested rootstocks (Rough lemon, Rangpur lime, *Carrizo citrange* and *Cleopatra mandarin*). Sour orange also displayed better tolerance to *Phytophthora* than 10 other tested rootstock genotypes [(Karan Jambhir, 2



Salt tolerant and susceptible rootstock genotypes after termination of the salinity treatments

strains of Rangpur lime, 3 strains of Rough lemon, Volkamer lemon, Troyer and Carrizo citranges (*Poncirus trifoliata* × *C. sinensis*) and Karna khatta].

- Application of 3 sprays of 1% KNO_3 and 150 litre of water/tree resulted in 77% increase in productivity (2.43 tonnes/ha) and also reduced spongy tissue incidence by 12% in mangoes.
- The centres organized 22 long (>10 days) and short (1–10 days) duration training programmes/ awareness workshops/ camps/ workshops leading to capacity building of 1,405 faculty and 260 farmers benefited through demonstrations or awareness programmes organized by Niche centres.

Centre for Advanced Faculty Training/Summer/Winter Schools and Short Courses:

During the year, 120 summer/winter schools/short courses comprising 69 summer/winter schools of 21 days and 51 short courses for 10 days were organized at various ICAR institutes and SAUs. The skills, knowledge and capacity building of 2,795 faculty were enhanced. The 39 functional Centres of Advanced Faculty Training provided training to about 1,378 scientists/faculty members from the National Agricultural Research System through 62 training programmes in cutting edge areas of agriculture and allied sciences. These training programmes were monitored through workflow based online management system.

Attracting talent

Admission to UG: The 24th AIEEA for undergraduate admission (for 15% ICAR quota seats) in various degree programmes in agriculture and allied subjects (other than veterinary sciences) including the award of National Talent Scholarship (NTS) was conducted online for the first time through National Testing Agency (NTA) on 1st July 2019. The examination attracted 2,36,931 candidates initially, out of which 1,08,979 candidates (46%) appeared and 2,339 finally recommended for admission in various accredited AUs through online counselling. The candidates joining a university outside their State of domicile, will be awarded NTS.

Master's degree (PG): Like AIEEA UG, the examination was conducted online on 1st July 2019 for admission to 25% seats in PG programmes at Accredited AUs, including award of ICAR-PG scholarship and award of NTS (PG). Initially 31,486 candidates registered and 27,164 appeared (86%) in the examination, out of which 2,773 candidates were recommended for admission in various AUs. To attract and retain more number of students, non-PG scholarship candidates who join the Master degree programme are eligible to get NTS (PG) for 2 years subject to fulfilment of prescribed terms and conditions.

- **Ph.D. admission and award of Junior/Senior Research Fellowship:** The examination was held on 1st July 2019 online and against 8,374 applicants, 7,102 candidates appeared in the





examination and 706 were finally recommended for admission.

- **Merit-Cum-Means scholarship:** Scholarships to meritorious 359 under-graduate students belonging to below poverty line families to study Agriculture, Agricultural Engineering, Community Science (erstwhile Home Science), Dairy and Animal Husbandry subjects, were awarded on the basis of merit-cum-means.
- **Post-Matric scholarship:** It was granted to 18 students from PV Narasimha Rao University.
- **Internship Allowance:** It was provided to Veterinary graduates (1,844) trained by Agricultural/ Veterinary Universities.
- **National Talent Scholarship (NTS):** During the year 7,873, UG and 3,827 PG students were provided NTS, including 1,211, UG and 1,282 PG students who were newly admitted through AIEEA.
- **ICAR Fellowships for post-graduate students:** In different disciplines of agriculture and allied sciences, 549 students were awarded ICAR-PG Scholarships and 262 students ICAR-JRF/ SRF(PGS) for Master's and Doctoral studies.

Globalization of agricultural education

ICAR coordinates the Netaji Subhas-ICAR International Fellowships, India-Africa Forum Summit (IAFS), Indo-Afghan Fellowship Scheme and Borlaug Higher Education for Agricultural Research and Development (BHEARD) Scholarships to support the agricultural human resource development through formal education of scientists/faculty/ students in India.

International fellowships: During the year, ICAR facilitated admission of 141 foreign students from 27 countries in Indian Agricultural Universities by considering the applications received through the DARE, Education Consultants India Ltd (EdCIL) and Indian Council of Cultural Relations (ICCR). In addition to this admission of 13 NRI candidates was also facilitated.

Netaji Subhas-ICAR International Fellowships: The amount of fellowships for Indian and overseas candidates is @ US\$ 2000 and ₹ 40,000/month respectively. During this year, 30 candidates were selected for their Ph.D. study including 22 Indian candidates at overseas universities and 8 foreign candidates at Indian SAUs/ICAR DUS.

India-Africa Fellowship Programme (III&I): India Africa Forum Summit III ensuing component of Special Agricultural Scholarships for African nationals (500 slots) to conduct higher degree programme from Indian Agricultural Universities. A total of 81 applications (52 PG; 29 Ph.D.) of African nationals from 12 countries were recommended in session 2019–20. Out of which 33 (23 PG; 10 Ph.D.) candidates were provisionally selected and 15 (12 PG; 03 Ph.D.) have joined so far. Information on joining of candidates from Indian Agricultural Universities are still under process. IAFS III was implemented from academic session 2017–18. A

total of 86 candidates (66 Master's; 20 Ph.D.) from 12 African countries have joined their degree programmes.

India-Afghan Fellowship Programme: Under India Afghanistan fellowship Programme, a total of 131 applications (2 Bachelor's, 101 Master's and 28 Doctoral) were screened during academic year 2019–20. Out of which, 77 candidates (1 Bachelor's, 62 Master's and 14 Doctoral) were provisionally selected and 30 (29 Master's and 01 Doctoral) candidates have joined so far. Total of 67 (5 Bachelor's, 60 Master's, 2 Ph.D) have joined the programme, during the year. Till date, a total of 425 candidates (77 Bachelor's; 344 Master's; 4 Doctoral) have been enrolled for higher degree programmes in 38 Indian AUs. Out of which 138 candidates (13 Bachelor's; 125 Master's) have completed their programme successfully.

Promoting Excellence

ICAR National Professor

There are 10 positions of National Professors including one B.P. Pal Chair in Genetics and Plant Breeding at IARI and one Norman Borlaug Chair in International Agriculture in ICAR-AU system. During the period under report, 6 National Professors were in position. Their areas of specialization were—Crop Sciences (4), Natural Resource Management (1) and Economics, Statistics and Management (1).

Salient achievements

- Whole set of marker defined chromosome segment substitution lines of rice were developed for the first time in India. These were developed from inter-specific crosses between two elite cultivars (MTU1010, Swarna) and two progenitor wild species (*Oryza nivara*, *O. rufipogon*).
- Swarna × *O. nivara* derivative RPBio4918-228S with high resistance to brown plant hopper and multiple pest resistance in AICRIP was registered with NBAGR as INGR18002.
- CMS based canola mustard hybrid RCH1 was approved by the research evaluation committee of Punjab Agricultural University for adaptive evaluation in farmers' field in Punjab. When commercially released, this will be first canola mustard hybrid in the country.
- A comprehensive temporal assessment of carbon footprint of green revolution technologies and their impact on sustainability of agriculture in Punjab was made. Carbon sustainability of various crops is declining, indicating that energy use efficiency is decreasing; the greatest decline is in rice followed by wheat and negligible in maize.
- The impact of rice establishment methods and conservation agricultural practices on C-sequestration in rice-wheat system was quantified. Growing of puddled transplanted rice followed by no-till sown wheat is the best bet technology for soil C-sequestration and environment conservation.





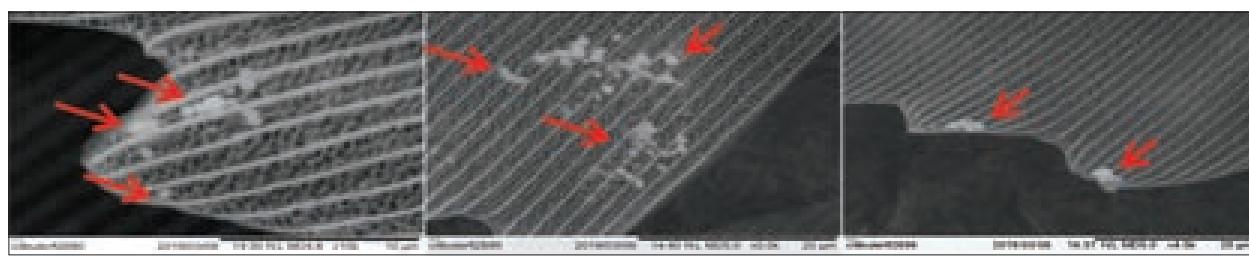
- A simple, easy to use, environment friendly and cost-effective method of total organic C determination in soil was developed. The method gives results similar to the standard dry combustion method.
- Promoter sequences (1000 base pair) of FHG (Floral Homeotic gene) and MADS (Minichromosome Maintenance1, Agamous, Deficient and Serum response protein) genes that expressed at high level in flower and pod wall of chickpea were isolated and their efficiency was confirmed. Cloned trypsin protease inhibitor gene (TI) from cultivated and wild accessions of chickpea and a cisgenic construct was generated.
- Developed a dynamic econometric model to assess the effect of crop diversification on resilience of agriculture to climatic shocks.
- Mustard hybrid, PHR 126 and canola mustard hybrid, RCH 1 approved by research evaluation committee of Punjab Agricultural University for farmer field evaluation. RCH 1 also evaluated in AVT1 (Zones 2,3) under AICRPR&M. Contributed mustard hybrids to national trials under AICRPR&P (IHT-5 hybrids) and ICAR aided network project on mustard hybrids (CPMLT-7 hybrids). Identified heat tolerant *Brassica juncea* introgression lines, carrying genomic fragments from *Erucastrum abyssinicum* and *Diploptaxis tenuissima*.
- Canola version of ogura CMS-FR system developed for Indian mustard.
- Established heterotic gene pools in mustard, on the basis of genetic diversity analysis of over 450 mustard germplasm lines (SNP genotypes), in combination with *per se* performance of hundreds of mustard hybrids.
- SNP genotyping and association mapping allowed identification of genomic regions associated with heat tolerance in mustard introgression lines.
- CMS based mustard hybrid PHR 126 was approved by the research evaluation committee of Punjab Agricultural University for adaptive evaluation in farmer fields in Punjab.
- Collection, characterization and evaluation for drought, flooding and salinity tolerance of 876 wild rice accessions from different parts of the country was done and database created. Developed a 50K SNP genotyping chip of rice.

ICAR National Fellow

There are 25 positions of National Fellows across National Agricultural Research and Education System. During the period under report, 22 National Fellows were in position. The areas of specialization in which they carried out research work were as diverse as Horticulture (3), Animal Science (7), Fishery Science (5), Natural Resource Management (3), Agricultural Engineering (2) and Economics, Statistics and Management (2).

Salient achievements

- Restoration of gene reporter assay was done by blocking LPS with polymyxin B in cultured fish cells.
- Abolished the ambiguity regarding taxonomy of goat warble fly (causing myiasis) and established its correlation with *Hypoderma lineatum*.
- Erosion induced carbon loss was calculated from erosion rate and SOC concentration. The carbon enrichment ratio (CER) varied from 136.68 kg/ha/yr to 383.84 kg/ha/yr for different erosion phases, leading to 27.33 to 76.76 kg C/ha/yr as net C-source to the atmosphere.
- Thermo-physiological, hematological, biochemical, and cellular responses associated with thermal stress in native (*Bos indicus*), crossbred and exotic (*Bos taurus*) cattle helped in establishing a scientific basis for superior heat tolerance potential of Indian native cattle breeds vis-à-vis exotic cattle to summer stress. Genome wide transcriptome data indicated difference in transcriptome signature in PBMCs of Sahiwal cows (*Bos indicus*), Holstein Frisian cows (*Bos taurus*) and Murrah buffaloes (*Bubalus bubalis*) in response to summer stress. The analysis revealed several heat responsive genes, immune related genes and molecular pathways that were highly impacted due to summer stress. The transcriptome of Sahiwal cows showed minimal variation during two extreme seasons, suggesting its better tolerance to summer stress.
- It was established that butterflies protect their wings using symbiotic microbes. The arrangement of scales on wings might be providing good thriving place for microbes. The possibility of a micro world existing on the wing working towards maintaining them, opens up a whole new area of study. 16S sequencing for the cultures from *Papilio polytes* wings identified *Bacillus*



SEM of unprocessed butterfly wings





thuringensis, *Lysinibacillus fusiformis* and *Acetobacter pasteurianus* on butterfly wings. These bacteria play role in production of biosurfactant, insecticidal activity and cellulose which might help to maintain the butterfly wing moisture and also provide carbon source for commensal bacteria.

- A Patent was granted (**Patent No. 309741**) on Novel kairomone blend ‘Arka Eggstra’ and application methodology for increasing fertile egg laying capacity in silk moth, *Bombyx mori*.
- Mode of action of few herbal antiparasitic extracts was understood by looking into targeted ion channel gene expression.
- Isolation in cell culture and complete genome characterization of major enteric viruses of porcine origin was done.
- Peptide-recombinant protein based antigen capture diagnostic immunoassay for direct detection of rotavirus A in field samples was developed.
- Recombinant VP6 protein based indirect immunoassay for detection of avian rotavirus D in diarrheic faecal samples was developed.
- Developed new statistical model: a nonparametric generalized linear mixed model with a mean structure was defined using spatial splines. This model is suitable for fitting aggregate level Discrete/Count Data. This model is also referred as Spatially Non-Linear Model.
- Copyrights from Registrar of Copyrights were granted for the “*Software for Small Area Estimation*” (Registration No. SW-10788/2018) and “*Data Entry Software for Crop Area and Yield Estimation Survey*” (Registration No. SW-10008/2018).
- Microencapsulation of marigold oleoresin, extracted from marigold flowers by supercritical fluid extraction was done. Developed curcumin-prebiotic based nano-emulsions for the preparation of microcapsules.
- Microencapsulation of palm oil using in-house developed spray chiller technology equipped with temperature controlling system.
- To identify the genes regulated by heat shock factor-1 (HSF-1), one of the key mediators of heat shock response in pigs, chromatin immunoprecipitation (ChIP) assay was conducted followed by isolation of ChIP DNA. The ChIP DNA was subjected to next generation sequencing and bioinformatics analysis. Based on the analysis a 21 DNA binding nucleotide consensus sequence was identified, which could be associated with heat responsive element in the genome.
- IVRI *Pashu prajanan app* (Android app) in Assamese language (No. L-79311/2018) developed.
- New technique was developed to measure GHG emission through bubble and sediments of mangrove-rice system in Sundarban.

- Six new microbial-germplasm isolated/identified from mangrove+ rice system in Sundarban and registered in NCBI.
- Potential shRNA molecules were identified for knocking down two lipid biosynthesis genes under *in vitro* cell culture system, which may be used for development of knock down chicken for producing low fat egg and meat.
- Paper dip assay kit was developed to detect presence of protein (SCD, SREBP1 and FASN) in serum by dipping a strip of special type of paper in the reaction mixture. This kit is very economical with a price of ₹ 10/sample. This kit is easy, simple and needs 10 min to obtain results. Patent was granted (**Patent No.: 309612**) on Diagnostic kit, primers and method for sex determination in chicks and adults of avian species.
- Standardization of minimal processing process protocol for pineapple, tender jackfruit, matured jackfruit and ripe jackfruit.
- Digital Sequence Information (DSI) has assumed great significance in the field of genetic resources. Based on the algorithm developed in this project (reported last year), an interactive application called G2G (Gene bank to Gene bank) was developed.

Emeritus scientists/professors

Emeritus Scientists (60) and Emeritus Professor (45) are currently appointed. The aim of this programme is to complete the work in hand 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 and use their experience in addressing nationally important issues in different ICAR-Institutes and SAUs.

Emeritus Scientist

Salient achievements

- A high nutrient containing genotype with 14% protein, > 30 ppm zinc and > 15 ppm iron in rice grains was identified.
- Novel universal symbiotically nodulating super strains of rhizobia were developed that can cross-infect and fix nitrogen efficiently across diverse *rabi* legumes like chickpeas, field peas and lentils.
- Developed hyper-immune sera for surra diagnostics and anti- *Trypanosoma evansi* nanobody clones for subsequent development of diagnostics.
- Chromatographic finger printing and spectroscopic characterization of secondary metabolites of Hadjod (*Cissus quadrangularis*), the healer of bone fractures used by traditional healers was done. The isolated 19 molecules from



the petroleum ether (14), ethyl acetate (2) and alcohol (3) extract in pure form while six molecules isolated from petroleum ether (4) and ethyl acetate (2) in 90% pure form were used for clinical trials to ascertain if the extract and its fraction will be responsible for callus formation in fractured area of experimental animals. Based on the HU values of CT scan (radiological studies) the callus formation at fractured proximal end was found and the ethyl acetate and alcohol extracts were most active in favour of callus formation.

- Results of a project on dissemination of Pilot scale results of inland saline aquaculture in different locations of Haryana and Maharashtra, revealed that integrated system with sub-surface drainage (SSD) and aquaculture improved soil quality at faster rate. The production enhanced 3–4 folds as compared to baseline production. Number of sugarcane tillers increased to 25–30 from each seed tiller as against baseline 5–6 tillers.
- Under the project development of Brood Bank and establishing demonstration hatcheries for commercial seed production of Asian catfish *Clarias batrachus*, an indoor portable magur hatchery was stabilized at ARTU wetlab, Chinchwad and is functioning for magur breeding.
- Phenotyping of RIL population for drought stress related traits in post rainy sorghum was done.
- A low cost fish food Spent brewer's yeast was developed with protein content almost equal to fishmeal. It gives immunity to the animal. Therefore, replacing fishmeal by Spent Brewer's yeast will reduce the feed cost and also give disease resistance to fish.
- Molecular analysis of F2 generation of 3 different crosses in carrot, namely IPC126 × Pusa Kulfi (73 lines), Pusa Meghali × 126 (72 lines) and Pusa Rudhira × 126 (24 lines) via genomic DNA PCR with Universal Rice Primer (URP4) and ISSR02 was carried out to study polymorphism in relation to carotenoids (beta carotene, lycopene, lutein) and anthocyanins.
- In a study on phenotyping based on chlorophyll fluorescence imaging under salinity-stagnant flooding stress and identification of quantitative trait loci of chlorophyll fluorescence traits in rice, RIL lines with different yielding capacity under stagnant flooding-salinity stress were identified.
- Isolated 270 endophytic fungal isolates belonging to 50 operational taxonomic units (OTUs) from plants adapted to coastal sand dunes (hydrohalophytes) and from inland salt pans (xero-halophytes). Fungal endophytes were isolated from 9 plant species adapted to the saline habitat of Marakkanam beach (Bay of Bengal) and Hudem (Karnataka). *Fusarium* fungi was predominant.

- LAT was developed and standardized to detect Marek's disease virus (MDV) serotype-1 antibody in field chicken serum samples.
- Analysis of *orf108* transcripts in *Brasica oxyrrhina* wild species indicated that the restorer gene present in this wild species should be able to restore male fertility in *B. juncea* CMS lines carrying not only *B. oxyrrhina* cytoplasm but also other cytoplasms such as *Moricandia arvensis*, *Diplotaxis berthautii*, *D. catholica*, *D. erucoides* and so on. Fertility restorer gene was introgressed from *B. oxyrrhina* into *B. juncea* and have affected crosses between various CMS lines and fertility restorer lines.
- DSSAT models for pigeonpea, cotton, sugarcane and potato crops were used to study the effect of change in temperature and rainfall on yields. Under RCP 4.5 and 8.5 during 2020 to 2099, temperature would increase, rainfall would show marginal increase, sunshine would decrease that would cause yield decrease.
- The selected 271 bread wheat genotypes were evaluated at four disease hot spot locations including Indore and Wellington for stem and leaf rust resistance, at Delhi for leaf and stripe rusts resistance, and at Daula kuan for only stripe rust resistance. Genotypes showing coefficient of infection (CT) values up to 10.0 were classified as resistant.

Emeritus Professor

Salient achievements

- As a part of their mandate, they developed six teaching manuals and five books on the topics of current importance. In addition to this they also guided 15 M.Sc and 9 Ph.D. students.

Library strengthening

Under this component ₹ 18.99 crore were provided to 45 Agricultural Universities for the digitization, strengthening and modernizing the library services. The main objective was to connect all the libraries through KOHA, installation of RFID, purchase of print book, print journals, e-books and e-journals except those available



Strengthened facilities at the libraries





Ekikrit Krishi Shiksha Takniki Ayam (EKTA-Education Portal)

Education Portal-ICAR (<https://education.icar.gov.in>) was developed as a single window platform for providing vital education information/announcements/ event schedules/e-learning resources from Agricultural Universities across the country in an easy and fast way. In addition, the complete information about accreditation of agricultural universities, the list of accredited universities is available on the portal. The portal also helps in management, monitoring and promoting activities/schemes of Education Division, ICAR. Various functionalities, viz. state wise, university



wise and college wise information is available. The proposals/ demands of all the sub schemes of the Agricultural Education Division, reports/ Student Unique Identification Number (UID) is generated on this portal. At present, UID has been generated for 1,16,855 students covering 72 AUs. The portal is a major source of information for providing details of various sub schemes being operated in agricultural education, their guidelines, information about various courses being offered by different agricultural universities. The platform provided information about various scholarships/ fellowships of ICAR, available for national and international admission at UG, PG, Ph.D. and post doctoral level.

in CERA, digitization of thesis (M.Sc. and Ph.D.) and other important documents etc. The support from Council under this component, helped the agricultural universities to enrich their resources by adding about 44,973 print books, e-books, e-journals and print journals, across universities. The AUs also installed 4,539 computers other hardware including RFID and other software towards digitization.

New books, e-journals, etc. helped students to improve research, formulate projects, improve in publication quality and this led to success at national and regional level competitions. Many students have succeeded in securing admission for Masters/ Doctoral studies in institutes of repute, within the country and abroad.

Algorithm for duplication of works: A copy detection method based on keywords for checking the duplicity for various items in the repository was attempted. A process for detecting duplicity mechanism in the digital document based on the keywords (frequency of keyword) was visualized and algorithm process was developed.

KrishiKosh is digital repository platform capable of decentralized management of content but centralized hosting and maintenance for convenience of multiple users. Each institution has its own repository with full control without botheration of maintaining hardware/software which is centrally managed at IARI, New Delhi. This platform provides open access to institutional knowledge for the NARES system. Till date 66 AUs have uploaded 111,256 thesis titles in KrishiKosh repository.

Support, upgradation and modernization of agricultural universities

New student hostels (36), examination halls (16), educational museums (2) were supported across agricultural universities as a step towards strengthening infrastructure. Teaching facilities were further enhanced with support for 62 smart classrooms, especially in off campus colleges. Funding support was also provided for upgradation of laboratories and other amenities pertaining to teaching and learning. Smart classrooms, with most up to date audio visual aids, enabled effective delivery of course curriculum, ensuring enriched learning experience.

Central Instrumentation facilities were encouraged and equipped preferentially across AUs. The upgradation of UG and PG laboratories improved both PG student research and practicals. Communication labs helped improved the language skills of the students as per requirement. Practical manuals were developed in various subjects.

Direct benefit transfer

The Direct benefit transfer (DBT) for 20 DARE/ ICAR components under various schemes is being done. During the year, data of 15,778 beneficiaries who were given ₹ 816,333,865 under the different components were uploaded on the portal. Regular meetings are being conducted to sensitize all the stakeholders for data updation on the DBT portal.

The DBT MIS was developed (in house) by the DBT Cell (DARE) and IASRI, New Delhi (<https://dbtdare.icar.gov.in>). Presently all data are transferred from the DBT DARE portal (<https://dbtbharat.gov.in>) to the DBT Bharat portal automatically through web service at a fixed date every month. A user manual was developed for data updation on the portal and is available at https://dbtdare.icar.gov.in/Files/DBT_manual.pdf. DBT related OM's are also placed at the website at https://dbtdare.icar.gov.in/Files/DBT_OM.pdf. The Aadhar notification under section-7 of the Aadhar act was processed for the eligible components and it will be published in the official gazette very shortly.





Computer lab, KAB, Thrissur



Girl's Hostel, UAS, Raichur

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.

National Agricultural Higher Education Project (NAHEP)

NAHEP is designed to strengthen the national agricultural education system in India with an overall objective to provide more relevant and high quality education to agricultural university students through promoting efficiency and competitiveness via increased teaching and research standards through improved and enhanced faculty competency and commitments. 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 (IG) to AUs.

Till September 2019, out of 75 participating AUs, 44 AUs were awarded under IDP, CAAST and IG component. Under Component 2 (Investments in ICAR for Leadership in Agricultural Higher Education) is awarded to IASRI lead centre and NAARM, Hyderabad and NIAP as a cooperating centres.

Institutional Development Plan: The major activities by AUs under IDP component included strengthening of teaching and research infrastructure,

training and capacity building, organization of seminars and workshops, industry interactions and student employments, creation of central instrumentation facilities, and improvements of campus social amenities and student well-being. Three new facilitative units (IIIC- Industry Institution Interaction Cell / Start up cell / incubation cell / experiential learning unit / placement cell etc.) for strengthening of teaching and research infrastructure have been established. Students from 19 participating AUs and faculty members were sent for overseas training. 202 Under Graduate (UG) students had received international trainings by 31st August 2019. Classes and demonstrations by Adjunct Professor for UG students on topics like organic farming and automatic production and processing of mushroom were organized.

MoUs (10) have been signed with overseas universities such as University of Arkansas and University of North Georgia for student and faculty training and exposure visit. Skill development programmes for stakeholders were also organized on Agro based Entrepreneurship at National Institute of Rural Development and Panchayati Raj (NIRD & PR), Hyderabad.

Key thematic areas of workshops organized under IDP universities were “Identification of industry needs and skill gaps for market driven agriculture”, “Right attitude and gaining confidence”, career opportunities and goal setting, Time management, Interpersonal skills, Leadership skills, Conflict management, Emotional intelligence and stress management, Job search process/skills, Writing skills, Group discussion and Interview skills. Investment under this component is towards improving the learning outcomes and employability of AU students on one hand and teaching and research performance of the faculty on the other. The international trainings organized for students were done so keeping in mind the ongoing academic sessions of the students. Similarly, for faculty members, their teaching, research and extension commitments were considered as well. The current demand in agriculture academics, research and industries were essentially thought of while organizing workshops and seminars throughout the participating AUs.

Centres for Advanced Agricultural Sciences and Technology (CAAST): The activities and research achievements of the AUs under CAAST are spread over a number of thematic areas such as Conservation Agriculture, Precision farming / Farm Mechanization, Secondary Agriculture, Specialty agriculture, Renewable Energy Sources, Integrated Farming System (IFS), Agriculture market intelligence, Good agricultural practices, Hitech/protected cultivation, Climate resilient agriculture, Food safety, Big data analysis and genomics-assisted breeding.

In UAS, Bengaluru, 241 fungal isolates were collected from the plants adapted to the cold desert (North Western Himalaya) and screened for different abiotic stress (drought and salinity stress) tolerance.





Some of the isolates showed significant drought tolerance to chilli and tomato and salinity tolerance in tomato and paddy. Further, these isolates are being evaluated under field condition. ICAR-NICRA pest predict models were validated and developed for forewarning pest and diseases in paddy (Gundhi Bug, Stem borer pest and blast disease).

MPKV, Rahuri developed the infrastructure for undertaking the advanced studies in Climate Smart Agriculture and Water Management for the post graduate/ Doctoral level students.

In the centre at BCKV, Mohanpur on Conservation Agriculture (CA) theme, Demonstration unit has been established in university farm, and experiments are being conducted on location specific conservation agriculture technologies. 22 Ph.D. and 13 M.Sc./M.Tech are currently pursuing research in this area. The centre also formulated and offered three specialized courses on conservation agriculture for the Ph.D. and M.Sc/ M.Tech students working on different thematic areas of the centre.

Genomics Assisted Crop Improvement and Management centre carried out research in the area of marker assisted selection for biotic stresses in rice, maize, chillies, groundnut and validation of SSR markers in finger millet, dolichos bean and horse gram were performed by IARI, New Delhi.

CAAST centres supported International training for faculty and students at 12th AFAF, Iloilo City, Philippines, Washington State University Pullman, USA, North Carolina State University, USA, etc .

Workshops and Discussions: Brain storming sessions, group discussions, and panel discussions were also organized on a number of topics Short course on “Protected cultivation of vegetable crops” was delivered to the university students. Additionally, a Skill Development Course on “Secondary Agriculture” was also conducted for 25 selected PG Students.

The overall focus of CAAST hinges upon development of multidisciplinary faculty, innovative approaches to teaching and research, technology development and commercialization. The holistic approach towards teaching and research for agriculture and rural development ingrained in this component, would be building capacities in a specialized thematic area and cutting-edge agricultural science and make AUs globally competitive and locally relevant.

ICAR Innovation Grants (IG) to AUs: Support has been provided to AUs to attain accreditation. Reform ready AUs mentoring the non-accredited AUs is also part of this component. 17 participating Agricultural Universities of ICAR have received Innovation Grants. The grants vary from accreditation support to modernization of technology usage in agriculture and allied sectors, strengthening of Agricultural Universities, capacity building in terms of renewable energy and also the National Knowledge Management for agriculture research and extension.

Dr PDKV, Akola organized a brainstorming session

on “Employment generation opportunities in Renewable Energy – A Scope in Agricultural Education System”, Boot-camp for identification of marketable innovative ideas, summer trainings including demonstration for AU students.

Innovation grants have been accorded to participating AUs for strengthening their establishments to gain accreditation and impart market relevant knowledge to students with the aid of updated facilities. Modernization of classrooms, digitization of libraries, development of webportals, establishment of placement cells, and development of digital language lab and establishment of entrepreneurship development cell are some of the activities supported under this subcomponent.

To complement the strengthening of Agricultural Universities, this subcomponent facilitates modernization of the technology and equipment usage. This enhances the practicality of the updated knowledge being imparted to the AU students and supports the research as well. Towards this area, IGs have supported strengthening of Hi-tech horticulture systems, establishment of hydroponic units, modernization of instructional farm drip and mini sprinklers and many other such practices.

Emphasis has also been given on entering MoUs with private partners so as to disseminate and commercialize the technologies developed through AUs.

AUs that currently lack the enabling environment to prepare and implement IDP and CAAST apply for funds through proposals under this subcomponent. Innovation Grants is inclined towards assisting the AUs in shaping such an environment which is reforms ready. These funds are used to encourage both faculty and students toward collaborative improvements at their AU and finance support to students' learning to attain accreditation.

Investments in ICAR for Leadership in Agricultural Higher Education: Adoption of next-generation management systems involving information, procurement, contract and financial management areas has been taken up under this Component. This includes initiation of Software Designing for Customization of Academic Management System in AUs on latest framework of NET. Software Designing has been finalized for some modules such as user registration module, course modules, etc.

The AUS have been sensitized towards NAHEP objectives for positive and conducive results through workshops. Workshop of all participating AUs held during March 2019 made the stakeholders and faculty members aware about the project and its modalities.

Establishing partnerships with globally recognized agricultural higher education institutions: ICAR has enabled partnerships with multiple international Agriculture Higher Education Institutions for multiple activities. A number of MoUs have been signed with such international institutions and universities for training programmes, student and faculty exchange



programmes, brainstorming sessions on relevant areas in agriculture and education, etc.

Industry linkages: As part of the Investments in ICAR for Leadership in Agricultural Higher Education ICAR has provided all the necessary support to AUs required for establishing industry linkages aiming at adoption of technology developed by AUs. The linkages with industries have been strengthened through establishment of career centres at AUs to enhance the employability of the agricultural students.

ICAR-National Academy of Agricultural Research Management (NAARM)

The National Academy of Agricultural Research Management (NAARM) focuses on creation, dissemination and application of knowledge through its academic, training, research, consultancy and policy support programmes. The Academy expanded its activities to reach all stakeholders of NARES. The Academy has also widened the scope of its activities and initiated number of activities to develop a new generation of young leaders and managers who can contribute to sustainable agricultural development at the national level.

Copyrights on Project Management Software: ICAR-NAARM developed management tools, viz. AHP Analyzer, Research Concept Writer and Project Log Frame Writer. These are Web based open access applications and all three software were copyright registered in 2019. These softwares' are being used by more than 2,000 users in more than 80 countries and are available on internet. The software also works as wonderful classroom teaching tool, and is available on: AHP Analyser: <https://naarm.org.in/ahp>, Research Concept Writer: <https://naarm.org.in/dwrf/>, Project Log frame Writer: <https://naarm.org.in/logframe>.

Capacity Building Programmes: Need-based and mandated capacity building programmes (71) of ICAR-NAARM were successfully completed. The programmes were—Foundation course for Agricultural Research Services, Induction training Programme to newly recruited Assistant Professors of SAUs, Management Development Programme, Entrepreneurship development programme, Off Campus Programme, etc. Several programmes for administrative and technical staff for enhancing competency and efficiency are also organized for discharging their functions.

In online certificate course, viz. Massive Open Online Course (MOOC) on Competency Enhancement for

Training programme for IFS Probationers

In accordance of MoU with Indira Gandhi National Forest Academy (IGNFA), Dehradun, a 60 IFS Probationers and 2 Officers belonging to the Royal Bhutan Forest Service participated in the Training Programme on "Participatory Rural Appraisal (PRA) and Communication Strategies including Integrated Watershed Management (IWM)" organized for the IFS Probationers (2018–20 Batch) at ICAR-NAARM during 26–29 September 2019.



Shri Narendra Singh Tomar, Union Minister of Agriculture and Farmers Welfare alongwith IFS participants and faculties of NAARM at ICAR-NAARM, Hyderabad

Effective Teaching, 1,192 participants registered aimed at improving the quality of teaching.

Educational programmes: The Academy continued its efforts in imparting postgraduate education in the niche areas of Agribusiness Management (PGDMA), Educational Technology and Management (PGDETM) and Technology Management in Agriculture (PGDTMA) and achieved 100% placement of final year PGDMA students of PGDMA.

Collaborative programmes: In campus and off campus programme were organized in collaboration with Coromandel International Limited, Institute of Hospitality Management, Catering Technology and Applied Nutrition (IHMCT & AN) and Assam Agricultural University during the period benefiting 294 stakeholders.

Start Up through AGRI UDAAN: The Academy in partnership with CIIE, IIM-A, supported by DST has launched Food and Agribusiness Accelerator Programme, 3.0 called "Agri Udaan" to encourage startups to scale up.

National Agricultural Higher Education Project (NAHEP) Component 2 A

Under component 2 A of NAHEP, Nine Workshops and training programmes, viz. National Workshop on Academic Excellence through Building Partnerships and Resources Generation, Consultative Workshop on Academia-Industry-Government linkages for Quality Agricultural Education, Training of Trainers Workshop for organizing workshops on Development of soft skills for Entrepreneurship among Agri Graduates, Training Workshop on Education Management and Academic Leadership, technical committee meetings were organized. A total of 377 participants have given their input for quality and relevance of agricultural higher education in the country.

Special programmes

Developing effective organizational leadership

Senior Executive Development Programme on Developing Effective Organizational Leadership for Senior Officers of ICAR conducted by Administrative Staff College of India (ASCI), Hyderabad. This programme is being organized with domestic component





Senior Executive Development Programme International training for Senior officers of ICAR at University of Wageningen, Netherlands.

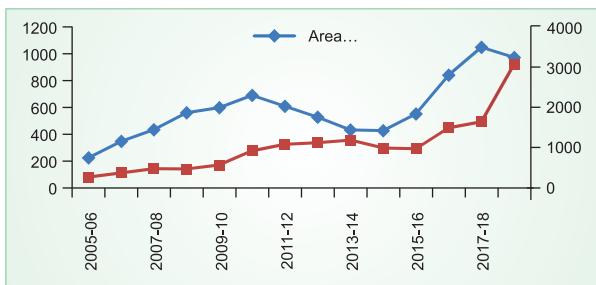
in India and international component in Netherlands, Germany, Belgium and Switzerland countries and with classroom lectures for two batches with 23 persons in each batch. Domestic component of Batch-I was completed during 2–4 August 2019, and for Batch-II during 9–11 August 2019. The International component for Batch-I with 23 participants (including two from NAHEP) has been completed during 21–30 September 2019. The training took place in The Netherlands, Belgium, Germany and Switzerland. The International component for Batch-II is scheduled during 12–21 October 2019. ICAR-NAARM is coordinating this programme. □



12. Social Science

Agricultural economics and policy

Adoption and impact of micro-irrigation: Efforts are being made to scale up micro-irrigation technology to improve the water use efficiency and produce more crops per drop of water. Government of India launched a Central Centre Scheme on Micro-irrigation in 2005–06 when the area under micro-irrigation was 2.24 million/ha. The public spending under micro-irrigation has increased by over 10 times from 2005–06 to 2018–19. About 3/4th of the total area under micro-irrigation lies in Andhra Pradesh, Gujarat, Karnataka, Maharashtra and Rajasthan. Although adoption of micro-irrigation is increasing significantly, even though 5.16% of gross sown area and 10.62% of gross irrigated area is covered under micro-irrigation technology. Thus, there exists a high potential to scale up micro-irrigation and improve water use efficiency in agriculture.



Progress of micro-irrigation in India during 2005–06 to 2017–18

Farm level studies in Punjab, Andhra Pradesh, Gujarat and Maharashtra during 2017–18 revealed that adoption of micro-irrigation technology lead to 15–40% savings in farm inputs (water, energy, fertilizer, labour), 18–54% increase in net income of the farmers. The micro-irrigation also increases the opportunity for employment in services related to maintenance of micro-irrigation. Credit constraints, poor maintenance and cumbersome operational process of availing benefits of ongoing schemes are major deterrents to the adoption of micro-irrigation technology by the farmers. Development of integrated ecosystem of financial agencies, technical assistance and operational support may help in scaling up of this viable technology of multiple benefits. A study in the Bundelkhand region revealed that the subsidy transfer as direct benefit transfer has a positive impact as farmers are becoming aware about their entitlements. Selection of farmers and disbursement of subsidies is transparent and speedy which gives extra satisfaction to farmers.

Doubling farmers' income (DFI) in India: strategy and implementation: The Government brought farmers' income into the core of its deliberations and incorporated it as the fulcrum of its strategy. The major sources of growth, operating within the traditional agriculture sector include: (i) improvement in crop productivity, (ii) improvement in livestock productivity, (iii) resource use efficiency or saving in cost of production, (iv) increase in cropping intensity, and (v) diversification towards high value crops; following sources of growth operate outside the traditional agriculture sector but contribute to farmers' income, (vi) improvement in real prices received by farmers, and (vii) shift from farm to non-farm occupations.

The DFI recommendations emphasize on promoting marketing, logistics and supply chain along with price support. Operation Green, which focuses on bringing the price stability in tomato, onion and potato, has been initiated with a focus on agri-logistics, processing and professional management. Farmer Producer Organizations (FPO) of less than ₹ 100 crore turnover, were exempted from income tax for the first five years to encourage professionalism in post-harvest value addition. Organic farming by village producer organizations (VPO) and FPOs is being encouraged. The e-NAM, a mission for integration of Agricultural Produce Market Committees (APMCs) across the country through a common online market platform to facilitate pan-India trade in agricultural commodities, helps to provide better price discovery along with timely online payment, is functional. In 16 states, 585 APMC markets have been integrated with e-NAM platform.

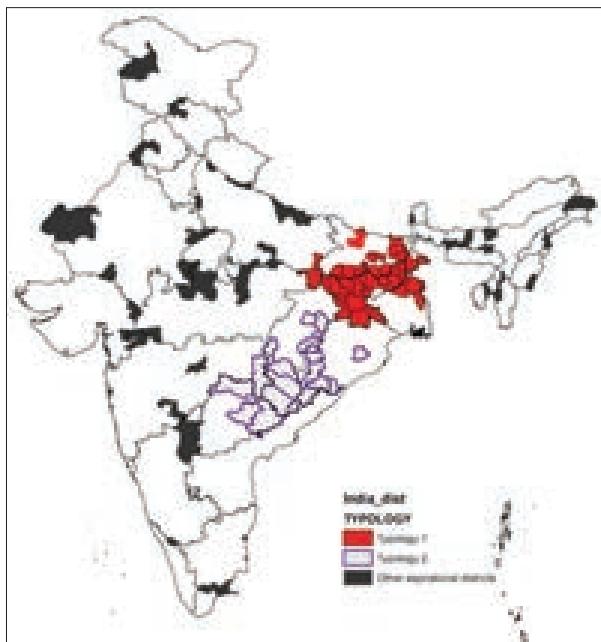
The DAC&FW through DFI Committee has been focusing on an income-centred approach rather than traditional approach of achieving farmers' welfare merely through augmenting the agricultural production. It focuses on higher profits from farming by achieving higher productivity, reduced cost of cultivation and remunerative prices of the produce. Agriculture is a State subject and their Governments undertake formulation of perspective plans and ensure effective implementation of the programmes/schemes. Also, Government of India supplements the efforts of the State Governments through various Schemes/Programmes. To ensure the reform agenda, steps have been initiated by DAC&FW to rank the States through an index, i.e. Ease of Doing Agriculture (EDA). ICAR-NIAP provided technical facilitation in designing the framework for Ease of Doing Agriculture Index. The basic apprehension is to consider farming not solely as a production oriented activity carried out to





achieve food security for the country, but also as a commercial activity carried out by the farmer as an entrepreneur. The index emphasizes on production/productivity, increased price realization, decreased input costs, risk mitigation and investment related attributes as its core components. The index will help in fostering agricultural development among various states.

Drivers of agricultural households' shift: The aspirational districts of the country were delineated into two broad typologies based on K-means clustering technique using the indicators, namely irrigation intensity, cropping intensity, rural literacy, rainfall and credit availability. Two broad typologies were obtained within the districts, which would help in formulating income policy. Further, to identify various socio-economic factors influencing the probability of shifting from traditional cultivation to non-cultivation sources, two scenarios were examined through the probability of shifting from cultivation to livestock (Scenario 1) and probability of shifting from cultivation to non-farm business (Scenario II).



Delineation of broad typologies within aspirational districts

In both the typologies, land holding size had a significant negative impact on the probability of shifting from cultivation to livestock while the square of land owned was positively related. The results also indicated that in typology-1, holding the job card reduces the probability of shifting to livestock as the sole source of income. Also, an educated farmer has greater tendency to diversify his farm with livestock. In typology-2, when a farmer holds ration card, the household will be reluctant in shifting to livestock for his earning. Also, household size was a significant driving force responsible for farmers shifting to other source of income.

Further, shifting towards non-farm enterprises was significant and positively related with the *pucca* home structure and was negatively influenced by land area possessed. This indicated that if the land under cultivation

is limited, the households often opt for non-farm business for a living. In typology 1, male headed households showed significant positive relation to shifting from traditional cultivation to non-farm business. In typology 2, possessing ration card and MGNREGA job card were negatively related with diversifying from cultivation, hence, households getting subsidized ration as well as assured labour employment were less likely to undertake non-farm business enterprises.

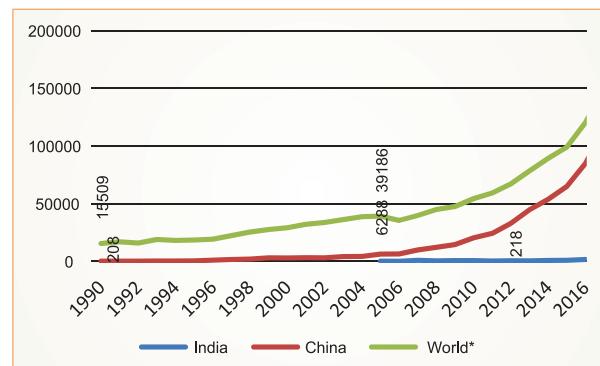
Performance and impact assessment of agricultural extension and advisory systems: Indian extension system is characterized by its pluralistic nature, wherein public, private, non-governmental organisations (NGOs), farmer based organisations (FBOs) etc., are involved in the dissemination of advisory services, input provision and other services to the farmers. This study assessed various organizational aspects and linkages among different extension and advisory service (EAS) providers in Maharashtra. A study on 28 organizations representing public EAS providers (2 district agriculture offices, 2 state agricultural universities, 6 Krishi Vigyan Kendras), FBO (3 cooperatives, 6 farmer producers companies), NGOs (4) and private companies (5) revealed the presence of linkages among all government organizations and all EAS providers with the government organizations indicating convergence and coordination among them. However, the degree of linkages varied among existing EAS in the state suggesting that more synergy can be brought among EAS providers for effective delivery and use of EAS to the farmers.

The present extension and advisory service (EAS) provision in Odisha revealed its pluralistic nature. With the existing staff strength of Village Agricultural Workers (VAWs) in Department of Agriculture, VAW to land holding ratio was 1:2011 in Odisha. In the state, 33 Krishi Vigyan Kendras are working. In addition to these public EAS provisions, several private players are also emerging mainly through information and communication technology (ICT) platform. They disseminate agro-advisories, livelihood and health related information and disaster warning to farmers through voice and text messages, audio and dial out conferences, local cable TV, All India Radio, print media, WhatsApp and field based programmes and trainings. At present they have more than 10 lakh beneficiaries in Odisha. These initiatives can supplement the public extension service provision and help in bridging the information gap among farmers.

The study assessed the source-wise access to EAS and its effects on technical efficiency of rice producing farms in Eastern India using Rice Monitoring Survey data for the year 2015–16. The study area included four states, viz. Bihar, Odisha, Uttar Pradesh (Eastern part) and West Bengal. The technical efficiency estimates revealed that farm households having access to EAS operated at comparatively higher level of technical efficiency than those without access to EAS. Technical efficiency was highest in farm households having EAS access from public, private and media sources (0.71) followed by

households having EAS access from public and private sources (0.69). The results indicated that pluralistic EAS provision can have a synergistic effect on farm technical efficiency.

Technology foresight in agriculture: The total number of patents registered in agriculture increased over the period. A region-wise comparison of the share of patents in agriculture showed that Asia accounts for the largest share of patents filed in agriculture (82.9%). The highest share of patent of Asia could be attributed to growth in number of patents filed by China.



Note: In WIPO India patent data is available from 2005.

Source: Extracted from WIPO patentscope database.
<https://patentscope.wipo.int/search/en/search.jsf>.

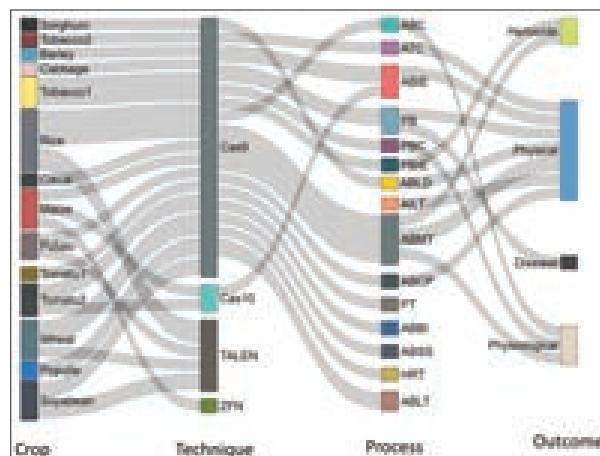
Comparison of the number of patent applications filed in India and China during the period from 1990 to 2017 revealed that the number of patents filed in China has grown from 208 in 1990 to 6,288 in 2005, later it increased sharply to 114,930 patents in 2017. In the last decade, the compound growth rate of cumulative patent filed in agricultural sector in India was 12.5%, which was higher than the growth rate of global total (11%). The steep rise in the number of patents in China could be attributed to transformation in the Chinese economy and huge investments made by the Chinese Government in patenting their research from public institutions. Though India came up with reforms in its patent act in 2005, to meet the necessary obligations under TRIPS agreement, unlike China, in terms of number no steep growth in investments is noticed. The study suggested more efforts in promoting and filing of patents for public institution are required.

Emerging genome editing technologies: In the technology foresight project we reviewed emerging genome editing techniques, its application in crops, and policy challenges in India. Bt crops were one among the few commercialized crops developed using genetic engineering techniques. Bt cotton was widely adopted in India, but Bt brinjal (eggplant), Bt maize (corn) faced regulatory hurdles. The main argument against this technology was the concern with access, social impact, health, environmental and biosafety due to the use of genetic material from different species. Genome editing technologies are emerging without few of those concerns raised against Bt technology.

The newer breeding technologies (NBTs) like

CRISPR-Cas9, TALENs and ZFN offer easier way to do cisgenic breeding (no-foreign DNA). This could be a ‘disruptive technology’ and will require a reassessment of governance, law and policy regarding its use. Among the genome editing technologies, CRISPR-Cas9 is emerging as the key technology. So far, the technology has been used for incremental changes in the crop.

There are concerns whether the technology would face the same issues faced by Bt technology in India. One of the key questions for the science policymakers and regulators is to decide whether the crops developed through these technologies are to be considered as GM or non-GM. Discussion based on the decisions done in other countries and also some insights into arguments in this regard are provided here. India follows European precautionary approach in decisions on GM crops. The authorities in India had decided to review on case-by-case basis and also it has to go through review at state (federal level). But the key issue, even if the regulation is based on the methods, is the challenge in detecting the method (modification made) in the end product.



Note: In crops numbers (1, 2) followed by its name denotes different species. Technique refers to genome editing technique; CC9-CRISPR Cas9, CC10-CRISPR Cas10. Process are starting with 'A' denoted its involves Agro-bacterium (with exception of HRT which is also Agro-bacterium mediated). ABC-Agrobacterium/Callus, ATC-Agro-transformation of cotyledons, ABIE-Agrobacterium/immature embryo, PB-Transformation using particle bombardment, PBC-Particle bombardment/callus, PBIE-Particle bombardment/immature embryo, ABLD-Agrobacterium/lad discs, AILT-Agroinfiltration/leaf tissue, ABMT-Agro-bacterium mediated transformation. ABCP-Agrobacterium/cotyledonary petioles, PT-Protoplast transformation, ABBI-Agrobacterium/Stem segments, HRT-Hairy root transformation by A. rhizogenes, ABLT-Agroinfiltration/leaf tissue.

Another major concern with this technology is the access. In a developing country like India, though these techniques present a relatively low cost means of achieving genetic modification, the wider issues would be with the social justice in terms of access to technology. But, most of the current research is in a few developed countries (US and China) and is protected by intellectual property rights. The concern would be how those technologies are going to be commercialized in developing countries. Issues of patenting and



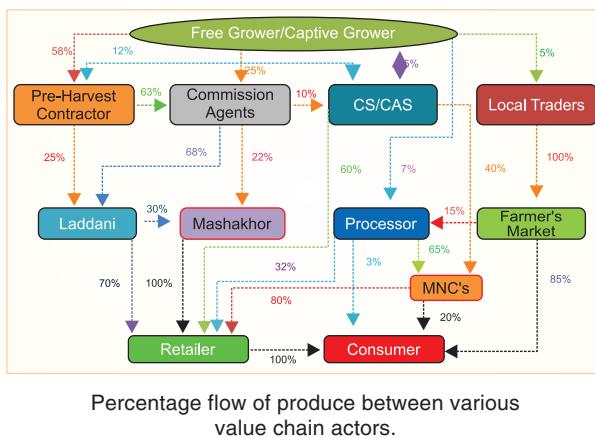


commercialization might make the method more expensive in developing countries.

Mapping of apple value chain: Apples in India are mainly grown in three mountainous states of North India. In J&K, about 48% of the area is covered under apple as per the horticulture census 2016–17 and also in terms of production (17.26 lakh MT) it provides the maximum marketable surplus. The harvesting of fruit begins from August for early maturing cultivars and continues till November with peak activity in September and October. Nearly 30% of total produce of apple crop is going waste due to pre-harvest drop, making total annual quantum of such fruit about 0.25 million metric tonnes (MT). A study on “Apple Value Chain” was conceived to analyze the apple value chain and its effectiveness. The survey sample of year 2018–19 gave information on distribution of apple from farmers’ field via different marketing channels to consumers round the year. Approximately 58% of total apple produced in Kashmir valley was circulated in the country through pre-harvest contractors purchased from captive growers. Free growers also sold 25% of apple through commission agents, 5% through local traders. Besides this, around 5% apple was stored by free growers directly in Cold storage/Controlled atmospheric storage. In addition to this around 7% of produce was purchased by processing plant that mainly included B-grade, C-grade and fallen apple. From pre-harvest contractors, 25% apple was purchased by Laddani and 65% by commission agents. Apart from this 12% of the produce was stored in CS/CAS located mainly in Lassipora, Pulwama, Sonipat and Badli, Haryana; 68% of the apple procured by commission agents moved through apple value chain by Laddani while 22% was moved across the channels by Mashkhors.

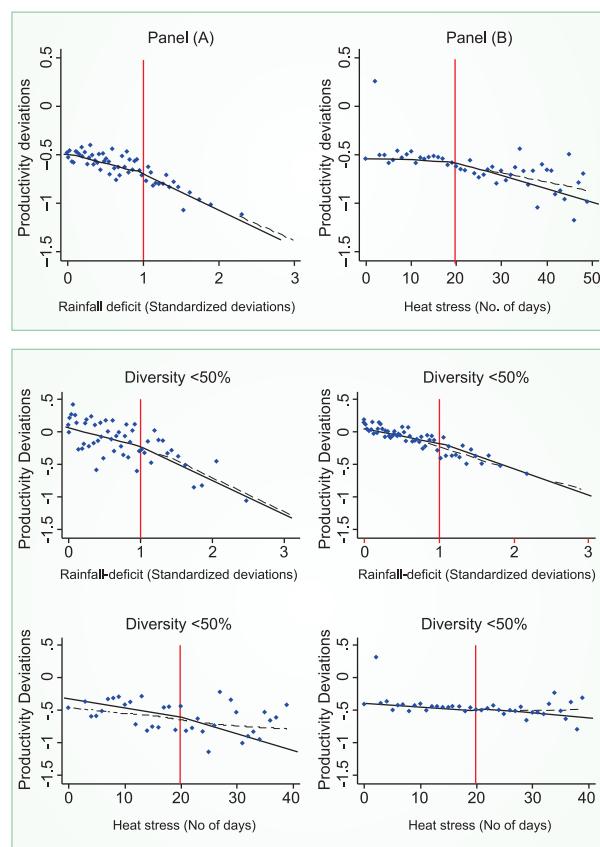
Crop diversification and resilience of agriculture to climatic shocks: Frequent occurrence of extreme climatic events adversely affects agricultural productivity and food supplies. This study assessed the dynamic effects of climatic shocks, i.e. rainfall deficit and heat-stress on agricultural productivity and the contribution of crop diversification in mitigating harmful effects of such shocks. The rainfall-deficit as well as heat-stress damage agricultural productivity, and the damage increases with increasing severity of climatic shocks.

The contribution of crop diversification in mitigating the harmful effects of climatic shocks was assessed by plotting climatic shocks and agricultural productivity at two levels of system diversity, i.e. less than 50% and more than 50% of the mean level of diversification index. There is a negative association between productivity and rainfall-deficit as well as heat-stress at low-level of system diversity. At higher level of the diversity, although the effects of climatic shocks remain negative, they are not as prominent as at the low level. The econometric analysis ascertained that marginal effect of rainfall-deficit and heat-stress is negative and significant confirming that climatic shocks reduce agricultural productivity, and the



effects get accentuated in the long-run. Marginal effect of diversification is positive and significant, and the gains are larger in the long-run. The marginal effects of climatic shocks as well as diversification vary across seasons.

These findings have two clear implications for policies aiming at making agriculture climate-resilient. One, since the climatic shocks are location-specific, there is a need to strengthen location-specific early warning systems to provide farmers timely information on weather conditions so that they are better-prepared to choose crops and other agronomic practices in anticipation of a weather shock. Yet, another related issue is of strengthening the agricultural information and input delivery systems, especially for seeds and agronomic practices that play



Binned scatter plot of climate shocks and productivity deviations.



an important role in management of risks *ex ante*. Two, there is a need to emphasize research on crop breeding for stress-tolerance. Unlike other management options, stress-tolerant seeds are inexpensive, easy to multiply and provide long-term solution.

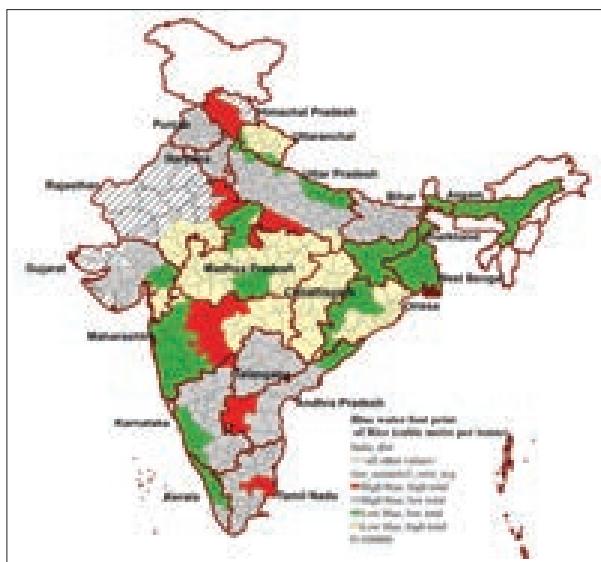
Regional level impact of climate change: The impact of climate change on agriculture system differs spatially within the country owing to large-scale heterogeneity in terms of biophysical characteristics and socio-economic developments. To develop location specific R&D and dynamic, diversified and flexible interventions it is imperative to understand the impact of climate variations at regional level. The study examined the impact of climate variations on major *kharif* and *rabi* crops during the period from 1966–2014, incorporating adaptations across different agro-climatic zones (ACZs) as delineated by the erstwhile Planning Commission of Government of India (1989). An examination of spatial and temporal variability in rainfall and temperatures revealed a rising trend in both maximum and minimum temperatures while a declining trend in rainfall was observed in most of the ACZs during the period except in few eastern and coastal regions. Inter-ACZ variations in climate impacts were observed among crops. Overall, the empirical results showed that climate change adversely impacts both the *kharif* and *rabi* crop yields across ACZs.

With the objective of formulating measurable developmental objectives and reducing regional disparity, livelihood security status of agro-climatic zones was examined using district level data across different dimensions of development; agriculture, economic, environment, infrastructure, health, nutrition and sanitation. Inter agro-climatic zone variations were observed via estimated dimensions indices and SLSI, suggesting the need for prioritizing vulnerable/ less developed areas to arrest regional imbalances, prevent overexploitation and to leverage unutilized potential of agro-climatic zones.

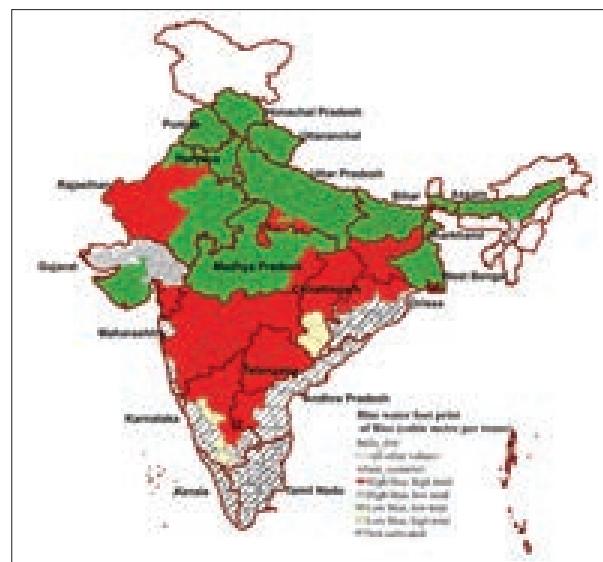
Further, to mainstream climate adaptation into the rural

development programmes, a typology of technological, informational, natural resources management and economic constraints was constructed that impede adaptations by the farmers. Moreover, a framework for mainstreaming was formulated wherein identified constraints faced by the rural/ farm households in adaptations were mapped with the appropriate policy options related to productivity enhancement and production augmentation, rural livelihood security, natural resource management, risk financing, foodgrain management, research and extension. Several programmatic interventions exist in the current rural development framework of the government that can help achieve the twin objective of adaptation and development, provided it effectively captures regional climatic considerations.

Identifying sustainable rice and wheat cultivation zones in India: This study estimated water footprints and identified the sustainable rice and wheat agro-climatic zones in India. The zones with different combinations of blue and total water footprints were categorized as highly sustainable (low blue and low total water footprints), sustainable (low blue and high total water footprints), low sustainable (high blue, low total water footprint) and unsustainable (high blue, high total water footprints) taking average water footprints of all the zones as the benchmark. Most of the agro-climatic zones of Assam, West Bengal, Odisha and Jharkhand; coastal and high rainfall hilly regions of Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra and Kerala; *Tarai* zones (low lying wet zones) of Uttarakhand and Uttar Pradesh; and Satpura plateau, Grid region and central Narmada valley of Madhya Pradesh were found to be most suitable for rice cultivation. Contrary to this, scarce rainfall zone of Andhra Pradesh, dry zones of Karnataka, central plateau zone of Maharashtra, Bundelkhand of Uttar Pradesh, western zones of Punjab, northern and southern alluvial zones of Bihar, and northern zones of Rajasthan were among



Identification of ACZs for rice production based on water use.



Identification of ACZs for wheat production based on water use.



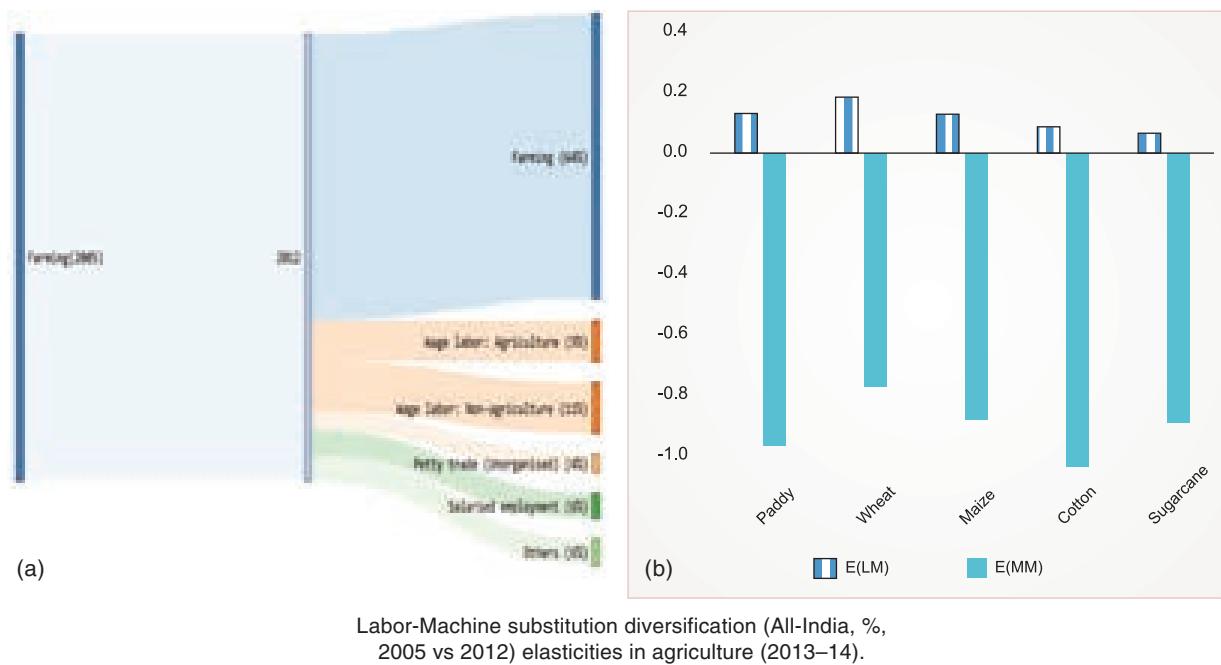
the least suitable zones. Policy intervention in terms of restriction on flooded rice cultivation is required in the latter zones.

In wheat, agro-climatic zones of western Rajasthan, Karnataka, Maharashtra, Chhattisgarh and Telangana were in the category of either unsustainable or low sustainable. In Telangana and Karnataka, unsustainability in wheat cultivation does not pose a serious threat as it is not a major crop in the region. However, in Rajasthan and Maharashtra considerable area is under wheat which necessitates promotion of alternative low water requiring *rabi* crops like mustard, gram, etc. ACZs of Assam, Madhya Pradesh, Bihar, Uttar Pradesh, Punjab and Haryana were found to be most suitable for wheat cultivation. Spread of wheat cultivation in non-traditional state of Assam may reduce the burden on freshwater sources to a certain extent. However, water conservation for supplementary irrigation and strengthening irrigation facilities is required for expansion of area under wheat in the state. Cultivation assisted with technological interventions is advocated in arid and semi-arid zones with high blue water footprints. The findings emphasize a much needed cropping pattern re-alignment across the zones based on water availability and footprints.

Structural transformation, regional disparity and institutional reforms in agriculture: Productivity growth in agriculture has improved despite absolute decline in number of farmers and agricultural labourers. To understand the extent of shift from agriculture, especially by the farm households whose major income comes from agriculture, their relative position of occupation was tested in two different years, viz. from 2004–05 and 2011–12 using the information provided in respective integrated human development surveys (IHDS). Results showed that out of all farm households during the year 2004–05, less than two-third (64%) of them continued agriculture during 2011–12. As high as

20% of them turned into wage labourers, in both farm and non-farm occupations. Further analysis was carried out to study the factors behind such shift using household level characteristics and a three-level mixed-effects logistic regression was employed. Results showed that marginal and small farm households are more likely to shift from agriculture, and such shift intensifies with exposure to distress factors. Analyzing the marginal impacts of household specific determinants (demographic, skill, security and mobility factors) of agricultural laborers belonging to different quantile classes clearly point out that raising education level and imparting technical skills to laborers would further accelerate such shift.

This labour shift, and resulting wage growth in agriculture has led to expansion of mechanization in farm operations. Still, such expansion had been crop and region specific. Descriptive statistics indicated that more than 90% of wheat and cotton growers mechanized at least to some part of their farm operations during the year 2013–14. These shares were more than 80% for paddy and maize but less than 70% in sugarcane. To understand the possibility of substituting labour with machines, an analysis was carried out and labour-machine substitution elasticities were calculated across crops during the years 2003–04 and 2013–14. For testing robustness of the results, both linear and non-linear seemingly unrelated regression equations (SURE) were used during analysis. Substitution elasticities indicated that though replacing labour with machines could be difficult, reducing the cost of hiring machines would enhance mechanization, especially in cotton and paddy. Experiences in field surveys in Madhya Pradesh showed that changes in collateral arrangements and flexibility in farm machinery composition would help the operators of custom hiring centres (CHCs) to improve their operations thereby could promote further mechanization.



Labor-Machine substitution diversification (All-India, %, 2005 vs 2012) elasticities in agriculture (2013–14).



STATISTICS AND COMPUTER APPLICATIONS

Small area estimation of survey weighted counts: An innovative methodology for small area estimation (SAE) that incorporates the information on sampling weights or clustering when estimating small area proportions or counts under an area level version of the GLMM was developed. This SAE method was applied to estimate the extent of household poverty in different districts of the rural part of Uttar Pradesh and West Bengal by linking data collected by the National Sample Survey Office of India and the 2011 Population Census. The results indicated a substantial gain in precision for the new methods compared to the direct survey estimates. The district level estimates of rural poverty incidence, produced using the developed method will be useful for various departments and ministries in Government of India as well as International organizations for their policy research and strategic planning.

VISTA—World's first crop variety identification system: The global use of germplasm is often encountered with sovereignty and access benefit sharing (ABS) issues. This has led to a great challenge to develop rapid and highly reliable method of plant Variety Identification System (VIS). A web-based tool named VISTA (Variety Identification System for *Triticum aestivum*) was developed to store genotype data. It is populated with DUS features of all varieties of model dataset. While obtaining the DNA signature based varietal identification, user gets display of its DUS feature also. This is freely accessible at <http://webtom.cabgrid.res.in/vista>. Its android version is also available at Google play store. As on today, SNP chips are available for >25 different agri-crop species, but there is no varietal signature with universal accessibility. This methodology can be of immediate use at pan-global level. The tool can be pivotal in management and implementation of material transfer agreement, trans-border movement, varietal piracy, patent dispute, sovereignty issues, Nagoya protocol and ABS issues, traceability and adulteration.

PolyMorphPredict: This is a rapid microsatellite marker polymorphism discovery tool for crop, animal and fish genome. Whole genome sequence data have revolutionized the microsatellite marker discovery and can catalogue such markers with chromosome number and location, making a catalogue or atlas of the genome. *PolyMorphPredict*, a tool available at <http://webtom.cabgrid.res.in/polypred> was developed at the ICAR-IASRI, New Delhi, and was evaluated for e-PCR genotyping efficacy in microsatellite polymorphism discovery. Predicted polymorphism was validated successfully by PCR using DNA samples of four Indian rice varieties in collaboration with ICAR-NBGR, New Delhi. Polymorphism discovery tool has module of microsatellite mining from genomic data and has module for polymorphism discovery based on amplicon size difference computed by e-PCR on user defined location on any chromosome of choice. For popularization of this

tool, provision was made for non-expert user to get self-trained by test run using 3 sample genomes available in tool. Provision was made to visualize the genotyping in simulated gel-electrophoresis. This tool can reduce the cost and time drastically by computational discovery of microsatellite polymorphism very advantageously using whole genome data of any re-sequencing and RNA sequencing projects. It has provision for e-PCR by using already published primers also. *PolyMorphPredict* would be of immense use in diversity estimation along with crop variety, animal and fish breed identification, population structure, MAS, QTL and gene discovery, traceability, parentage testing, fungal diagnostics and genome finishing.

KRISHI Portal (<https://krishi.icar.gov.in>):

Knowledge Based Resources Information Systems Hub for Innovations in Agriculture is being strengthened to streamline research data management in ICAR System. This portal serves as a gateway to enhance visibility of digital research outputs of ICAR to stakeholders. The significant additions and salient achievements includes:

- Workflow based Information System on (i) AICRP on Farm Implements and Machinery; (ii) AICRP on Post-Harvest Engineering and Technology; and (iii) AICRP on Fruits for creating research data repository. These information systems help in data reporting, compilation and report generation.
- Inter-Portal-Harvester (<http://krishi.icar.gov.in/>) provides access for unified search to more than 485,000 records on agricultural research.
- Developed technology repository as a workflow based information system for submission of proven technologies and generation of reports. A keyword search facility is also available for searching. At present, more than 525 technologies from 46 Institutes are available in public domain. ICAR Technologies are also made available at Open Government Data Platform using web-services through JSON.
- ICAR Publication and Data Inventory Repository allows individual scientists as well as nodal officers to submit publications and data, and provides access rights as per ICAR Data Management Policy. At present, more than 21,300 publications and 470 data details in data inventory are available. This Publication and Data Inventory repository is being indexed by Google Scholar, Base: Bielefeld Academic Search Engine and OpenDOAR: Directory of Open Access Repositories.
- Spatially referenced information is being presented through ICAR Geo-Portal. More than 100 spatial/map layers are now available on 14 different themes for visualization and query. The portal provides the current situation of (i) paddy residue burning in Punjab, Haryana and Uttar Pradesh for Monitoring Paddy Residue Burning in North India using Satellite Remote Sensing





on daily basis from October to November; (ii) Wheat residue burning in Indo-Gangetic plains (April 15–May 31); (iii) All Crop Residue burning (June 1, 2019 onwards). A workflow based application for Spatial Meta Data Repository was also developed.

- Different master tables, which are used by different applications are now available in the form of web-services e.g. JSON or XML so that the same may be used in various ICT applications developed by ICAR institutes.
- An android app called KISAAN- Krishi Integrated Solution for Agri Apps Navigation was developed. The app is used to provide an integrated interface for more than 110 apps in agriculture and allied areas, developed by ICAR institutions.
- At present links of 200+ mobile apps, 1,530+ videos and 350+ other are also available to bring more visibility and easy access.

Training Management Information System (TMIS): Training Management Information System (TMIS) was developed for training related needs and details for ICAR employees. It is now mandatory for all ICAR-Institutes/Headquarters/PC Units with ICAR employees to submit the Annual Training Plan (ATP) and applications for attending training program in ICAR/Non-ICAR institutes. (URL: <https://hrm.icar.gov.in/>).

Foreign Visit Management System: Foreign Visit Management System of DARE-ICAR (DARE-ICAR FVMS) is an online system (URL: <https://fvms.icar.gov.in>) for managing all activities of foreign visits/training/fellowships undertaken by ICAR employees. The workflow process of foreign visit application is digitized in FVMS thereby reducing delays in foreign visit proposals. The system enables the employee to submit the application online which goes through the online approval process and the status of the application is displayed to the employee. It benefits both applicant and DARE officers in processing of visit application more efficiently and transparently. The system maintains repository on the foreign visit deputation report in searchable format.

KVK Portal and KVK Mobile App: Krishi Vigyan Kendra Knowledge Network or KVK Portal (<https://kvk.icar.gov.in>) and KVK Mobile App were developed to disseminate knowledge and information from KVKS to farmers. The significant achievements during the year includes effective monitoring and management of Krishi Kalyan Abhiyan (KKA) along with other events through the system. Module for Direct Benefit Transfer (DBT) under Agriculture Extension Scheme was also developed and implemented.

IVRI-Waste Management App: The App was developed to impart information and knowledge to graduating veterinarians, field vets, general public, farmers and other stakeholders about management of waste originating from agriculture, livestock and household activities.

IVRI-Dairy Manager App: App was developed to

impart knowledge and skills to graduating veterinarians, field veterinary officers, development organizations and entrepreneurs for promoting dairy farming.

IVRI-Artificial Insemination App: The app is targeted to impart knowledge and skills on various aspects related to AI, viz. symptoms of heat, stages of estrus cycle, heat detection, AI kit, proper time of AI, common sanitary measures, thawing, loading of AI gun, semen deposition and post AI advice and follow-up. Hindi version has been released.

IVRI-Vaccination Guide App: It was designed and developed to impart knowledge and skills on vaccination in livestock related to all the major bacterial and viral diseases. For each of the disease in various species, the information on the causative agents, types of vaccines available, serotype/strain used for the vaccines, vaccination schedule and commercially available vaccines are provided in the App. The App also provides detailed information about the Government and Private Institutions involved in vaccine production in the country. The app is available in Google Play Store and can be installed freely.

IVRI-Pig Ration App: This App is targeted to impart and promote scientific knowledge and skills about formulation of balanced ration for various categories of pigs based on locally available feed ingredients. The App additionally provides readymade diets for pigs. Use of this Mobile App for balanced pig ration can help to enhance the profitability of the piggery enterprise. The app is available in Google Play Store and can be installed freely.

DBT DARE Portal: DBT portal for DARE (<https://dbtdare.icar.gov.in>) was developed to capture record of individual transaction (in kind or cash) under the DBT applicable schemes of DARE. The portal facilitates ICAR organizations, State Agricultural Universities (SAUs), Central Agricultural Universities (CAUs), ICAR Institutes and Krishi Vigyan Kendras (KVKS) to report all transactions (in cash or kind) under various DBT schemes of DARE. There is MIS integration between this portal and national level DBT Bharat Portal (<https://dbtbharat.gov.in>) through web service. Thus, consolidated information related to all DBT schemes of DARE are uploaded and integrated with DBT Bharat portal.

CICR Mobile App: An android application ‘CICR Mobile App’ for the smart phones was developed to support cotton stakeholders involved with cotton production. It covers all aspects of cotton cultivation. Any user can refer this App at any time in offline mode as well. The size of app is 24 MB that makes users to download in no time. The targeted end users are farmers, students, researchers, state department personnel, extension functionaries, KVK personnel, policy makers etc. Weekly advisories on cotton which are being sent to all State Government and are available with ICAR-CICR website are also linked with the cotton app for taking actions on weekly recommendations. The link for the app is: <https://play.google.com/store/apps/>





details?id= cicr.com.cicr.circottonapp.

Management System for Post Graduate System (PGMS): This system was developed and implemented in 2009 (<http://pgs.iasri.res.in>) as an online system for management of PG School. The system is operational in nine agricultural universities as of today. Significant additions during the year includes system implemented for undergraduate programme; online fee collection; adding various user type in system; multi-role functionality; hostel management system; examination module for UG; approval cycle for UG student roaster form; and various reports like fee detail report.

Sampling methodology for estimation of harvest and post-harvest losses: Sampling methodologies for estimation of harvest and post-harvest losses were developed for horticultural crops (fruits and vegetables), livestock (meat and milk), and fish (capture and culture fisheries). Accordingly, three separate guidelines were developed. The developed sampling methodology for fruits and vegetables and for meat and milk was field tested in Mexico and Zambia respectively. These three methodologies along with methodology for food grains developed by FAO and peer-reviewed by the Institute were accepted at the international level for measuring food losses along the production and supply chains as announced by the FAO.

Under field test study, the Food Loss Index (FLI) compilation (SDG Indicator 12.3.1: Global Food Loss Index) was tested on India's data. India is the only country that has carried out two nation-wide sample surveys on food losses along the entire supply chain for 45 commodities. The main challenge is not in the calculation of the FLI, rather the availability of loss factors along the various stages of the supply chain for the key food commodities.

Besides field testing in Mexico and Zambia, technical guidance is being provided to Nepal and Thailand for field testing of the developed methodologies for food loss measurement in tomato and milk in Nepal and mung bean and banana in Thailand. Classroom training as well as field training has been imparted in both the countries. Sampling design and sample size were suggested for both the countries for implementation of the developed methodologies at National level.

FAO Chief Statistician presented the status of "SDG Indicator 12.3.1: Global Food Loss Index" and submitted for Tier Reclassification at 8th meeting of Inter-Agency Expert Group on the Sustainable Development Goals (IAEG-SDG) in November 2018. The presentation was based on the methodologies developed and fields tested in different countries. FAO Statistics Division has announced that the IAEG-SDG has decided to upgrade its sub-indicator 12.3.1.a Food Loss Index to Tier II at its 8th meeting in November 2018. A Tier II indicator means that countries now have an internationally accepted methodology for measuring food losses along production and supply chains.

Integrated sampling methodology for crop yield estimation: An integrated sampling methodology for

Agricultural Research Data Book (ARDB) 2019

This ARDB 2019 is the 22nd edition in this series. It has 10 sections, and provides information on natural resources, agricultural inputs, animal husbandry, dairying, fisheries, horticulture, production, productivity, agricultural engineering, export, import, place of India in world agriculture and human resources. It has 173 tables on different aspects of agriculture.

The ARDB 2019 contains the latest information/data as available by the end of June 2019 in the country. The ARDB

2019 has some value additions like predicting the future year production of food grains, pictorial/graphical representations of data, depicting state-wise data and thematic maps using Geographical Information System (GIS). The ARDB 2019 also contains latest available information on emerging areas in agriculture sectors.



crop yield estimation for crop insurance using field surveys, remote sensing, GIS and spatial interpolation techniques is being developed to optimize the number of crop cutting experiments (CCEs) being conducted under *Pradhan Mantri Fasal Bima Yojna* (PMFBY). To develop this methodology, the survey was conducted in Buldhana district of Maharashtra during *kharif* season for cotton as well as Murena district of Madhya Pradesh for mustard and Barabanki district of Uttar Pradesh for wheat during *rabi* season. The study revealed encouraging results with significant reduction in CCEs in producing reliable estimates of crop yield.

WOMEN EMPOWERMENT

The ICAR-Central Institute for Women in Agriculture (ICAR-CIWA), is recognized as a unique institute globally for carrying out research exclusively for women farmers. The mandate of the institute is to carry out research on gender issues in agriculture, gender-equitable agricultural policies/programmes and co-ordinate research activities of AICRP on Home Science. The significant research achievements are gender based information, databases, refined and developed technologies and models which will be immensely beneficial for women farmers as well as other stakeholders.

Gender sensitization: A gender sensitization hub was designed to sensitize various stakeholders for engendering agricultural research and extension. Selected women friendly technologies (42) were identified. Assessment of gender sensitization level extension functionaries indicated that only 20–33% were highly sensitized. Accordingly, training programmes on 'Gender sensitization of extension functionaries for engendering agriculture' were organized wherein participants from 30 districts of Odisha had attended.

The gender knowledge system (GKS) database on





publications and technologies for women in agriculture was synchronized with the Krishi portal of ICAR; 314 publications of the Institute were updated on the portal.

Priority districts were identified by calculating the Milk Production Priority Index (MPPI), for taking up technological interventions. Based on the MPPI, all the districts in Eastern states were ranked and reclassified into four priority classes. Out of 50 high priority districts for milk production in Eastern India, 23 are in Bihar, 21 in Eastern Uttar Pradesh, 5 in West Bengal and 1 in Odisha.

Nutrition and livelihood enhancement of Tribal families: The data on cropping pattern, sources of livelihood, diet pattern of farm families were collected from Nabarangpur district (a zero hunger district) of Odisha; 58% of female were under mild to moderate level of chronic energy deficiency (CED) compared to 34.1% of male in the same age group. Interventions such as introduction of pulses, Terafill water filter for safe and hygienic drinking water, drudgery reducing tools and improved smokeless *chulha* were made to improve nutritional status and quality health of tribal families.

Emphasizing on doubling farmers' income by addressing gender concerns and technological gaps through developing gender sensitive model, a project was taken up at Khorda and Puri districts of Odisha. Relating to doubling the farm income, information on existing income generating activities, income and expenditure pattern of farm families were analyzed. Also capacity building and skill upgradation programmes on improved methods of paddy cultivation, cropping pattern for year round vegetable cultivation, pro-tray method of nursery raising and plasticulture in agriculture were organized.

Nutrition and livelihood enhancement of Farm women: Good agricultural practices in mango were popularized among the farming community of Mayurbhanj district. A prototype of mobile hot water treatment trolley for mango was designed to facilitate the treatment in farmers' field.

Women farmers were trained on improved aquaculture practices to enhance household fish consumption and income. Supplementary feeding with groundnut oil cake and rice bran in 1:1 ratio at 5% of the biomass, resulted in enhancement of weight of 400–500 g of Indian major carps within 5 months period. A prototype of dip net to facilitate easy harvesting of fish was designed. Market linkage with private partners for sale of small and indigenous fresh water fish species (SIFFS) was initiated. Besides, a prototype of tent type solar dryer was also made for promoting hygienic drying of SIFFS. Among several constraints faced by women in family poultry production (FPP), lack of scientific management of chicks during initial 4 weeks of age was the major problem reported by women farmers.

In peri-urban dairy farming, skill oriented capacity development programme, access to input resources and marketing opportunity were identified as the major limitations. About 80% of dairy women handle care of new born calves, milking, cleaning and preparation of

cow dung cakes. Majority (70%) of women in dairy farming perceived that knowledge about balanced feeding and feeding of pregnant animals is the critical area for capacity building.

An action research was conducted to develop a suitable model for FPP (Family Poultry Production) especially for women farmers. The supplementary feeding resulted in higher weight gain of poultry birds along with enhancement of income per beneficiary. Growing kids fed on oil cake and mineral mixture recorded the highest average daily gain and feed efficiency. The supplementary feeding of locally available proteinaceous groundnut oil cake along with mineral mixture had beneficial effect on reducing age at first service, post parturient complications of female goats.

Integrated floating cage aquageoponics system (IFCAS) was designed to utilize the perennial household pond surface for growing vegetables as well as fish for nutritional security and economic fortification of farm families. The benefit: cost ratio of this model was 1.4 during one season.

Under the project 'Adding value to fish: a potential livelihood option for rural women of Odisha', capacity building programmes were conducted to equip fisher women with adequate knowledge and skills on scientific and hygienic preparation of value added fish products and by products as potential livelihood option. Recipes of innovative value added products like fish chutney powder, prawn badi, fish papad, fish cutlet, fish momos and organic manure from fish silage were standardized.



Prototypes of disc type ridger considering the female anthropometry were developed for drudgery reduction of women farmers.

Drudgery reduction of farm women: Two prototypes of disc type ridger considering the female anthropometry were developed for drudgery reduction of women farmers. The first prototype needs two persons for operation in pushing and pulling action. The second prototype can be operated by single person in pushing mode.

The major production constraints and occupational health hazards faced by fisher women in fish processing were—lack of improved tools and protective gears, lack of water source, scarcity of human labour and unavailability of fish seed. Among several activities in





fishery sector, net making, fish marketing and shrimp processing are mostly carried out by women. Several capacity building programmes were conducted to equip the farm women in fishery sector with adequate knowledge and skill on scientific and hygienic preparation of value added fish products and by-products. The recipe for various innovative value added products, viz. fish chutney powder, prawn badi, fish papad and organic manure from fish silage were standardized.

Skill based training of master trainers, on-farm skill demonstration and interactive sessions were organized to empower women farmers with gender friendly farm equipments. Field trainings (176) were imparted to the beneficiaries. The impact study on provision of gender friendly farm tools in watershed areas revealed that equipments, viz. mandwa weeder, hand compression sprayer, improved sickle, pedal thresher, CRRI hand winnower and twin wheel hoe were frequently used by the women farmers of Rayagada, Nabrangpur and Koraput district of Odisha. However, need for capacity building programme and assistance for maintenance and repair of tools and equipments were also expressed by majority of women farmers. Under the AICRP on Ergonomics and Safety in Agriculture, a multipurpose harvesting bag and women friendly power operated groundnut decorticator were developed.

Extension systems: Grass-root institution and capacity building: Training programmes on women leadership and a review workshop on “Capacity needs assessment of extension and advisory service providers in Odisha” were conducted. A producer group involving 1,031 women farmers was developed for marketing of aromatic rice.

AICRP on Home Science

The AICRP on Home Science focused on gender mainstreaming and empowerment of rural women, drudgery assessment and mitigation, nutritional security and dietary approaches for addressing non communicable diseases, parenting and reproductive health, sustainable livelihood security of rural families through locally available natural resources and capacity building of agrarian families to adopt different IFS models for facing climate related issues and digitization of knowledge products for rural families.

Foods (362) from different major food groups having low glycemic index (GI) were documented, and a database on 135 region specific low glycemic index foods for the management of diabetes was prepared. Recipes (37) of traditional products were modified towards low glycemic index by incorporation of region specific low glycemic index plant foods. The developed products were nutritionally and economically evaluated. The highest overall acceptability was obtained in the products prepared by TNAU centre, i.e. Kavuni rice puttu (8.80), kodo millet based chapathi (8.80), kodo millet based puttu (8.70) followed by AAU centre and PJTSAU centre, i.e. multigrain khichidi (8.60) and rice (8.60), respectively.

Formulation of high fibre multigrain mix from locally

available cereals, millets, pulses and other functional food ingredients (FFIs) for management of over-nutrition and formulation of nutrient dense multigrain mix from locally available cereals, millets, pulses and other FFIs for management of under-nutrition among farm women of the adopted villages were developed. These products were nutritionally analyzed along with sensory and economic evaluation.

The drudgery perceived by women farmers in rice, maize, vegetables based production system were characterized. In vegetable cultivation, the highest workload score was given to cutting/ plucking of vegetables (4.6). Resource centres for training on gender friendly drudgery reducing technologies were established in project adopted villages. For food processing units, ergonomically designed low working table, storage shelves and portable trolley for the workers were designed and developed.

Farm Women Knowledge Groups were promoted to assess the use of ICT in agriculture and allied sectors. Majority (nearly 67%) of respondents irrespective of gender had favourable attitude towards ICT, and more than 70% respondents irrespective of gender perceived that ICT had a positive effect in enhancing knowledge however, the respondents were not aware about KIOSKs, AGRINET, Kisan Mobile Sandesh, and Village Information Centre. The need of information through ICT (mobile phone) was highest for crop production.



Data collection on use of ICT in agriculture and allied sectors.

The extent of awareness of women farmers on indicators of climate change and climate variables influencing production, revealed that 51.06% of respondents were fully aware about increase in temperature followed by 40.68% about changes in water level and 33% about irregular rainfall. Regarding adoption of practices for coping with climate change, 39.63% had changed their planting calendar, 36.09% adopted inter-cropping, 32.27% adopted crop diversification, 31% shifted to integrated farming system and 29% adopted crop rotation. A conceptual framework for scoping IFS models from gender perspective with emphasis on income enhancement was developed and altogether 37 IFS models were identified based upon agro-climatic zones.





The fibre extraction procedure were standardized for non-conventional sources of underutilized fibres, viz. 6 bast fibres, 2 leaf/sheath fibres, and 2 seed hair fibres, and were processed for value addition. The extracted fibres were analyzed for the chemical composition and fibre quality parameters. A natural dyed castor fibre showed good to extremely good sunlight fastness and very good to excellent fastness for washing, rubbing and perspiration. Underutilized fibres, viz. mesta fibre was also utilized for sanitary napkins preparation.

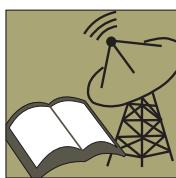
Fibre extracted from selected plant biomass

Under popularization and product diversification of ethnic crafts on textiles with ICT application, traditional designs and motifs were documented, which will be tested for the acceptance of the fusion of art forms and subsequently the designs, will be digitized for commercial production and development of a business model.

Data on reproductive health, maternal health and child

care and psychological well being were collected in 11 states. The standard norms for prevalent levels of psychological well being, reproductive health knowledge and maternal and child health knowledge of rural women were established and intervention packages were developed to bring improvement. Awareness camps on reproductive and maternal health were also organized. To prepare woman for conception and delivery of a healthy child and to nurture the child in healthy environment, information and risk factors about maternal and child care in rural families and knowledge of farm women regarding reproductive health were collected. The total Maternal and Child Health Awareness (MCHA) showed significant relationship with reproductive health awareness, psychological well being and socio-economic status. With regard to reproduction health awareness significant positive correlation was found with intellectual health dimension and total well-being.





13. Information, Communication and Publicity Service

The Directorate of Knowledge Management in Agriculture works for swift, effectual and cost effective delivery of useful information for enhancing effectiveness and sustainability of agricultural practices followed by stakeholders in the agricultural sector. The Directorate is adopting modern methods of print and electronic mode to showcase the technologies, policies and other activities of ICAR. Directorate also designs, maintains, and updates ICAR website and network connectivity across ICAR institutes and KVKS alongwith Public relation and publicity support to the council and its constituent managing institutes across the country. DKMA is part of the showcasing of impact analysis of the Farmers FIRST project through print as well as social media.

Knowledge and information products

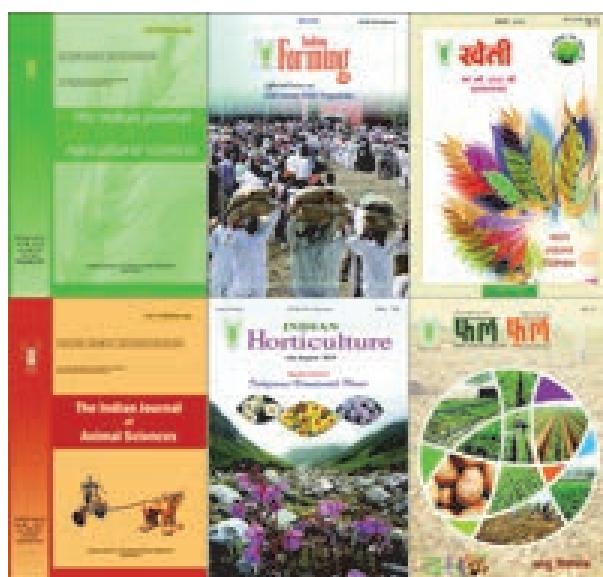
The Indian Journal of Agricultural Sciences and *The Indian Journal of Animal Sciences* the flagship monthly research journals of the Council, have been put in the open access mode (<http://epubs.icar.org.in/ejournal>). The in-house journals like *ICAR Reporter* and *ICAR News* are also made available for wider global reach on ICAR website. Special issues of the *Indian Farming* were brought out on Success Stories of Farmer FIRST (May 2019, June 2019). The three special issues of *Indian Horticulture* were on Success Stories of Farmer FIRST (Horticulture module, May–June 2019), Beautiful World of Indigenous Ornamental Plants (July–August 2019) and Potato (November–December 2019). During this period the two special issues of *Kheti*, the flagship monthly Hindi Journal of ICAR on Sugarcane and Nutrition, *Krishi Khabrein desh-videsh ki* column

was introduced in the magazine to make it more interesting and informative for readers. The layout and designing of the bimonthly Hindi Journal '*Phal Phul*' is being modified to make it more attractive. In order to achieve National goal, i.e. based on doubling farmers' income and articles on success stories of progressive farmers were published on a regular basis in all popular magazines. Articles on emerging challenges of agriculture, the climate change, efficient water use, food processing were published on priority basis for the benefit of farming community. The economic aspect of technologies was also included in the articles to inform readers about the economic viability of the technology. The popular magazines of ICAR were reoriented to make these demand-driven and competitive and also linked with the Facebook of ICAR. To share the agricultural knowledge and information through value added information products in print, the DKMA has brought out 10 books in English and one book in Hindi. More than 83 textbooks are in process under UG/PG Level textbooks programme for the Agricultural Universities, as these are written as per the syllabus of the V Deans' Committee Report. The benchmark publications of ICAR under Handbook series—*Handbook of Agriculture* and *Handbook of Agricultural Extension* are in process at different stages. Two Volumes of *Handbook of Horticulture* were released on the occasion of the Foundation Day of ICAR, i.e. 16 July 2019. The in-house faculty was also involved in conducting trainings on 'Online article processing', 'Writing for Quality Research Journals', 'Role of Reviewer in Quality Research Journals', 'Book Writing' and 'Success Stories'.

The ICAR web pages were revised and current news items were posted in web mode. Development of e-resources on agricultural knowledge and information for global exposure is done through <http://www.icar.org.in> and <http://epub.icar.org.in/ejournal>. The Directorate has facilitated online access to 3,300 journals from a single subscription in more than 152 website institutions under CeRA. During the reporting period Business Unit has achieved the target of ₹ 69 lakh through sales of ICAR publications. Business Unit participated in major agricultural and science related events for distribution of ICAR publications and showcasing ICAR publications to agricultural community.

Social media

In order to disseminate information in real-time and also the last time, the ICAR website is updated on regular basis, and in total 1,320 pages were created,

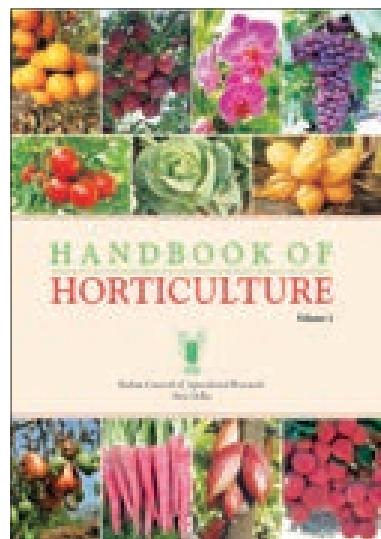




and page-views 3,642,753 from more than 200 countries. Knowledge seekers from across the globe visited the website. The top five countries visiting the website include India, United States of America, United Kingdom, United Arab Emirates, and Nepal. DARE website received GIGW certification in 2018. The website is updated regularly. *E-Krishi Manch*, a web based public utility, is a public-connect platform for stakeholders in more efficient, quick and simple manner by direct approach. On ICAR facebook total 254 posts were published and it has 185,145 followers. ICAR twitter handle <https://twitter.com/icarindia> has more than 60 thousand followers. On an average one tweet is posted every day, there are total 280 tweets. The YouTube Channel of ICAR has video films, animations, lectures/interviews by dignitaries and eminent scientists, proceedings of national and international events, etc. Some of the popular documentaries have received more than 250,000 views.

Agricultural Knowledge Management

Agricultural Knowledge Management Unit (AKMU) of Indian Council of Agricultural Research undertakes management and maintenance of ICT infrastructure which includes Gigabit-speed wired and wireless network in premises of ICAR at Krishi Anusandhan Bhawan-1, Krishi Anusandhan Bhawan-2 and National Agricultural Science Centre Complex. An e-Publishing system developed and implemented in-house is hosted in secure network center of ICAR at KAB-1, Pusa Campus, New Delhi. The e-publishing system is used by readers, authors and research reviewers globally from 184 countries, 24x7, through Internet for accessing and publishing research in ICAR's research journals. Two new online journals namely *Indian Journal of Agroforestry* and *Annals of Plant Protection Sciences*



etc., were hosted online on the e-Publishing portal <http://epubs.icar.org.in/ejournal>, a unified gateway of research journals of ICAR. Presently a total of 42 research journals are hosted. Other important activities undertaken by AKMU were: Management and maintenance of web-based e-Publishing system of



ICAR; An android app called KISAAN-Krishi Integrated Solution for Agri Apps Navigation, which provides an integrated interface for more than 110 apps in agriculture and allied areas prepared by ICAR institutions, was developed. It is a multi-lingual app. Technological backstopping provided to thirty six professional agricultural societies for e-Publishing of their journals using online e-Publishing system developed and maintained by AKMU, ICAR.



14.



Technology Assessment, Demonstration and Capacity Development

The frontline extension systems as part of National Agricultural Research System of the country, has taken up activities through Krishi Vigyan Kendras (KVKs) and other programmes for application of farm technologies in farmers' fields. Besides taking up technology assessment, demonstration and capacity development programmes during the year, the other initiatives such as Farmer FIRST, Attracting and Retaining Youth in Agriculture (ARYA), Cluster Frontline Demonstration of Pulses and Oilseeds, National Innovations in Climate Resilient Agriculture (NICRA), Pulses Seed Hubs, KVK Portal, ATICs, *Mera Gaon Mera Gaurav* and awareness creation about mega government schemes etc. were also implemented to espouse the cause of farming community through technology application with their active participation.

Technology assessment

Technology assessment is one of the main activities of KVKs to identify the location specificity of agricultural technologies developed by National Agricultural Research Systems (NARS) under various farming systems. The details of technologies assessed at different locations are as follows:

Assessment: A total of 4,750 technologies of various crops were assessed at 15,501 locations by KVKs through conducting 24,016 trials on the farmers' field under 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 technologies, seeds and planting materials production, storage techniques besides varietal assessment for cereals, pulses, oilseeds, fruits, vegetable crops and commercial crops. Varietal evaluation was the major theme of technology assessment under which 1,091 technologies were assessed through 5,614 trials. Other major themes on which technology assessment was conducted included integrated nutrient management (674 technologies, 3,719 trials, 2,386 locations) and integrated pest management (631 technologies, 3,424 trials, 2,001 locations).

Under livestock, 777 technological interventions across 3,832 locations conducting 6,763 trials on animals under the thematic areas of disease management, evaluation of breeds, feed and fodder management, nutrition management, production management, processing and value-addition were taken up for assessment. The major theme was feed and fodder

management with 161 technologies and 933 trials at 678 locations. The major livestock species covered were cow, buffalo, sheep, goat, poultry, pig and fish.

Under enterprises category, 598 technologies were tested at 1,426 locations through 3,653 trials. Besides, 202 technologies exclusively related to rural women were assessed through 2,282 trials at 628 locations. Major thematic areas under enterprises were drudgery reduction, processing and value addition, health and nutrition, energy conservation, small-scale income generation, storage techniques, household food security, organic farming, agroforestry management, mechanization, resource conservation technology. The major enterprises included were mushroom cultivation, vermicompost production, processing of fruits and vegetables, nutritional garden and rural craft.

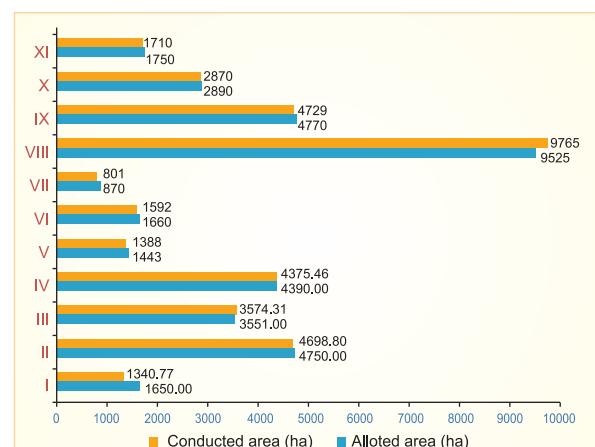
Frontline demonstrations

Cluster frontline demonstrations

Pulses: National Level Cluster Frontline Demonstrations (CFLDs) on pulses were initiated to demonstrate the production potential of new pulses varieties and the related technologies. The project also aimed for enhancing the pulses production in the country.

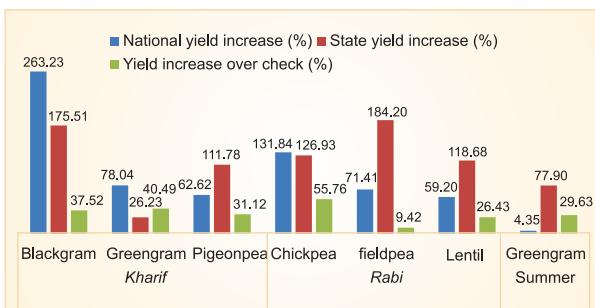
At the national level, 37,249 ha area was planned; out of which 36,844.34 ha area was actually covered with 75,139 demonstrations across the country under CFLDs on pulses. The budget allocation for CFPDs on pulses was ₹ 25.29 crore. In kharif 14,300 ha, rabi 17,832 ha and summer 4,712 ha area was covered under CFLDs of pulses.

There was 263.23, 175.51 and 37.52% increase in yield over national average yield, state average yield and



Zone-wise allotment and actual area covered under pulses demonstrations (2018–19)



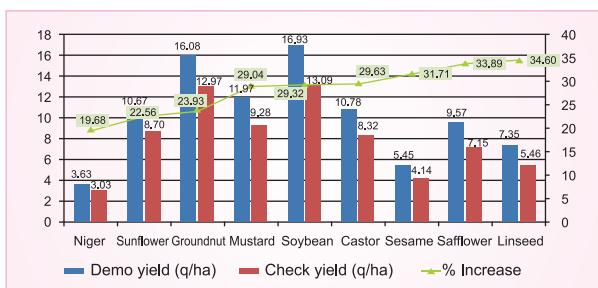


Yield advantages through CFLDs pulses as against the national, state and check yield

local check, respectively, in blackgram; 78.04, 26.23 and 40.49% in greengram; 62.62, 111.78 and 31.12% in pigeonpea; 131.84, 126.93 and 55.76% in chickpea; 71.41, 184.20 and 9.42% in fieldpea; 59.20, 118.68 and 26.43% in lentil; and 4.35, 77.90 and 29.63% in summer greengram under CFLDs on pulses.

Oilseeds: During the reporting period, under CFLDs on oilseeds, 22,245 ha area was allotted out of which CFLDs on oilseeds were conducted in 20,654.45 ha (50,669 demonstrations) across the country. Demonstrations in 8,687.65 ha during *kharif*, 10,709.6 ha during *rabi* and 1,257.2 ha during summer were conducted.

On national level, the yield advantage in oilseed crops over the farmer's practice was recorded highest in linseed (34.60%) followed by safflower (33.89%), sesame (31.71%), castor (29.63%), soybean (29.32%), mustard (29.04%), groundnut (23.93%), sunflower (22.56%) and niger (19.68%). This was due to suitable technology interventions and skilling of farmer.



Yield performance of oilseed crops

Frontline demonstrations: Demonstrations (69,597 other than CFLDs) on crops covering 21,816 ha, 7,617 demonstrations on farm machineries, 19,811 on livestock and fisheries and 21,217 demonstrations on other enterprises were organized.

Cereals: In rice, wheat, maize, and barley, 21,566 demonstrations were conducted on 8,017 ha. The highest increase in yield in demonstrations was in maize (68.7%) over the yield obtained in farmers' practice followed by rice (40.3%), buckwheat (31.25%) and wheat (14.3%).

Millets: FLDs (1,390) were laid out covering 530 ha under millet crops including foxtail millet, finger millet, pearl millet and kodo millet during the year, achieving yield increase of 71.2% in finger millets followed by kodo millets (36.6%) over the yield obtained in farmers' practice.

Pulses (other than CFLDs): FLDs (7,951) on different pulse crops other than CFLDs were conducted covering an area of 3,329 ha. Highest number of demonstrations were conducted on chickpea (2,043), followed by blackgram (1,822) and greengram (1,137). The yield increase in demonstration was 49.07% in pea over the yield obtained in farmers' practice followed by cowpea (46.75%), greengram (33.9%), chickpea (30.5%), blackgram (29.66%), horsegram (24.61%) and pigeonpea (20.09%).

Oilseeds (other than CFLDs): Demonstrations (5,395) were conducted covering an area of 2,475 ha. Demonstrations were more on groundnut (1,472) followed by mustard (1,154), soybean (840) and sesame (649). Groundnut yield showed an increase of 36.5% in demonstrations over the yield obtained in farmers' practice followed by sunflower (34.9%) and mustard (31.6%).

Commercial crops: The KVks conducted 1,421 demonstrations on different commercial crops covering an area of 630 ha. Highest number of FLDs were conducted on cotton (870) followed by sugarcane (351) and jute (200). The yield increase in demonstration was 19.1% in cotton over the yield obtained in farmers' practice, 23% in jute and 15% in sugarcane.

Fodder crops: Demonstrations (3,264) on different fodder crops (berseem, maize, sorghum, napier grass, etc.) were conducted on farmers' fields covering an area of 547 ha. The yield increase in demonstration on maize was 76.4%, oats 25.7%, berseem and lucerne 22.4%, and bajra 11.5% over the yield obtained in farmer's produce.

Horticultural crops: Demonstrations (20,503) on vegetables (14,108), fruits (2,153), flowers (515), spices and condiments (2,380), plantation crops (685) and medicinal plants (662) were conducted in 4,218 ha. The yield increase in demonstration was 36.9% in spices and condiments over the yield obtained in farmers' practice, 35.8% in plantation crops, 32.6% in fruits, 32.3% in vegetables and 28.5% in flowers.

Hybrids: Demonstrations (8,107) on hybrids of cereals, oilseeds, pulses, fodder crops, commercial crops and horticultural crops were laid out in 2,070 ha. In cereals, 2,509 demonstrations were conducted in 846 ha.

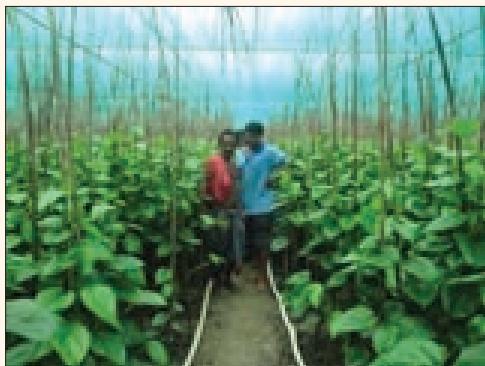


Demonstrations on hybrids of oilseeds were conducted in 236 ha with yield advantage of 29.3% over the yield obtained in farmers' practice, while 3,176 demonstrations were conducted on vegetables, fruits, flowers and spices

Success Story

Hi-Tech Pan Boroz: A new vista in betelvine cultivation

Betel leaf is one of the important commercial crops of the district South 24 Parganas. Out of total cultivable area of 368,197 ha of the district, betel leaf occupies 2,685 ha area covering around 35,000 households from six blocks. This crop has become mainstay of occupation for blocks namely Sagar, Namkhana and Pathar Pratima.



Betel crop on modified *boroz* structure

Betelvine, a shade loving crop, is usually grown in *boroz*—an artificial shade structure made up of bamboo, paddy straw and other related bio-degradable items. Growing betel vine within this structure is prone to numerous diseases and insect pests. These structures are also frequently affected by storms and cyclones in the coastal area. A durable *boroz* structure using GI pipes on concrete basement fitted with green shade net, 75% on the top and 50% on the side walls, was developed by KVK of South 24 Pargana. It is made up of non-degradable items, thereby, chances of pest and disease attack are very low. This *boroz* is fitted with micro-sprinkler irrigation facility, which reduces irrigation cost, maintains temperature and humidity within the *boroz* during the hot summer and dry winter. It gives uniform shading resulting in uniform colouration of leaf. After adopting this modern *boroz*, farmers are experiencing better profitability in betelvine cultivation due to lower cost of cultivation, minimum/no recurring cost for maintenance of *boroz* structure, higher production and higher market value of the produce (leaf) due to good colour, shape (roundish) and lustre of the leaf. The construction cost of a Hi-Tech *boroz* of 500 m² size is ₹ 300,000. Farmer needs to bear 50% of the total cost and the rest is assisted by State Department of Horticulture through NHM scheme. KVK has made an arrangement of getting bank loan of the farmers' contribution amount (50% of the total cost) through a tying-up programme with local banks. For the ease of the farmers, door step bank account opening was done at village level. At present, around 2,000 farmers approached KVK for getting this type of hi-tech *boroz* in lieu of their traditional one.

in 424 ha area. In hybrid cotton, 1,065 demonstrations were conducted in 437 ha with yield increase of 16.9% over the yield obtained in farmers' practice. Hybrids of fodder crops were demonstrated conducting 118 FLDs with an average yield increase of 57.3% over the yield obtained in farmers' practice.

Farm mechanization: Demonstrations (7,617) on improved tools and farm implements including drudgery reduction technologies were laid out covering 5,090 ha.

Livestock and fisheries: Demonstrations on dairy animals, sheep and goat, including chicken, quail, turkey and duck, piggery, rabbit etc., were carried out in which 17,490 farmers were benefited. In the demonstration on fisheries, 2,321 fish farmers were benefited.

Other enterprises: Demonstrations on 23 allied enterprises like mushroom cultivation, apiary, sericulture, value-addition, vermicomposting, nursery etc., were conducted involving 21,217 farmers.

Capacity development

A total of 17.98 lakh farmers/ farm women, rural youth and extension personnel were trained on various aspects of agriculture and allied sectors through 64,620 training programmes including the sponsored training courses.

Farmers and farm women: Training courses (49,833) on various technologies benefited 14.98 lakh farmers and farm women out of which 10.52 lakh (70%) participants were from other classes while 4.45 lakh (30%) were from SC/ST category. These courses targeted productivity enhancement and cost reduction of field crops (20.62%), horticultural crops (11.21%), plant protection (11.99%), livestock production and management (10.52%), soil health and fertility management (11.28%), empowerment of rural women including home science (11.14%), agricultural engineering (4.85%), capacity building for group actions (4.73%), production of inputs (2.37%), fisheries (2.18%) and others including agroforestry (9.06%). Out of these training courses, 35.04% were organized on-farm while rest (64.96%) were organized off-campus. Within field crops, integrated crop management was the leading theme in which 24.28% courses were organized followed by seed production (11.78%), weed management (9.06%), cropping systems (7.88%), integrated farming (7.58%), resource conservation technologies (6.78), nursery management (3.25%), crop diversification (5.63%), water

Mobile advisory services

Timely and need based information to the farming community was provided by 637 KVKs using mobile advisory services during the reporting period. Farmers were alerted and advised on suitable actions based on weather forecasts, outbreak of pest and disease incidence and market prices. As many as 1,207,561 messages were sent by KVKs benefiting 1,049.56 lakh farmers on various aspects of agriculture, horticulture and animal husbandry, weather forecast, and pest and disease using in Kisan Portal.





Success Story

Backyard nutritional kitchen garden for nutritional security and additional income

Backyard nutritional kitchen garden was demonstrated to farm women's families in Nutri Smart Village Morjhira, Burhanpur District, Madhya Pradesh. Training, exposure visit and farm women-scientist interaction on various aspects including vegetable grown in homestead, homestead vegetable utilization, average vegetable consumption, nutrient contribution from homestead vegetable gardening were undertaken by KVK Burhanpur. Pre-survey was conducted to obtain information regarding profile and dietary food habits and nutritional deficiency diseases. After one year of



Demonstration and training on nutritional kitchen garden

establishment of nutritional garden, a survey was done to analyze the impact of kitchen gardens on nutritional status of selected farm women's families. The information showed increase in vegetable production, utilization and consumption among the farm families. From 250 m² land, average production of vegetable is 6 q/annum. On an average, cost of cultivation is ₹ 1,500, average gross return is ₹ 3,600 and average net return is ₹ 2,100. Intake of energy, protein and iron increased after intervention of nutritional kitchen garden which changed nutritional status of the farm women's family members. Farm women are getting additional income with nutritional security. Nutritional Kitchen Garden is gaining momentum in the Morjhira village as 23 families other than selected ones also adopted this concept.

management (2.93%) and production of organic inputs (3.37%). Among the training courses on horticulture, vegetable crops constituted 50.38% while proportion of courses on fruits was 26.16%. However, the respective share of training courses on medicinal and aromatic plants, spices, tuber crops, plantation crops and ornamental plants was less than 6%.

Rural youth: Training courses (10,839) for the capacity development of rural youth were organized for 1.84 lakh participants out of which 66,941 (36.43%) were the young women during this year. The highest proportion of training courses were imparted on mushroom production (8.00%) followed by seed production (7.39%), value addition (5.82%), nursery management of horticulture crops (5.31%), vermiculture (5.25%),

dairying (5.15%), bee keeping (4.86%), integrated farming (4.66%) and production of organic inputs (3.00%). There were other areas also on which relatively smaller number of training courses were organized for the rural youth. About 40% of these trainings were conducted on-campus.

Extension personnel: Capacity development of 1.16 lakh extension personnel (23.45% female participants) was carried out through 3,948 courses in the country. Extension functionaries working both in government and non-government organizations were included in these trainings, which mainly focused on agricultural technologies and knowledge enhancement in field crops (15.39%), integrated pest management (15.39%), integrated nutrient management (10.37%), protected cultivation technology (5.75%), information networking among farmers (5.32%) and women and child care (4.76%). Information management of farm animals, livestock feed and fodder production, protected cultivation technologies and information communication technology (ICT) applications were other areas under such training courses. Higher proportion of trainings for extension personnel were organized on-campus (59.86%) compared to the off-campus (40.14%).

Sponsored training programmes: Sponsored training courses (6,680) were organized for 2.41 lakh participants comprising farmers, farm-women, and rural youth and extension personnel. The women participants constituted 32.22% training programmes. The programmes mainly focused on crop production and management (59.86%), livestock and fisheries (15.09%), home science (9.31%), agricultural extension (8.88%), farm machinery (1.95%) and miscellaneous (16.52%). Similarly, there were 3,303 sponsored training for vocational courses which benefited 56,702 rural youth of the country.

Extension programmes

KVKS organized extension programmes/activities (6.30 lakh) 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 ghosthi*, *kisan melas*, lectures delivered as resource

Technology Week Celebration

Under Technology Week Celebration programme, 26,521 activities were organized by 364 KVKS benefiting 3,937,926 farmers. The main activities were distribution of seeds (24,832.73 q), bio-fertilizers (4,230.14 q) and bio-products to 1,503 farmers and other activities like gosthies (2,044), lectures (3,589), exhibition (940), film show (1,866), fair, farm visits (187), diagnostic practical (10,401), distribution of literature (31,471), distribution of planting materials (30,03,627), distribution of fingerlings (8,27,032) and distribution of livestock specimen (51,784) were also conducted.





Success Story

Actualizing *in situ* crop residue management in Punjab, Haryana and UP

The region of Punjab, Haryana and Western Uttar Pradesh is witnessing severe crop residue burning incidences. KVKs (60) were involved in implementation of the Information, Education and Communication (IEC) component of the Scheme on "Promotion of agricultural mechanization for *in situ* management of crop residue in the state of Punjab, Haryana, Uttar Pradesh and NCT of Delhi".

About 4,000 walls of prominent buildings and structures were painted; more than 10,000 posters, banners and hoardings were installed; more than 100 panel discussions and awareness programmes were telecast on DD Kisan and publicity materials were distributed to stakeholders to sensitize them about the harmful effect of residue burning, benefits of *in situ* residue management and government schemes to procure subsidized machines. Similarly, around 700 awareness programmes at village, block and district levels and 75 *Kisan Melas* with about 2 lakh participants, were organized. Likewise, about 40,000 students from 250 schools and colleges were involved to spread the message against residue burning. Environmentalists and religious saints like *Padma Shri* Baba Balbir Singh Seechewal and *Padma Shri* Baba Sewa Singh were roped into mobilize the stakeholders. Hands-on trainings for about 20,000 farmers, tractor owners and machine operators were organized. Frontline demonstrations in more than 12,000 ha area were organized. About 200 exposure visits, 250 field days and harvest days were also organized in which more than 10,000 farmers were exposed to the technologies. The festival of *Baisakhi* was celebrated as "no crop residue burning day".

The efforts also made 132 villages of Punjab and Haryana free from burning (<80–85% burning) in 2018 covering more than 45,000 ha area. The comparison between fire intensity classes suggest change of about 1.2% (Punjab), 5.5% (Haryana) and 4.6% (Uttar Pradesh) of fire event's intensity from very high to low. Wheat area under Zero tilled/ Happy Seeder sown wheat in Punjab and Haryana increased to 8 lakh ha. The data for Punjab depicts improvement in the Air Quality Index (AQI).

persons, 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. These programmes were attended by 183.66 lakh participants of which 180.37 lakh were farmers and 3.29 lakh extension personnel.

Besides, a total of 4.65 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 (184,051). About 182,999 farmers made their foot fall to KVK and 22,958 news items were published

in local and national dailies. Scientists of KVKs published 4,423 popular articles, 773 research articles besides 4,277 radio talks and 8,294 TV talks.

Production of technological products

Several technological products were produced at KVKs, which benefited 13.77 lakh farmers in the country.

Seeds: During the year, 2.01 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 2.72 lakh farmers.

Planting materials: A total of 348.01 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 6.42 lakh farmers.

Bio-products: Bio-products, namely, bio-agents (1,651.41 q), bio-pesticides (1,828.07 q), bio-fertilizers (17,760.72 q), vermicompost, mineral mixture etc., were produced and supplied to the extent of 2,61,301.91 q benefiting 4.17 lakh farmers.

Livestock, poultry and fish fingerlings: Improved breeds of cow, sheep, goat, buffalo and breeding bull were produced and supplied to 4,752 farmers. Different strains/breeds/eggs of poultry birds (chickens, quails, ducks and turkey) were provided to 35,511 farmers. Improved breeds of pigs were provided to 464 farmers. KVKs also enabled 18 farmers to establish small rabbit

Success Story

Management of soil acidity through dolomite application for rice cultivation

Rice, one of the major crops in Kanyakumari district of Tamil Nadu, occupies more than 12,000 ha area in two seasons of the year. Soil of around 50 to 60% of the rice area of the district is acidic in nature. Mobilization and reduction of ferric iron to ferrous iron due to low pH and continuous submergence causes nutritional imbalance and disorder in rice crop. This results in yield reduction due to less productive and ill-filled grains. The KVK Kanyakumari, during OFTs, found that application of dolomite @ 500 kg/ha during the last plough is effective in reclamation of soil acidity and also adds calcium and magnesium which are deficient in these soils. Training programmes and demonstrations were conducted on reclamation of soil acidity using low cost amendment (dolomite) and application of the micronutrients in different villages. The application of dolomite increased the yield of rice from 5 to 8.32 t/ha. The rice yield increased from 10.5 to 32.2%.

Regular application of dolomite also helped in employment generation in terms of dolomite incorporation @ 1 man day/acre. Additional employment can be generated in processing of produce @ 1 man day/acre. The technology has spread to around 3,000 ha in the district. The dolomite application also resulted in an additional income of ₹ 7,000 to 12,500/ha.





Rainwater Harvesting Units

Rainwater harvesting units with micro irrigation system, established in 312 KVKs, were utilized to conduct training courses (807) and demonstrations (660) and produce 2,066,809 planting materials. Further, 181,551 farmers and 17,909 officials visited these units and got acquainted with the rainwater harvesting techniques.

rearing units by providing 402 rabbits. Fish fingerlings (401.74 lakh) were produced and supplied to 4,757 farmers. Thus, a total of 409.06 lakh livestock strains, poultry birds and fish fingerlings were produced and provided to 45,502 farmers.

Soil, water and plant analysis

Soil, water, plant and manure samples brought by farmers were analyzed at KVKs, and suitable advisories based on analysis were provided to them. During the reporting period, 5.99 lakh samples comprising 5.60 lakh soil samples, 0.33 lakh water samples, 0.06 lakh plant samples and 0.004 lakh manure samples were analyzed by KVKs covering 13.89 lakh farmers belonging to 0.53 lakh villages in India and the revenue generated was ₹ 502.21 lakh. Soil health cards (12.27 lakh) were also issued to farmers by KVKs.

Technology backstopping to KVKs

The Directorates of Extension Education (DEEs) of the SAUs/CAUs (57) played pivotal role in technological backstopping to the staff of KVKs. They organized 592 capacity development programmes for updating the technical knowhow of the 21,328 KVK staff in the country. Besides, 'Agricultural Technology Application Research Institutions also upgraded the knowledge and skill of 7,282 KVK staff by organizing 165 training programmes. DEEs facilitated technological backstopping and information delivery for KVKs by conducting 2,826 training programmes, 683 field days, 1,502 FLDs, 976 OFTs, 21,559 group meetings/discussions/interfaces/farmer scientist interactions, 102 *Kisan melas*, 266 *kisan goshities* and 183 technology week celebrations. Furthermore, monitoring of KVK interventions (428), *rabi* and *kharif* campaigns (129), animal health camps (254), diagnostic visits (781) and technology exhibitions (209) were also conducted by the DEEs. Officials of these directorates made 4,523 visits to the KVKs of their jurisdiction on various occasions to review and monitor the technology dissemination process at KVKs. The DEEs also undertook the technological backstopping by delivering 1,351 lectures, 139 TV talks, 210 radio talks and 2,433 news reports in newspapers. A total of 173,884 farmers visited Directorate of SAUs/ CAUs for improved technology knowledge during the period.

Agricultural Technology Information Centre

Agricultural Technology Information Centres (ATICs);

47) are serving as single window delivery system in the country by providing technology information, advisory services and technological inputs to the farmers. During the reporting period, 6.66 lakh farmers visited ATICs for obtaining solutions related to their agricultural problems. ATICs provided information related to various aspects of farming to 1.86 lakh farmers, both through print and electronic media. Farmers (5.31 lakh) were provided 19,934 q of disease free seed of various crops, 44.49 lakh of improved planting material, 8,962 poultry birds and 1,903.3 q of bio-products by the ATICs. Besides these, 5.01 lakh farmers benefited from these technological services by the ATICs. Soil Health Cards (16,603 farmers), Kisan Call Centre (105,033 farmers' calls), Mobile Agro Advisory (46,467) and special extension programmes (190,182) were also provided by ATICs. Overall 3.86 lakh farmers were beneficiaries of these technological services.

Success Story

Integrated rabbit and poultry enterprise: A case of agriculture graduate entrepreneur

Rabbit farming has come up as an option for alleviating rural poverty among the farming community in recent times. Shri Mohan of Raichur district established the rabbit unit in Karnataka–Telangana border to access breedable rabbit from a Hyderabad firm under the guidance of KVK, Raichur. He gets around 5 kits from each mother in every delivery after 28 to 30 days of crossing. These kits are reared for 30 days and then weaned from its mother who is then rebred. The rabbit bunnies segregated for meat purpose are reared for 90 days and after attaining 2 kg body weight are sold @ 370 ₹ /kg. He supplies 70–80 kg rabbit meat/week at the farm gate. Weekly, he is able to earn about ₹ 10,000 from rabbit farm. He also established backyard poultry (Aseel) inside the rabbit house to optimize the space utilization. His stock of 100 *desi* birds in each batch fetches him about ₹ 10,000 additional revenue/week. Combination of rabbit and poultry has ensured weekly income of up to ₹ 20,000.

He designed his own rabbit cage, and a mechanism to place the young bunnies in a cardboard box allowing mother rabbit to feed the bunnies in the box at a specified time of a day. This ensured neonatal mortality less than 20%. Further, designed an innovative water channel system with nipples of appropriate shape and size from which rabbits suck the water whenever required. This increased the water consumption which directly influences the growth rate. Standardized the right shaped earthen pots that reduced feed wastage. Integrated backyard poultry inside the rabbit house was an instant success. These birds are in great demand not only for meat purpose but also for backyard poultry rearing. He also trained the rural unemployed youth on scientific slaughtering and tied up with meat buyers from Hyderabad city. The assured market for meat is stable not only in terms of demand but also in terms of price. Shri Mohan with his rabbit farm is now a successful farmer and an entrepreneur as well. He is also a master trainer in the field of rabbit rearing.





(A) Black pepper nursery established under ARYA KVK Kannur, Kerala; (B) Walk-in-tunnel for year round production of off season vegetables under ARYA KVK North Sikkim, Sikkim; (C) Poultry unit as part of IFS under ARYA KVK Nalgonda, Telangana; (D) Goat farming unit under ARYA KVK, Banswara, Rajasthan; (E) Stunted fingerling production under ARYA KVK Nayagarh, Odisha

Special programmes and projects

Attracting and Retaining Youth in Agriculture (ARYA): The ARYApject is operational in 97 KVks. During the reporting period, 6,487 rural youth were trained on 13 broad group of agro-based enterprises in the country. A total of 1,114 youth were trained on mushroom production followed by 998 youth on poultry enterprise. Trainings were provided on value addition to 919 youth, goat farming enterprise to 680 youth, nursery enterprise to 679 youth, bee keeping to 612 youth, cultivation of various crops as an enterprise to 568 youth, piggery enterprise to 476 youth, vermicompost production as an enterprise to 271 youth, and fishery/ fish production to 110 youth. Training was also offered on composting, seed production and custom hiring.

During the reporting period, 1,949 agro-based enterprise units were established in villages under 12 broad categories benefiting 3,790 rural youth. Among the enterprises, there were 462 mushroom production units, 345 poultry units, 216 value addition units for agro-products, 212 bee keeping units, 95 vegetable and fruit nursery, 69 vermicompost units, 68 fishery units, 52 piggery units and 20 custom hiring units. Crop cultivation was taken up by 422 rural youth by establishing 277 units of commercial floriculture, fruits, lac, and vegetables cultivation. Among the 12 broad groups of enterprises, mushroom production was taken up by 629 rural youth followed by value addition of farm produces by 603 rural

youth, poultry farming enterprises by 528 rural youth and goat farming by 481 rural youth. Crop cultivation includes commercial floriculture, fruit production, lac cultivation, spices, vegetable cultivation, protected cultivation of vegetables and walk-in tunnels for vegetable production. Enterprises on value addition of agro produces includes post-harvest processing, value added products from banana and coconut, bakery products, fruit and vegetable processing, milk processing, mini dallmills, mini grading and cleaning mills, mini oil mills, namkin making, amla products, lac products, minor millets processing, non-timber forest products, spice processing etc.

National Innovations on Climate Resilient Agriculture (NICRA): The Technology Demonstration Component (TDC) of NICRA is being implemented by



Weather station at Jaintia hills

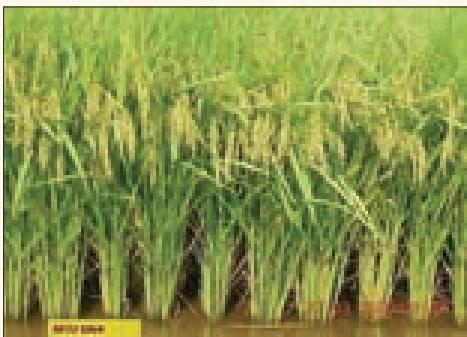




Success Story

Popularization of flood tolerant paddy varieties in West Godavari, Andhra Pradesh

Lodging due to frequent floods and cyclones, is the main problem in paddy crop grown in West Godavari district of Andhra Pradesh. The yield loss ranged from 50 to 100% based on stage of crop affected. The popular variety in the district is Swarna (MTU 7029), which is highly prone to lodging, leading to huge losses to farmers. The average yields of Swarna during cyclonic situation is around 2.8 to 4.7 t/ha. To combat the problem, the KVK West Godavari (Undi) conducted OFTs and FLDs on flood tolerant varieties MTU 1061(Indra) and MTU 1064 (Amara) and organized training for farmers and extension personnel. Besides, information on these varieties were also disseminated through print and electronic media, literature and awareness programmes.



FLD on flood tolerant variety MTU-1064

The average yield of MTU 1,061(Indra) and MTU 1064 (Amara) in OFTs and FLDs were around 6.5 to 7.5 t/ha. Practicing farmers were convinced with these varieties and they opined that both varieties withstood up to 10 days in submerged conditions. Besides, quality of grains of MTU 1061 (Indra) was good and fetched higher market price than popular varieties like Swarna and Samba Mashoori. Both the varieties are resistant to biotic stresses like brown plant hopper and blast. Around 30% of total paddy area is now occupied with MTU 1061 and MTU 1064 varieties. The farmers are realising around ₹ 87,000/ ha as gross income with new varieties ₹ 62,000/ ha with old variety Swarna.

KVKS in 121 vulnerable districts belongs to 28 states and 1 union territory. Demonstrations of proven location-specific technologies related to natural resource management (NRM), crop production, livestock and fisheries were taken up for enhancing adaptation gains and imparting resilience against drought, flood, cyclone, heat stress, coastal salinity, etc. During the year, 12,453.93 ha and 9,061.34 ha was covered through 16,355 and 25,325 demonstrations in NRM and crop production modules, respectively. Animals (48,846) were provided vaccination, feed supplements, etc. KVKS conducted 1,644 training programmes and 4,367 extension activities on successful climate resilient agriculture practices covering 42,655 and 80,684 farmers, respectively.

Skill Development Training in Agriculture: To

speed-up the skill development in agriculture sector, the DARE/ICAR signed an MoU with Ministry of Skill Development and Entrepreneurship. National Skills Qualifications Framework (NSQF) aligned skills training programmes (945) of 200 hours or more were conducted by KVKS ICAR Institutes/Agricultural Universities benefiting 19,076 rural youth during 2016–19. During 2019–20, as many as 967 skill training programmes have been proposed for training of 19,340 rural youth.

Majority of trainings programmes were organized in the job roles of Mushroom Grower, Nursery Worker, Assistant Gardener/Gardener, Bee-Keeper, Vermicompost Producer, Small Poultry Farmer, Floriculturist—Open/Protected cultivation, Quality Seed Grower, Agriculture Extension Service Provider, Dairy Farmer—Entrepreneur, Aquaculture Worker, Tractor Operator, Organic Grower, Sericulturist and Friends of Coconut Tree.

Farmer FIRST: The Farmer FIRST (Farm, Innovations, Resources, Science and Technology) initiative was launched 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. It emphasizes on resource management, climate resilient agriculture, production management including storage, marketing, supply chains, value chains, innovation systems, information systems, etc. The Agricultural Extension Division of ICAR, New Delhi has funded 51 FFP (Farmer FIRST Programme) centres under ICAR and SAUs spread over 20 states of India. In addition, ICAR-NAARM, ICAR-NIAP, ICAR-IASRI and ICAR-DKMA are also involved in management, capacity building, impact assessment, content development and showcasing of technological interventions of this programme. During the year, 25,227 demonstrations were conducted, 1,218 extension programmes were organized, 65,461 animals were benefited and 109,627 farm families were covered in all modules.

Highest number of demonstrations (8,418) were conducted in crop module followed by 6,858 demonstrations in livestock and poultry, 5,996 demonstrations in horticulture module, 2,541 demonstrations in NRM module and 1,414



The Farmer FIRST (Farm, Innovations, Resources, Science and Technology) initiative was launched to privilege the small holder agriculture.





Demonstration of SIF culture in Hapa

demonstrations in IFS module.

Out of the total farm families, 8,075 farm families in NRM module, 23,836 farm families in crop module, 16,491 farm families in horticulture module, 18,293 farm

families in livestock and poultry module, 3,420 farm families in IFS module and 39,512 farm families in extension programme were covered.

Mera Gaon Mera Gaurav (MGMG): It is an innovative flagship programme of ICAR operational and being monitored by 11 zones in the country. Total 126 institutions including ICAR institutes and SAUs implemented MGMG programme which is monitored by concerned ATARIs. During reporting year, total 5,149 scientists from 1,329 groups were involved covering 5,615 villages and benefited 6,96,109 farmers.

Pulses seed-hubs: Seed-hubs have been set-up at 97 KVKs for production of quality seeds of major pulse crops. During the year, 39,648.14 q seeds of pigeonpea, blackgram, greengram, lentil, chickpea, field pea and lathyrus were produced and made available to farmers.





15.

Research for Tribal and Hill Regions

North-west Himalayas

ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, caters to the agricultural research needs of the north-western Himalayan states of Uttarakhand, Himachal Pradesh and Jammu & Kashmir. The salient accomplishments during the period under report are presented here.

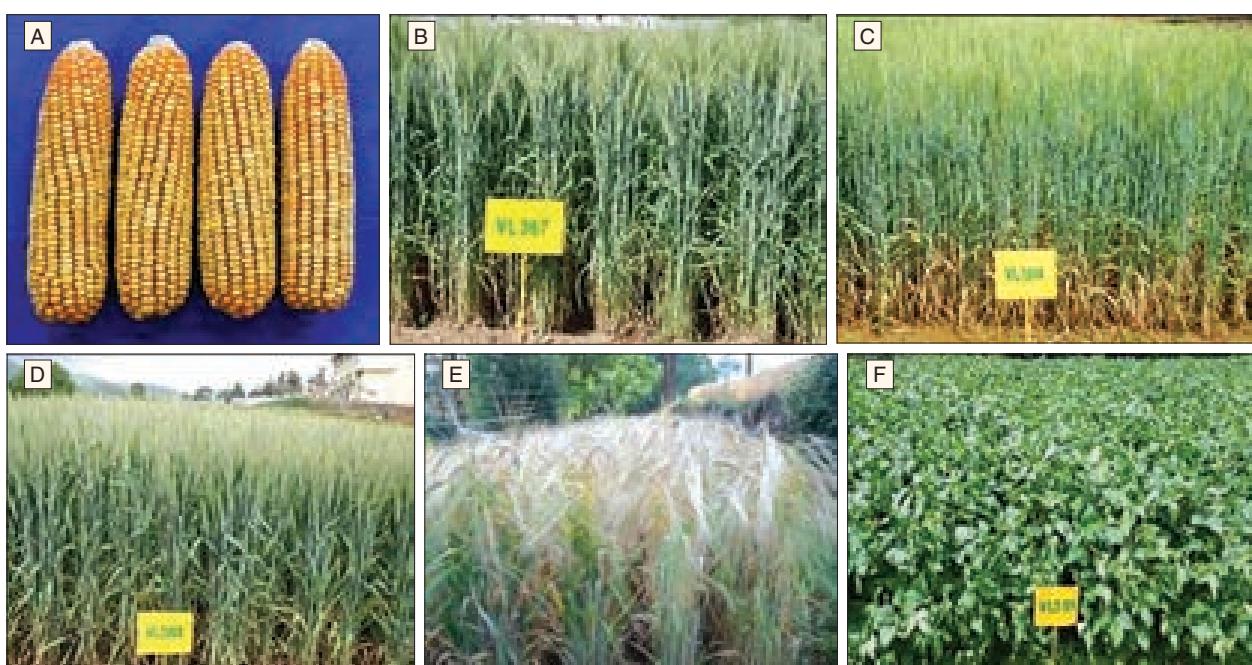
Varieties released and notified: The following varieties of various hill crops were released and notified by the Central Sub-committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops (CSC on CSN&RVAC).

Vivek Maize Hybrid 57, a high yielding single-cross normal corn hybrid (6,766 kg/ha, 95–100 days) was released and notified for Jammu & Kashmir, Himachal Pradesh, Uttarakhand (Hills) and NE Hill Region. The variety is moderately resistant to *Turcicum* and *Maydis* leaf blight. VL Gehun 967, a wheat variety, that matures in 160–170 days and yields 18–20 q/ha, was released and notified for timely sown organic rainfed conditions of Uttarakhand hills. Wheat variety VL Gehun 2014, which yields 50–52 q/ha and matures in 130–135 days, was released and notified for timely sown irrigated conditions of Uttarakhand Plains. VL Gehun 3004, matures in 120–123 days and yields 40–45 q/ha, was released and notified for late sown irrigated conditions of Uttarakhand plains. All these varieties are resistant to yellow and brown rust diseases.

VLB 130, a dual purpose barley variety with yield and maturity of 18–20 q/ha and 150–155 days, respectively, was released and notified for organic rainfed conditions of Uttarakhand hills. It is resistant to yellow rust and stripe rust diseases. A soybean variety VL Soya 89 with yield and maturity of 2,324 kg/ha and 115–120 days, respectively, was released and notified for timely sown rainfed condition of Northern Hill Zone (Uttarakhand and Himachal Pradesh).

Two varieties of garden pea were released and notified for Uttarakhand hills. VL Sabji Matar 13, an early maturing (124–125 days) variety has average green pod yield 115 q/ha. At maturity, it escapes incidence of powdery mildew disease. VL Sabji Matar 15 is a medium maturing variety (126–130 days), with average green pod yield 128.10 q/ha. The variety is moderately resistant to powdery mildew disease. Both varieties have long pods and high shelling percentage (46–50%).

Early sowing of irrigated wheat: Optimization of sowing dates for irrigated wheat in mid-hill region of Uttarakhand to adjust to changing rainfall pattern indicated that when the expected rainfall for the entire season is about half of the normal, sowing by October 25 gives maximum yield. When the expected rainfall is near normal, sowing around the first week of November is ideal. Yield loss of 28 kg grain/ha/day for sowing during the second fortnight of November is estimated in the same region.

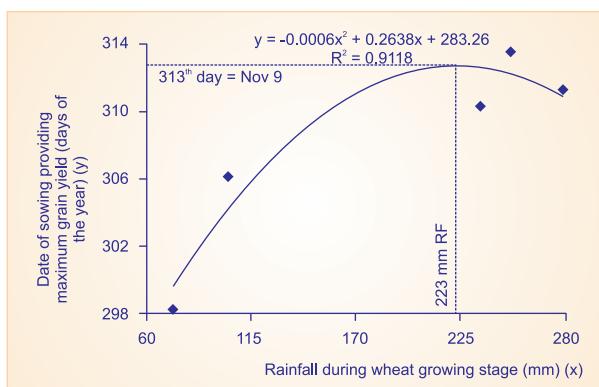


Field crop varieties notified—(A) Vivek maize hybrid 57, (B) VL Gehun 967, (C) VL Gehun 2014, (D) VL Gehun 3004, (E) VLB 130, (f) VL Soya 89

**Promising new varieties notified/released for NEH regions**

Crop variety	Characteristics
Gomati Dhan (Rice)	For rainfed shallow lowland and irrigated land of Tripura in <i>kharif</i> season; yield potential 5.8–6.0 t/ha (<i>kharif</i>), 6.0–6.4 t/ha (<i>boro</i>), duration 130–135 days. Fine grains with good cooking quality. Head rice recovery (HRR) of 69.8%, free from chalkiness, moderately resistant to blast, sheath blight and BLB.
Tripura Nirog (Rice)	For irrigated and favourable rainfed shallow lowland of Tripura. Duration 120–125 days, almost disease free reaction to all major diseases in Tripura. Yield 6.0–6.1 t/ha (<i>kharif</i>) and 6.2–6.4 t/ha (<i>boro</i>); head rice recovery of 72%
Tripura Chikan (Rice)	For irrigated and favourable rainfed shallow lowland of Tripura, in <i>boro</i> season; fine grain premium quality, duration 125–130 days, yield 5.6–5.8 t/ha (<i>boro</i> , irrigated). Moderately resistant to blast, non-lodging, head rice recovery 69.4%.
Khowai (Rice)	For rainfed or irrigated lowland of Tripura; yield, 5.4–5.6 t/ha (<i>kharif</i>) and 5.6–5.8 t/ha (<i>boro</i>); matures in 125–135 days. Non-lodging, moderately resistant to blast, BLB and brown spot; head rice recovery (69.8%).
Tripura Sarat (Rice)	For irrigated and favourable rainfed shallow lowland of Tripura; yield: 5.5–5.7 t/ ha (<i>kharif</i>), 5.8–6.0 t/ha (<i>boro</i>), duration 125–128 days; moderately resistant to blast and brown spot. Head rice recovery 66.9%.
Tripura Jala (Rice)	For water stagnation condition (up to 60 cm) of Tripura; duration 145 days, yield 4.8–5.2 t/ha (<i>kharif</i>). Moderate resistance to blast, sheath blight, sheath rot, stem borer and leaf folder; head rice recovery 68.5%; very good for making high quality puffed rice.
Tripura Khara 1 (Rice)	For rainfed drought prone lowlands of Tripura; plant height 104–110 cm; matures in 115–120 days; yield potential, 5.6–5.8 t/ha; head rice recovery of 52.9%.
Tripura Khara 2(Rice)	For rainfed drought prone lowlands of Tripura; plant height 105–115 cm; matures in 115–120 days, yield potential, 5.6–5.8 t/ha; head rice recovery of 52.9%.
Tripura Hakuchuk-1 (Rice)	For transplanted lowland and direct seeded upland of Tripura; early duration drought tolerant variety, duration 98–100 (transplanted), 90–92 days (direct seeded); yield potential, 5.44 t/ha (transplanted), 3.5–3.75 t/ha (direct seeded). Head rice recovery of 64.6%. Moderate resistance to blast, sheath blight, BLB and brown spot.
Tripura Hakuchuk-2 (Rice)	For transplanted early duration and direct seeded upland of Tripura; early duration drought tolerant variety, duration 95–100 (transplanted), 90–95 (direct seeded); yield potential, 5.54 t/ha (transplanted), 3.5–3.7 t/ha (direct seeded); head rice recovery 64.1%.
Tripura AUS (Rice)	For transplanted and direct seeded <i>Aus</i> ; but can be grown in all seasons; drought tolerant, short duration variety with duration 98–100 days (transplanted), 85–90 days (direct seeded); non-lodging, moderate resistant to blast, BLB and sheath blight; yield potential 5.0–5.45 t/ha (transplanted), 3.9 t/ha (direct seeded).
TRCP-9 (Field pea)	For North Hill Zone (NHZ), suitable for late sown and low fertility conditions; Tolerant to powdery mildew and rust; yield potential 1,800–2,000 kg/ha.
Tripura Maskolai(Blackgram)	For rainfed uplands and medium lands of Tripura for post <i>kharif</i> cultivation; yield potential, 1,500–1,600 kg/ha.
Tripura Mung-1 (Greengram)	For rainfed uplands and medium lands of Tripura; matures in 58–60 days; yield potential, 1,300–1,400 kg/ha.
Tripura Siping (Sesame)	For rainfed uplands of Tripura, matures in 83–90 days. 160–170 capsules/plant, 58–64 seeds/capsule, oil content 42%, low shattering. Moderately tolerant to <i>Phytophthora</i> light.
Tripura Toria (Toria)	For rainfed rice fallow of NEH; duration 86 days; oil content 42.6%; seed yield potential, 9 q/ha.
Umiam Soybean-1 (Soybean)	A pure selection (PK 1137×Bragg). Erect type, flowering duration of 68–72% days, yield potential 2.6–2.9 t/ha
Megha Supreme (Guava)	For rainfed subtropics, progeny of Sour type × Red Fleshed Local; upright plant growth, fruit yield 17–19 t/ha; fruit mature 8–12 days earlier at mid hill; pulp creamy white, soft seeded, rich in vitamin C (230–246 mg/100 g) and pectin (1.26–1.37%). Suitable for table and processing purpose.
Megha Magenta (Guava)	A progeny of Red fleshed × Allahabad Safeda; spreading growth habit; yield potential 11–14 t/ha; fruits medium to big (180–200 g); red pulp and retains the attractive pulp colour in processing.
Megha Wonder (Guava)	A progeny of Lucknow 49 × Pear Shaped; dropping type, suitable for high density planting; fruit yield 12–15 t/ha. Pulp is creamy white with less seeds (107–119 seeds 100 g fruit weight) and soft seeded, high in sugar (7.96–8.39%), pectin (1.29–1.40%) and phenol content (358.14–369 mg GAE/100 g); suitable for table and processing.
Megha Seedless (Guava)	A low seeded selection from Meghalaya Local. Spreading type, yield potential 11–13 t/ha. Fruits sweet (TSS: 11.88–12.50°B), rich in pectin (1.28–1.32%), phenol (330.65–340.11/mg GAE/100 g) and vitamin C (207–215.33 mg/100 g); suitable for table and processing.





Response of sowing date of irrigated wheat to amount of rainfall during crop growing stage in the mid-Himalayas

VL Metallic plough: An animal drawn plough, VL Metallic Plough, was developed which is 1.5 times more efficient than the traditional wooden plough. The plough is environment friendly as it is completely metallic, durable and has adjustments for operator/animal height, angle and depth, fuse bolt. All these reduce drudgery of the operator as well as the draught animal. The fuse bolt provides protection against injury to the draught animal. The plough being metallic is expected to save four mature oak trees during its life span of 6–8 years.



Virulence analysis of *Magnaporthe oryzae*: Virulence analysis of *Magnaporthe oryzae* showed that an isolate Mo-nhz-09 collected from Mukteshwar (2280 m asl) was the most virulent. This isolate is interesting because it survived at a location where rice is usually not cultivated because of low temperature. Among the 16 races identified, U42-i7-k177-z17-ta513 was the predominant race.

Eastern Himalayas

Land resource inventory (LRI): National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) is preparing Land Resource Inventory (LRI) of different blocks in the country on 1:10,000 scale to workout block level agricultural land use plan. The soil maps of East Siang district, Arunachal Pradesh, and Dhalai district, Tripura at 1:10,000 scale were prepared.

Runoff, soil losses and erosion potential of farming systems: A simulation study was carried out for estimation of soil losses across 24 years old (1983–2006) well established eight micro-watersheds (MW) at ICAR Research Complex for NEH Region, Umiam, Meghalaya. The eight MWs had different farming systems (FS) based on livestock (W1), forestry (W2), agroforestry (W3), agriculture (W4), agri-horti-silviculture (W5), horticulture (W6), natural fallow (W7) and jhum (as control, W8). Among the eight combinations of FS, horticulture based system was most resilient against erosion evident from lowest annual soil losses (LPA: 9.36 t/ha) while traditional jhumming (with sparse broom

grasses) practices encouraged the soil losses and recorded the highest LPA soil losses (17.62 t/ha).

Integrated farming system model on sloppy land of NEH region: Under IFS, 1 ha land was optimized for different components—7,000 m² area to agri/vegetable based cropping system; 2,000 m² horticulture; and 500 m² water harvesting pond in which fish was cultured. Livestock sector was utilized under 500 m² area where vermi-composting unit, threshing floor and miscellaneous uses were accommodated. The economics of various components of IFS was worked out separately. Analysis revealed that the maximum net income of ₹ 126,557 was obtained only from cropping system followed by ₹ 20,481 from livestock component. Horticulture system recorded the maximum B:C ratio with a value of 2.25 followed by cropping component (2.05). The minimum B:C ratio (1.12) was registered from livestock component. As a whole, the IFS gave a net return of ₹ 169,794/ha annually after deducting total cost of production/rearing of ₹ 315,557. Total dry matter production amounting to 8.54 tonnes was generated from the system. Out of which, 6.94 tonnes was produced from the field crops and 1.50 tonnes from livestock unit. Horticulture unit produced 106.4 kg dry biomass for income. The other dry biomass produced from maize stalk, toria, ginger and turmeric along with livestock excreta and farm waste materials was used to make compost. Overall, 5.73 tonnes dry matter was used for composting and vermi-composting.

Agri-horti-silvi-pastoral system for jhum cultivated area: Agri-horti-silvi-pastoral system was developed in 1.58 ha area as an initiative for jhum improvement programme. Nearly 0.55 ha was under forest while 1.03 ha under planned land use. The system was standardized in 0.80 ha area. In this system, 0.10 ha of the foothills was used for agricultural use, 0.25 ha for horticultural and 0.44 ha for silvi-pastoral crops, respectively. The agri-horti-silvi-pastoral system produced 6.64 tonnes REY (rice equivalent yield). The highest REY of 3.01 tonnes was estimated with cow milk followed by capsicum–french bean–pea (0.62 tonne REY). Economic analysis indicated gross return of ₹ 82,611 from the system while net return of ₹ 41,612 was obtained from one cow dairy unit. Vegetable component registered a net income of ₹ 7,068 amounting to a total net income of ₹ 32,113 from the system.

Integrated organic farming system model: An integrated organic farming system (IOFS) model was developed for lowland valley ecosystem to utilize all the resources available on- and off-farm effectively and, to improve the income. The IOFS model comprised enterprises such as cereals (rice and maize), pulses (lentil, pea), oilseeds (soybean, rapeseed), vegetable crops (French bean, tomato, carrot, okra, brinjal, cabbage, potato, broccoli, cauliflower, chili, coriander, etc.), fruits (Assam lemon, papaya, peach), dairy unit (a milch cow + calf), fodder crops, central farm pond, farmyard manure pits and vermicomposting unit. The total cost of cultivation was ₹ 56,835/year for an area of 0.43 ha while



total net return was ₹ 73,903/year. About 94.3% of the total N, 81.2% of the total P₂O₅ and 98.2% of total K₂O requirement could be met within the model itself.

ISLAND AND COASTAL REGION

Coastal region

Goa Dhan 3 (Goa Rice Selection 1): Goa Dhan 3—a selection from the saltol QTL introgressed rice lines received from International Rice Research Institute (IRRI), Philippines was recommended for cultivation in the salt-affected coastal saline soils of Goa state. The variety is white-kernelled semi-tall type with long-bold grains, with an average yield of 3.0–3.5 t/ha under stress and up to 6.0 t/ha under normal condition.

Goa Dhan 4 [JK 238 (Jyothi × Korgut)]: A red-kernelled long-slender grain type, high-yielding, salinity tolerant rice variety Goa Dhan 4 (cross between Jyothi × Korgut) suitable for cultivation in the coastal saline soils and rainfed shallow lowland ecology of Goa was developed. Its average yield is 3.0–3.5 t/ha under stress and up to 5.5 t/ha under normal condition.

Brinjal: Bacterial wilt resistant brinjal varieties, viz. Goa Brinjal 1, Goa Brinjal 2, Goa Brinjal 3 and Goa Brinjal 4 were released for the state of Goa. The yield of Goa Brinjal 1, Goa Brinjal 2 and Goa Brinjal 4 were 27.5 t/ha, 20.5 t/ha and 25 t/ha, respectively.

Okra: The Goa Bhendi 1, is derived from pure line selection from local accession from South Goa. Fruits are seven ridged, hairy, long (20–22 cm) and tender with less fibre. Each plant produces around 9–11 fruits in 75 days duration with 7–8 t/ha yield. The fruit is highly palatable and preferred by consumers.



Goa Bhendi-1 is derived from pure line selection from local accession

New variety of seed purpose watermelon (Kalingada) released: A new watermelon variety CAZJK-13-2 (CAZRI Kalingada 1) was developed and released for cultivation in Rajasthan and Gujarat. The variety is superior to checks, in seed yield and at par in quality parameters, i.e. 25–35% oil content, 30–40% saturated fatty acid and 60–70% unsaturated fatty acids.

Island

Trinket cattle—Cattle germplasm of Nicobar Islands: Trinket cattle, a small herd of 150 feral cattle, is inhabitant of a small island, Trinket. The herd of cattle

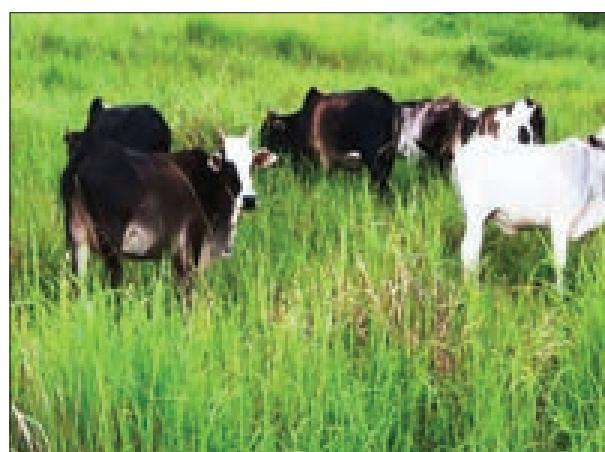
Swarna Shakti Dhan: A promising rice genotype identified for aerobic condition

An aerobic rice genotype IET 25640 (RCPR 22) was identified for Zones II (Haryana), III (Odisha, Bihar and Jharkhand), V (Chhattisgarh) and VI (Gujarat and Maharashtra). IET 25640 is an early duration



(115–120 days), semi-dwarf, high yielding (4.5–5.0 t/ha), multiple stress (drought, disease and insect pest) tolerant rice genotype with desirable cooking quality traits and high micronutrient (zinc) content. IET 25640 is suitable for cultivation under direct seeded condition in water limiting irrigated areas and rainfed shallow lowland to medium upland ecosystems. This genotype showed desirable quality parameters like high hulling (76.3%), milling (66.36%) and high head rice recovery (63.2%).

was introduced to Trinket Island by Danish people during their dynasty in Nicobar archipelago. At that point of time, the cattle were neither semi-feral nor feral in nature. When the Island was abandoned by foreign invaders, Nicobarese utilized the animal resource for meat purpose especially during their earmarked festivals. As a result, the cattle became semi-feral in nature. After the Great Sumatra earthquake and Indian Ocean Tsunami in 2004, Trinket Island was left abandoned by indigenous and the cattle became totally feral in nature. There was a long lasting mystery about the genetic root of the cattle. To resolve the issue, a study was undertaken based on sequence information of mitochondrial D loop and cytochrome b gene. Phylogenetic analysis based on D loop and CytB gene of mitochondrial genome revealed that these cattle belong to *Bos indicus* (I2 haplotype),



Trinket cattle in Trinket island





which is a species or sub-species of domestic cattle originating in the Indian subcontinent.

Complete mitochondrial genome of Trinket cattle: Trinket cattle were further characterized by sequencing of the whole mitochondrial genome. The complete mitochondrial DNA sequence of Trinket cattle was deposited to GenBank with accession number MK335920. A physical map of the mitogenome, and graphical representation of the complete mitochondrial genome organization of Trinket cattle, were prepared.

Climate resilient agriculture practices in salinity affected land: Vanaraja birds for broiler purpose (100 birds unit) were evaluated by releasing one-day old chicks into a poultry shed constructed over tsunami water. Standard feed schedule and safe drinking water were provided. At the end of 7-week study, birds attained a mean live body weight of 1.6 kg and sale of birds and poultry manure improved income of farmers.

Performance of a duckery unit (50 birds) was evaluated in tsunami lands. The ducks showed 100% survival and they attained a mean weight of 2.0 kg with egg production @ 100 eggs/week. It is also most successful intervention with control of mosquito larvae in water bodies surrounding the farmers' homes, besides using water bodies of tsunami lands for foraging effectively.

Raft cultivation of vegetables: In tsunami



waterlogged areas, Ograbraj, raft technology was developed using local materials (bamboo), that floated on tubes filled with air. The leafy vegetables, dhania (*Coriandrum sativum*) and amaranth were grown successfully.

Yield enhancement in brinjal: ICAR-CIARI developed CIARI Bio-consortia consisting of native *Bacillus* species conferring general plant growth promotion and soil-borne plant disease management in vegetable crops. Training cum demonstrations on “Application of CIARI Bio-consortia for plant health management” were held in various locations of Andaman and Nicobar Islands. Few farmers were given CIARI Bio-consortia along with technical know-how on application methodologies. An organic vegetable grower from Mayabunder informed that out of 250 brinjal plants of Muktakeshi variety, only 3 plants died. Owing to bumper crop, he could get four times more yield from the same organic field. Seeing his success story, many other farmers have now started using CIARI Bio-consortia.

New species described to science: *Gymnothorax andamanensis* sp. nov., a new short brown moray eel, is described here on the basis of two specimens collected from Port Mout, Port Blair, South Andaman (11.659327°N; 92.696148°E), caught using baited hand-lines in a sandy habitat at a depth of less than 2 m. This species is the third unpatterned brown moray eel described from India and the 10th species in the world. A new species of snakehead fish (*Channa royi*) has been described from the Andaman Islands based on integrated taxonomy. The new species possesses good export value as an ornamental fish in the domestic and international markets.

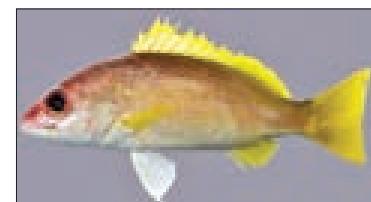
New distributional record of marine snapper: *Lutjanus xanthopinnis*, commercially important snapper fish, is a new distributional record to the Andaman Islands and India, which was previously known only in the western Pacific Ocean.



Gymnothorax andamanensis



Channa royi



Lutjanus xanthopinnis



Efficient utilization of dried *Cymbidium* leaves in traditional art-crafts

Under the waste to wealth programme, a technique to utilize the waste dry leaves of *Cymbidium* orchids in preparation of art-crafts like fruit and vegetable baskets, containers, sitting mats etc. were successfully standardized and demonstrated in Sikkim.

Noni—A climate resilient crop for augmenting the income of farmers

Morinda citrifolia, commonly known as Noni, a small tree of varied therapeutic values is native to south-east Asia, Australia and Pacific Islands. Noni shows a wide range of environmental tolerance as it grows from elevations near sea level, up to 800 m amsl, endures temperatures up to 39°C in tropical humid island environment, thrives well in infertile, acidic, alkaline and sandy carbonatic soils of atolls that are poorly suited to agriculture, tolerates brackish tidal pools and flooded conditions for long periods of time; making it an invaluable component in various agroforestry systems aimed at climate change adaptation. It integrates well with a wide range of cropping systems, viz. multi-storey cropping, intercropping, home gardens, alley cropping and mixed forests.

In 2006–07, CIARI promoted Noni cultivation across Andaman and Nicobar Islands for a vocation in challenged areas after Tsunami 2004. It was planted in 18 ha as intercrop in arecanut and coconut, all in rolling terrain and sloped hilly lands. Though the economic yield started by the third year after planting, the firm could not find any prospective buyer in the early period but over the years, its sales destinations



expanded. There was loss of market due to exorbitant freight cost involved in transporting the bulky consignments of fresh fruits to mainland, hence, a noni processing plant was established and since then selling Noni as processed material to mainland has started. Given the huge demand for noni pulp in the mainland @ 10 t/week @ ₹ 200/kg and the assured market price of noni juice @ ₹ 750/450 ml, the acreage under Noni was expanded for another 79 ha at Minne Bay, North Bay and Chunnabhatta with its own saplings of CIARI Sampada and other promising varieties,

Jalshakti

Jalshakti Abhiyan to improve water harvesting capacity was initiated in the Darim Cluster of Nanital district. Farmer field workshop-cum-demonstration on water management was organized. A farmers'-scientists interaction meeting on water management in hills



was also held during the occasion. About 300 participants including farmers, members of gram panchayat and school students attended the programme. In the first phase (July 1 to Sep. 15), 65 poly-lined tanks were constructed/renovated. All poly-tanks were constructed at spots identified through GIS contour mapping for maximum water collection without obstructing water flow to the natural stream. All poly-lined tanks were geotagged indicating farmer's name on the map. Variations in depth and slope of tanks were decided as per the contour, soil type and rainfall in the area. All tanks were lined with silpaulin. A total of 33.31 (33.32 including renovated structures) million litre water harvesting capacity was added in the area. Analysis of rainfall data of the area from 1900–2018 indicated that these tanks will be able to harvest 78–1,000 m³ rainwater in different months of the year.

anticipating a bright future ahead. As a low input-high value crop, Noni is an ideal choice for alternate/additional source of income from marginal lands. The economic yield starts from the fourth year with 20–30 kg fruits/tree/annum, selling of which to the nearby processing unit at the rate of ₹ 20/kg fetches a good income.

Tribal Sub Plan (TSP)

Tribal welfare programmes were supported in 11 agricultural universities with financial support of ₹ 29.94 crore. The major activities were promotion of agricultural centric sustainable livelihood security, sericulture, agrotechnological intervention, modern goat farming, waste management through vermicomposting, quality planting material production in horticultural crops, agroforestry and non-timber forest product, beekeeping, backyard poultry, sustainable livestock production, small ruminants productivity etc. in different tribal districts of Assam, Bihar, Chhattisgarh, Gujarat, Jharkhand, Jammu and Kashmir, Madhya Pradesh, Odisha and West Bengal. Two meetings of Tribal Sub Plan were organized on 17th September 2018 and 5th October 2018, at ICAR, New Delhi. Various programmes were executed through more





than 773 training programmes, 1,750 frontline demonstrations and 137 awareness camps/exhibitions/exposure visits etc. leading to the capacity building and awareness among more than 25,000 tribal farmers.

KVKs: Under Tribal Sub Plan (TSP) during the year, KVKs across the country conducted 6,009 on-farm trials and 34,958 frontline demonstrations. Capacity development of 607,936 farmers/farm women and 60,136 extension personnel was achieved through training programs. Extension activities organized by the KVKs under TSP benefited 971,423 participants. The technological inputs like seeds (33,121 q), planting material (58.84 lakh) and livestock strains and fish fingerlings (15.64 lakh) were produced by KVKs. Besides analyzing 86,040 samples of soil, water, plant and manure, mobile advisory services were sent to 36.12 lakh farmers on various aspects of agriculture.

District Agricultural Meteorological Units (DAMU): Indian Meteorological Department (IMD) is establishing weather observing system and development of Gramin Krishi Mausam Sewa in the country. In pursuance of this, IMD has sanctioned DAMUs which are multidisciplinary units in selected KVKs for preparation and dissemination of district and sub-district agro-met advisories under ATARIs. Total 199 KVKs have established DAMUs.

Micro-Irrigation Units: During 2018–19, DAC and FW (Department of Agriculture Cooperation and Farmers welfare) has sanctioned a project to Division of Agricultural Extension, ICAR, New Delhi for establishment of demonstration units on Micro Irrigation Systems (Drip/Sprinkler) in 190 KVKs under PMKSY-PDMC. Out of this, total 162 KVKs belonging to aspirational districts and ICAR Institutes have established demonstration units on Micro Irrigation Systems including drip, sprinkler, micro-sprinkler and mist irrigations.

Himachal Pradesh: Front line demonstrations of Vivek Maize Hybrid 45 were conducted during *kharif* 2019 in tribal clusters of district Chamba in Himachal Pradesh in collaboration with Krishi Vigyan Kendra, Chamba. The FLDs were conducted in 20.0 ha with 50 farmers. A *Kharif-poorva Krishak Gosthi* was organized at KVK, Chamba on the occasion of seed distribution, during which the farmers were provided



Organization of maize field day at village Bhanota

Success Story

Mushroom spawn production entrepreneur

Through support from ICAR AICRP-Mushroom project, ICAR-CIARI, Port Blair has been imparting trainings on mushroom spawn production to the interested progressive farmers for mushroom spawn production to meet out the growing demand of mushroom spawn all over the islands.

Mr Sainath Shenoy and Dr Nitu Sindhu started mushroom cultivation after getting training from ICAR-CIARI, Port Blair. Initially, they started cultivation of oyster mushroom in small business mode. However by seeing huge demand of mushrooms in the islands, Dr Nitu Sindhu wished to initiate spawn production at her own unit and got practical training. She also received financial support of ₹ 4.5 lakh from Department of Agriculture through HVADA (High Value Agriculture Development Agency) scheme. At present she is able to supply mushroom spawn to nearly 20 farmers of the islands of which 10 farmers are regular mushroom growers. She further informed, through this venture, she could earn ₹ 35,000–40,000/month.

information about hybrid maize varieties and improved cultivation practices of maize to the farmers. At crop maturity, fields were visited to assess performance of VMH 45 in farmers' field and obtain their feedback. In Maize Field Day, farmers appreciated the performance of Vivek Maize Hybrid 45 for its higher yield and tolerance to lodging. The yield of VMH 45 ranged from 45–55 q/ha and the superiority over the local cultivar was 37–52%. The farmers expressed interest in growing VMH 45 in next *kharif* also.

Uttarakhand: Seeds (12 q) of early garden pea variety Arkel, were distributed among tribal farmers of 8 villages of Joshimath block, Chamoli, Uttarakhand. Farmers-Scientist Interactions were also organized in villages of the cluster before the seed distribution. Some demonstrations of newly released varieties of garden pea (VL Sabji Matar 13 and 15) were also conducted in the area. Performance of VL Sabji Matar 13 and 15 was excellent and farmers preferred the variety over the old varieties like Arkel and 14 and 21% superiority over Arkel was observed, respectively.

NEH states: ICAR-VPKAS, in collaboration with ATARI-Umiam and ATARI-Guwahati provided 65 tonnes rice, 5.5 tonnes of French bean, 5 tonnes of vegetable pea and 1.2 tonnes of rajmash for FLDs. Eighteen millet threshers were provided to millet growing areas in three NEH states (Arunachal Pradesh, Meghalaya and Sikkim). At the second hub in Mylliem, improved vegetable seeds (pea, capsicum, tomato, cauliflower, cabbage and French bean) were provided to farmers. Two six-day inter-state farmers' training programmes were organized at the Experimental Farm, Hawalbagh of ICAR-VPKAS, Almora. In the trainings, farmers from Meghalaya, Tripura, Manipur, Mizoram and Nagaland participated. The training program focused on vegetable production technologies while imparting knowledge on overall crop





Development of a vegetable hub in Mylliem area of upper Shillong, Meghalaya—Village level meeting with farmers

production technologies for hills.

To promote oil palm cultivation in North Eastern Hill regions, a total of three trainings on oil palm production technologies; two in Arunachal Pradesh and one in Mizoram, benefiting 150 farmers were organized. Demonstrations on application of Arbuscular Mycorrhizal fungi in oil palm seed gardens and harvesting of oil palm bunches from tall palms benefiting 120 farmers of Mizoram were conducted and harvesting poles attached with sickle were distributed to 90 oil palm growers.

Training program on Micro Irrigation Technician: ICAR-VPKAS organized a one-month training program Micro Irrigation Technician for farmers/students. The main aim of the training was to create awareness about water resource and identify/familiarize candidates with components of micro-irrigation system, equipments, design, layout, installation of micro-irrigation system at field level, care and maintenance. The training also focused on water management demonstration and hands on activities.

Training program on Mushroom Growers: A 25 days training program, Mushroom Growers for farmers/students was organized at ICAR-VPKAS. The program was aimed to impart knowledge about different mushroom cultivation technologies. In this training, a total of 20 participants (16 male and 04 females) from Almora and Nainital districts participated.



Women farmers of Soliga tribe of BR Hills, Karnataka were trained in mushroom cultivation and utilization. They were also provided Ready to fruit (RTF) bags to grow mushroom in kitchen garden. Multi-fuel boiler and sterilization unit and a chaff cutter were provided to the tribal farmers to initiate spawn production.

Livestock

Himachal Pradesh: In Garola and Ullansa of Chamba district of Himachal Pradesh, 101 milch crossbred goats

Reaching the unreached through promotion of spices

Tribal farmers (1998) at Pottangi (Odisha), Chintapalle (Andhra Pradesh) and Raigarh (Chhattisgarh) were benefited through training and demonstration on cultivation of spices.

- Organic ginger and turmeric cultivation, seed storage and post-harvest management in turmeric and ginger.
- Improved cultivation of spice varieties and post-harvest process in black pepper and long pepper.
- Integrated pest management in spices.
- Black pepper cuttings (5,500), seedlings (1,678) of cinnamon, seedlings (1,500) of cardamom, turmeric rhizomes (20 tonnes), ginger rhizomes (15 tonnes) and coriander seeds (2.5 q) were distributed to tribal farmers.

including 10 bucks, fodder, feed, mineral mixture, and medicine kits were distributed

Jharkhand: ICAR-IIAB supported 1,008 tribal farm families from 10 villages of Latehar, Hazaribag, and Ranchi districts. ICAR-IIAB supported more than 1,000 scheduled caste beneficiaries of Latehar, Khunti, Hazaribagh, Ramgarh, Giridih and Deoghar districts by providing agricultural machineries like power tillers, pump sets, automatic spraying machines, etc. besides critical agricultural inputs like high-quality seeds, fertilizers, and insecticides.

North Eastern Hill (NEH) Programme: ICAR-IVRI, Eastern Regional Station (ERS), Kolkata organized various activities in collaboration with KVK-Geyzing, West Sikkim; KVK-Goalpara, Assam; KVK-Dhubri, Assam and KVK-Ri-Bhoi, Meghalaya. Piglets and pig feed were distributed to beneficiaries.

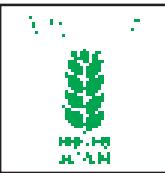
Karnataka: In Karnataka, TSP was implemented in Jadeswammy Doddi, Sebinakobe, Budipadaga and Kavlikatte dam of Kollegal taluk, Chamaraja Nagar district, and goat units were distributed. Bull calves were also distributed among tribal beneficiaries of Chamaraja Nagar district. In addition to this, mineral mixture, aluminum buckets and dewormers were distributed among the selected beneficiaries for good goat husbandry practices.

Maharashtra: Two tribal villages of Nandurbar district and one tribal village of Nashik district were chosen for promoting goat husbandry for livelihood support. A unit, comprising one male and four female Osmanabadi goats, were distributed to 10 tribal beneficiaries.

Uttarakhand: Backyard poultry farming was introduced in Sunkharikala and Jhankt village of Sitarganj block of US Nagar district of Uttarakhand. Beneficiaries were provided chicks of CARI-Debendra (No. 500), feed supplements, chicken wire net, feeder and drinker.

West Bengal: In four tribal dominated villages of Nadia district of West Bengal, farmers were provided chicks along with feed.





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, horticultural science, natural resource management, agricultural engineering, animal science, fisheries science, agricultural education and agriculture extension in the entire country. With 112 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. the Central Agricultural Universities (CAUs) at Imphal (Manipur), Jhansi (Uttar Pradesh), and Pusa (Bihar); and AgriInnovate India Limited, Delhi under its administrative control. The AgriInnovate 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 AgriInnovate 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 I and II and NASC Complex, Pusa, New Delhi. The Union Minister of Agriculture and Farmers Welfare is the President of the ICAR. The Principal Executive Officer of the ICAR is the Director General, who also functions as Secretary, Department of Agricultural 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 (Appendix 1). The Governing Body (Appendix 2) 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, educationists, 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 Divisions (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 Property and Technology Management, International Relations and Human Resources Management also assist the Director General in their respective job roles. The Senior Officers at the ICAR (headquarters) are listed in Appendix 3. The research set up of the ICAR includes 112 Institutes: 72 Research Institutes (Appendix 4), 6 National Bureaux (Appendix 5), 22 Project Directorates and Agricultural Technology Application Research Institutes (Appendix 6), 12 National Research Centres (Appendix 7), and 82 All India Coordinated Research Projects+Network Research Projects (Appendix 8). 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, AKMU, 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 (Appendix 9).





ADMINISTRATION

Filling up of posts

During the year, the following posts were filled up under the promotion quota—Director (Special Duty) of Joint Secretary level on two occasions, four Director/Joint Director cum Registrars, four Director (F)/Comptrollers, five Deputy Directors (F)/Chief Finance & Account Officers, one Deputy-Secretary & four Chief Administrative Officers, one Senior Finance & Account Officer, three Under-Secretaries, nine Senior Administrative Officers, two Deputy Directors (OL), ten Administrative Officers, one Finance & Accounts Officers. Besides, four posts of Section Officer, five LDCs, three UDCs, and four Assistants were also filled up by promotion at the ICAR Hqrs.

Patents granted

Agrochemicals: Process for synthesizing a multi-nutrient organic manure

Bio-chemistry: Production process for improved yield of *Trichoderma* biomass; Biosynthesis of metal nano-particle from fungi, product containing anti-inflammatory principles from green mussel.

Biotechnology: Development of gene specific probe and primers for detection of Indian isolate of mourilyan virus in *Penaeus monodon* shrimp by real time PCR. Casein hydrolysates rich in caseino phospeptides; Diagnostic kit, primers, and method for sex determination in chicks and adults of avian species; Genetically modified potato with reduced level of reducing sugars and improved cold chipping attributes; Process for preparing storable insecticidal formulation; Rice polynucleotide associated with blast resistance; Spectro photometric method of estimation of tannin acyl hydrolase activity in rumen digesta.

Chemistry: Heat stable anthocyanin rich composition and process; Micronutrient composition for ginger and its process for soils with pH above and below 7; Nanofabrication of phosphorus on kaolin mineral receptacles; Nano-induced bacterial polysaccharide production; Novel kairomone blend Arka Eggstra and application methodology for increasing fertile egg laying capacity in silk moth, *Bombyx mori*; Soxhlet Extractor.

Food: Novel Ready To Eat (RTE) salty crisp milk product (Milk Nimiki); Formulation and process for ready to-reconstitute basundi mix; Process for preparation of Feta cheese from buffalo milk using microbial rennet; Process for shelf stable low-fat tomato-whey soup.

General and mechanical engineering: Corral apparatus and method for transport of animals; Device for breeding and culturing marine fish in open sea; Improved aeration device for large aquaculture ponds; Insect rearing cage; Method and composition for land-based culturing of pearl oyster in marine body and device; Pigeonpea pod stripper; Raw stone apple slicer; Unit of three stage thin film scraped surface heat exchanger for continuous manufacture of khoa.

Pharmaceutical: Nano-drug delivery for quinapyramine sulphate; Phyto-pharmaceutical preparation for the control of acaricide resistant tick infestations in animals.

Financial upgradation granted under MACP Scheme

During the year, 44 eligible officers and staff of ICAR (Hqrs.) and Institutes were granted the benefits of financial up-gradation under the Modified Assured Career Progression scheme in accordance with the Government of India (Department of Personal and Training) instructions in this regard.

Policy initiatives

1. A formal comprehensive inter-institutional transfer policy for the officers of the combined cadre of Administrative Officers and Finances & Accounts Officers has also been framed, circulated and implemented during the year through a specially designed 'Online' portal. This was done to ensure transparency in the process of transfer/posting.
2. Review of the post of SSS in ICAR was undertaken and a policy in this regard has been framed and circulated on 07.03.2019.

INTELLECTUAL PROPERTY AND TECHNOLOGY MANAGEMENT

IP protection and grant of titles

Patents: ICAR assessed its 129 patent applications, viz. filed (41), published (50) and granted (38) by 39 institutes. The cumulative figure of filed patent applications is 1,119 and granted is 297. The applications granted during the period of report were classified by IPO as mentioned below:

Copyrights: Research outcomes, including data entry softwares, books, research reports and other creative activities were protected under copyright act. A total of 206 filed copyrights have been thus recorded from different ICAR institutes.

Designs: Five applications were filed by CIAH, Bikaner; CRIJAF, Kolkata; and CPRI, Simla. These included: (i) Packaging boxes for ber; (ii) Jute Ribboner; and (iii) Jute Seeder, (iv) Design of spade, (v) Design of weeder; 31 filed design applications were recorded from 7 ICAR institutes.

Trademarks: Sixteen trademark applications were filed by 10 ICAR institutes for different products and processes, viz. CIFA Brood, CIFRI GI Cage, CIFRI Pen HDPE, Ciflin, etc. Till date, 131 trademark applications have been filed by 27 ICAR institutes, out of that 30 applications were registered.

Plant varieties: To protect the plant varieties, 26 (22 extant and 4 new varieties) varieties were filed at protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA). From the applications filed earlier, 29 (27 extant and 2 new varieties) varieties were granted registration certificates during this period; which raised the cumulative figure of registered varieties to 859. The cumulative total for plant variety protection applications rose to 1,244.





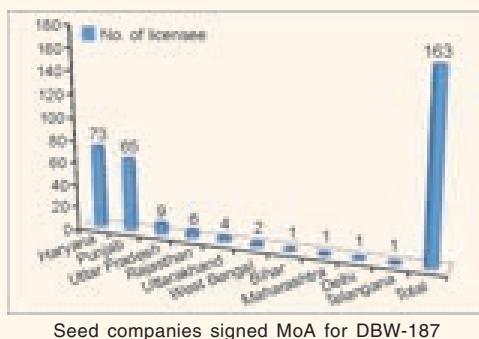
Start-up success stories

Technology commercialization

HD-3226 (Pusa Yashaswi), developed by ICAR-IARI, New Delhi, is resistant to yellow, brown and black rust and also highly resistant to Karnal Bunt besides other fungal pathogen diseases. It is recommended for commercial cultivation in North-Western Zone of India. With a mission of 'Translating Research into Prosperity', Zonal Technology Management (ZTM) Unit of ICAR-IARI launched an extensive marketing campaign of HD 3226. In the first year of its release in 2019, the unit has successfully commercialized it to 70 seed companies in the Indo-Gangetic Plains belt, comprising Punjab, Haryana, Western Uttar Pradesh and Rajasthan.



DBW 187 (Karan Vandana) has registered significant yield of 48.8 q/ha in North Eastern Plane Zone (NEPZ) coupled with better inbuilt resistance against leaf rust, leaf blight and a blast like disease. This variety is endowed with better chapatti making quality with 7.7/10 score and high iron content (43.1 ppm) in grains. A modest beginning of commercialization of this variety was initiated, which resulted in inking of 163 MoUs with different seed companies.



Seed companies signed MoA for DBW-187

Capacity building and outreach activities: In this year 39 ICAR institutes organized 110 Awareness generation programs/ Interface/ Product-specific meets/ Workshops/Seminars, wherein 4,575 scientists/ researchers/business professionals/social workers benefited. Further, 79 persons from different ICAR institutes were deputed to attend 71 capacity building programmes organized by 36 different national/ international organizations.

Technology transfer/commercialization: ICAR institutes (43) finalized 526 partnership agreements with 373 public and private organizations for 183 technologies of agriculture and its allied fields, viz. animal production and processes (11); crop production

technologies (16); farm machines and tools (24); fish farming and processes (17); food processing and value addition (63); plant protection measures (18); seed and planting material (32); and others (2). Out of 183 technologies 40 were protected by filing patents/copyrights/trademarks/plant varieties etc.

Professional services: Twenty-three ICAR institutes finalized 111 consultancy/contract research and service partnership agreements with 89 public and private organizations.

Agri-business incubation: This initiative addresses the much-needed requirements of business incubation for converting agriculture technologies into an attractive commercial proposition. In various institutes 25 ABI centres were supported/ established; and 25 new ABIs were sanctioned, taking the total strength of ABIs in ICAR network to 50. These ABIs facilitated the business environment in the ICAR institutes, which include, Agri-entrepreneurs/Incubators admitted for incubation (207); Agri-entrepreneurs/Incubators graduated (91); Entrepreneur Development Programme (EDPs) organized (86); and Agri-business Development/ Awareness Programmes organized (290).

PROGRESSIVE USE OF HINDI

Individual orders were issued by the Secretary, ICAR in respect of officers/employees of the council possessing proficiency in Hindi to do their cent per cent administrative work in Hindi. During the period under report 14 ICAR institutes/centres were notified in the Gazette under Official Language Rule 10(4). Till date, 141, ICAR institutes/centres have been notified in the Gazette. Four meetings of the Joint Official Language Implementation Committee of DARE and ICAR were held under the chairmanship of Special Secretary, DARE and Secretary, ICAR. In most of the ICAR institutes/centres Official Language Implementation Committees were constituted and their meetings were conducted regularly and proceedings received at the headquarters were reviewed regularly. Appropriate suggestions and guidelines were given to the concerned institutes for taking remedial measures. The quarterly progress reports were sent on-line to the Regional Implementation Office. The quarterly progress reports received from various Institutes were reviewed and suggestions were given to them for effective implementation. ICAR headquarters is participating regularly in TOLIC's meetings.

The employees were nominated regularly for Hindi language, Hindi typing and shorthand training in every session. At headquarters, training in Unicode typing was imparted by the Hindi Anubhag.

During the period, 4 Hindi Workshops were conducted. First workshop was conducted on Standardisation of Scientific and Technical Glossary for Technical officers; Second workshop was conducted for Dy. Secretaries and Under Secretaries on Official Language Rules, Act and its implementation and targets



set up in Annual Programme; Third workshop was conducted for Assistants; Fourth workshop was conducted for the Hindi Officers posted in subordinate offices located in 'A' region. Participants found these Hindi workshops useful.

During this year, Rajbhasha Ullas week/*Pakhwara*/month was organized at Council's Headquarter and its institutes. During Rajbhasha Ullas Pakhwara, various competitions were conducted. Under the cash award scheme of Official Language being run at this Headquarter, 10 personnel were given cash award for doing their maximum work in Hindi during the year 2018–19. Two more award schemes are being implemented by the council.

- (i) *Rajarshi Tandon Rajbhasha Purskar Yojana*: Under this scheme, the institutes are awarded for excellent implementation of official language in A, B and C region-wise categories and in the category of big institute.

Big Institutes	Award
1. Indian Sugarcane Research Institute, Lucknow	First
2. Indian Agriculture Statistics Research Institute, Pusa, New Delhi	Second
Institutes/Centres of 'A' and 'B' Region	
1. Central Cotton Research Institute, Nagpur	First
2. National Integrated Pest Management Research Institute, Pusa, New Delhi	Second
Institutes/Centres of 'C' Region	
1. Central Marine Fisheries Research Institute, Cochin.	First
2. National Institute of Natural Fibres Engineering and Technology, Kolkata	Second

- (ii) *Ganesh Shankar Vidyarthi Hindi Patrika Purskar yojana*: This scheme is applicable for the Official Language Magazines published by various ICAR Institutes. Under this Scheme, awards are given in two categories, one is for

A, and B region institutes and other is for institutes located in 'C' region for the best magazine.

Name of magazine	Name of the Institute (Institutes of A and B region)
First <i>Udhyam Rasmi</i>	Central Institute for Subtropical Horticulture, Lucknow
Second <i>Laksha</i>	Indian Institute of Natural Resins and Gums, Ranchi
Third <i>Avipunj</i>	Central Sheep and Wool Research Institute, Avikanagar
Institutes of 'C' Region	
First <i>Devanjali</i>	National Institute of Natural Fibres Engineering and Technology, Kolkata
Second <i>Krishi Jal</i>	Indian Water Management Institute, Bhubaneswar
Third <i>Ganna Prakash</i>	Sugarcane Breeding Institute, Coimbatore

In accordance with the instructions/orders of Official Language Department, Ministry of Home Affairs, 10 Institutes were inspected 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. House magazine of ICAR headquarters *Rajbhasha Alok* depicting the Hindi activities of different Institutes was published and released on 16 July 2019 on the occasion of the Foundation Day of the Council.

Various training programmes of public interest and useful for the farmers were organized in Hindi and regional languages by various ICAR Institutes. Besides all materials to be presented in the Parliament, works related to annual action report, review of grants, governing body, standing finance committee, Parliamentary Committee of Ministry of Agriculture and

ICAR-NDRI PhD Scholar awarded first prize in BRICS Young Innovator Prize

Mr Ravi Prakash, Ph.D. Scholar from ICAR-National Dairy Research Institute has been awarded First Prize in 4th BRICS-Young Scientist Forum (YSF)-2019 held at Rio de Janeiro, Brazil on 8 November, 2019. Mr. Ravi Prakash is carrying out research at Southern Regional Station of ICAR-NDRI Bengaluru, under the guidance of Dr. Menon Rekha Ravindra, Principal Scientist (Dairy Engineering). He developed a field level cooling unit, which can cool the milk while milking the animal. The unit can cool 5 litre of milk from a temperature of 37°C to less than 7°C in 30 min and uses the nano-fluid based phase change material. The innovation would be of great help to millions of dairy farmers across the country to cool the milk at farm level, thus enhancing the quality of milk across the supply chain. The competition was organized at Rio de Janeiro, Brazil during 6–8 November 2019 and there were 100 participants from BRICS (20 each from Brazil, Russia, India, China and South Africa) countries below the age of 35 years which included Ph D Students, post-doctoral scholars and assistant professors. The innovation by Mr Ravi Prakash was judged the best and was awarded first prize, which carries a cash award of US\$ 25,000 along with a certificate.





Farmers Welfare, including annual general body meetings of ICAR Society, all proceedings of these various meetings were prepared bilingually in Hindi and English.

FINANCE

Finance: The revised estimates in respect of DARE/ICAR for 2018–2019 was ₹ 7,952.73 crore. An internal resources of ₹ 349.23 crore (including interest on Loans & Advances, income from Revolving Fund Schemes and interest on Short Term Deposits) was generated during the year 2018–19. The total allocation budget estimates for 2019–2020 is ₹ 8,078.76 crore.

TECHNICAL COORDINATION

ICAR Directors' Conference and meetings of ICAR Regional Committees No. VI, VII and VIII were held during the reporting period. 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 provides 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 participate in the meeting, which is 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 actions taken on the issues raised in the previous Regional Committee Meetings, were also reviewed. During the reported period the council provided financial support to 76 societies for the publication of Scientific Journals. In addition, societies/associations/universities were supported for holding National Seminars/Symposia/Conferences (113) and International Seminars/Symposia/Conferences (50). Annual Report of DARE/ICAR for the year 2018–2019 along with review statement was laid on the table of Lok Sabha (25-06-2019) and Rajya Sabha (28-08-2019). The Annual Account and Audit Report of ICAR along with review and delay statement was laid on the table of Lok Sabha and Rajya Sabha on 02-07-2019 and 28-06-2019, respectively.

The umbrella Memorandum of Understanding (MoU) are being 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. The 10 such MoUs were signed with the Central/State Universities. Besides these, 4 Memorandum of Understanding (MoU) were signed with other organization to collaborate research activities of national interest.

91st Foundation Day of ICAR and Award Ceremony

Incentivizing individual employees and teams for their outstanding performance, across organizations, makes them more efficient, responsive and productive apart from improving their level of job satisfaction. The awards, besides recognizing merit and accomplishments, generate healthy competition among individuals, groups and institutions to strive and attain still higher levels of excellence in their respective areas of work. The Indian Council of Agricultural Research has been recognizing and rewarding the institutions, scientists, teachers, farmers and agricultural journalists every year. To



commemorate the 91st Foundation day of ICAR, the Award ceremony was organized at NASC, New Delhi on 16th July 2019. Various ICAR Awards for the year 2018 were presented to the winners on the occasion. The awards were given in 21 different categories to 150 awardees, comprising 101 scientists, 8 administrative personnel (including 2 women), 3 journalists and 20 farmers (including 4 women farmers). It is heartening to note that out of the 80 scientists, 13 are women. Three Institutes, 1 university, 2 AICRPs, 12 KVKs were also awarded.





17. Partnership and Linkages

DARE

International collaboration

Consultative Group on International Agricultural Research (CGIAR) is an international organization having close collaboration with Department of Agricultural Research and Education (DARE) and Indian Council of Agricultural Research (ICAR). It works through its 15 Research Centres. India has been a donor member of the CGIAR System for decades. Accordingly, it contributes to CGIAR System through its budgetary provisions. Out of these 15 Centres, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has its headquarters at Hyderabad in the State of Telangana, India. The remaining CGIAR research organizations have headquarters elsewhere, but have strong presence in India in the form of a country or South Asia representative offices in India.

India is also a voting member in CGIAR System. The Council and has assumed important role in CGIAR System as a permanent voting member. This responsibility requires reciprocation from India also. Activities carried out with CGIAR System and its Centres, during the stated period are presented here.

Work plan

- Work Plan between Indian Council of Agricultural Research (ICAR) and WorldFish (WFC) signed on 2nd January 2019.
- Work Plan between Indian Council of Agricultural Research (ICAR) and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) signed on 24th January 2019.
- Work Plan between Indian Council of Agricultural Research (ICAR) and International Livestock Research Institute (ILRI) signed on 25th February 2019.



Collaborative research projects

- KISAN MITRA project for doubling the farmers' income in Bundelkhand region of Uttar Pradesh, in collaboration with ICAR-Indian

Grassland and Fodder Research Institute (IGFRI), Jhansi and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, for the period of four years.

- Heat stress tolerance maize for Asia through Public Private Partnership (HTMA-II), for funding from United State Agency for International Development and ICAR-Indian Institute of Maize Research (IIMR), Ludhiana in collaboration with International Wheat and Maize Research Centre (CIMMYT) for the period of five years.
- Exploitation of inter-specific diversity for Durum wheat improvement, in collaboration with University of Nottingham, International Center for Agricultural Research in the Dry Areas (ICARDA) and International Wheat and Maize Research Centre (CIMMYT) and ICAR-Indian Institute of Wheat and Barley Research (IIWBR), Karnal, for the extended period of one year.
- Deployment of High-Yielding stress tolerant and top industrial quality Durum wheat elites to targeted growing regions of India, in collaboration with ICAR-Indian Agricultural Research Institute (IARI), New Delhi and International Centre for Agricultural Research in the Dry Areas (ICARDA) for the period of four years.

MoUs/Work plans signed

- Workplan 2019–21 between ICAR and the State Secretary of Agro-industry of the Ministry of Production and Labour of the Argentine Republic for Cooperation in the field of Agricultural Research and Education signed on 18 February, 2019.
- Workplan 2019–23 between ICAR and Western Sydney University for cooperation in the field of Agricultural Research and Education signed on 26 March 2019.
- MoU signed between ICAR and International Bamboo and Rattan Organization (INBAR), PR China for cooperation in Agricultural Research and Education signed on 19 June 2019.

Foreign visits of ICAR Scientists/Officers

IC-CG Section has processed approval of 74 visits/deputations proposal in respect of ICAR's Scientists/Officers for participation in the different events in different Countries.

Foreign deputation cases

Applications for various training programmes abroad under various foreign governments, announced by DBT/DST etc, UN/ International organizations, International





agencies in various fields of agricultural research and education were issued. Applications for various fellowships/scholarships announced by ICAR, HRD, foreign governments, etc. for higher studies/research/ PhD/ Post Doctoral Research abroad were processed. Applications of the Scientists for foreign assignments in foreign governments and International organizations were processed. The vacancies notified by CGIAR organizations, other International organizations/ agencies such as ADB, Work Bank, Commonwealth Secretariat, UN, etc. were circulated. ICAR scientists (total 108 scientists) were granted permission for various fellowships/training at foreign organizations/ institutes. Permission was granted to six scientist for extension of fellowship/ training in international organizations. NOC was granted to 38 ICAR scientists to apply in different training/ fellowship in international organizations. Permission was granted to 12 ICAR scientists apply for position in different international organizations.

Germplasm exchange

The cases of export of germplasm were processed as per the provisions/ guidelines of the Biological Diversity Act, 2002 and the Biological Diversity Rules, 2004 also subject to guidelines/ notifications issued by Ministry of Environment and Forests, from time to time.

The six Bureaus/ Institutes under ICAR system were designated by Ministry of Environment and Forests to act as repositories under the BD Act, 2002 for different categories of biological resources. Cases of germplasm exchange are processed in DARE for approval of the competent authority in consultation with the Bureaus/ Institutes/ Subject Matter Division. In the area of exchange of genetic resources, cases from concerned scientists of ICAR through authorized national bureaus on the basis of signed/agreed collaborative research projects involving ICAR, were processed in accordance with the provisions of Biodiversity Act and further guidelines notified in this regard. Approvals of competent authority in respect of 3 cases were conveyed.

Annual Membership Contribution

An Annual Contribution of US \$ 60,000 for the years 2018–19 was paid by ICAR to Network of Aquaculture Centres in Asia-Pacific (NACA), Bangkok, Thailand. An Annual Contribution of US \$ 10,000 for the years 2018–19 was released by ICAR to Asia-Pacific Association of Agricultural Research Institutions (APAARI), Bangkok, Thailand. Annual Membership contribution to Centre for Sustainable Agricultural Mechanization, CSAM (Regional Institution of UN ESCAP) Beijing, China amounting to US \$ 15,000 released for the year 2018–2019. Annual contribution to International Seed Testing Laboratory (ISTA), Switzerland on behalf of Seed Testing Laboratory, IARI, New Delhi amounting to ₹ 380,613 was released for the year 2019.

Indo-ASEAN Research Collaboration

The 6th ASEAN India Working group on Agriculture

and Forestry Meeting was held at Bangkok, Thailand during 5–6 July 2019. The meeting discussed the various prospects of the implementation of the ASEAN India Work Plan 2016–20. The 7th ASEAN India Working Group meeting on Agriculture and Forestry was held on 14 October 2019 in Brunei Darussalam. The 5th ASEAN India Ministerial Meeting on Agriculture and forestry (AIMMAF) was held during 16–17 October 2019 at Brunei Darussalam. The Ministerial Meeting reaffirmed the commitment to contribute towards the vision and priorities of the ASEAN-India Partnership for Peace, Progress and Shared Prosperity (2016–20), post-2015 Sustainable Development Goals and related goals of the UN Zero Hunger Challenge. The meeting noted the progress made in the implementation of the ASEAN-India Plan of Action (2016–20), and encouraged both sides to focus on the development and implementation of priority projects for 2020, namely: (i) climate-smart agriculture, (ii) application of robotics and drones in agriculture production and electromagnetic waves in food processing, (iii) promotion of post-harvest technology for fruits and vegetables, and (iv) transboundary diseases and health management for crops, livestock and aquaculture. The meeting agreed to review the implementation of the ASEAN-India Plan of Action (2016–20) by an independent consultant and looked forward to developing a new Plan of Action for 2021–25 that will layout priorities and measures to be undertaken by both sides in realizing the full potential of agriculture and forestry cooperation for the next five years.

Indo-BIMSTEC Collaboration

The Seventh Meeting of the BIMSTEC Expert Group on Agricultural Cooperation was held on 24–25 April 2019 in Dhaka, Bangladesh. The First BIMSTEC Ministerial Meeting on Agriculture (1st BAMM) and the First Meeting of the BIMSTEC Senior Officials on Agriculture (1st SOM-A) was held on 11–12 July, 2019 in Nay Pyi Taw, Myanmar. The meeting emphasized on more capacity building programmes in different areas of Agriculture.

Indo Afghanistan Research Collaboration

Indian Agricultural Research Institute (IARI) is playing an important role in developing trained human resource for agricultural research in Afghanistan and in establishing Afghan National Agricultural Sciences and Technology University (ANASTU) at Kandahar, Afghanistan, with the support of the Ministry of External Affairs (MEA), Government of India under the bilateral cooperation programme between Afghanistan and India. A long-term plan has been developed so that ANASTU becomes a self-sustaining university by 2028. It will be referred further as ANASTU's 10 Year Plan (2019–28). A complete set of books published by the ICAR has been sent to ANASTU in 2018. The approval of the MEA for establishing tele-education facility at ANASTU and IARI has been received. A proposal to establish Afghanistan





Agro-Biodiversity Genetic Garden (AAGG) at ANASTU, Kandahar was submitted to the MEA for approval. The AAGG is a part of the 10 Year Plan.

Agrinovate India Limited

Agrinovate India Limited is steadily moving towards meeting its objectives and building ‘A world of Innovative Partnerships’. The Vision of the company is to stimulate, foster, enhance and catalyze innovation and capacity driven agricultural development through partnerships. In the financial year 2018–19 the Company has earned net profit of ₹ 23,663,549.

Business development activities: AgIn participated in various workshops and national level meets such as Rural Entrepreneurship & Innovation Conversation and Exhibition (Patiala, Punjab), National Agricultural Committee Meeting 2018 (FICCI Federation House, New Delhi), Yes Bank Global Institute Annual Start-up Conclave (India International Centre, New Delhi), Workshop on ‘Problems and Prospects for Commercialization of Trichoderma’ (NASC Complex, New Delhi), Workshop On ‘Microbe Based Technologies for Soil Health and Plant Nutrition’ (NASC Complex, New Delhi).

Promotional activities: With its vision to promote ICAR technologies globally and increase its outreach, AgIn actively collaborated with African-Asian Rural Development Organization (AARDO) and also strengthened the association with ASEAN Secretariat for organizing International capacity building programs and other projects. AgIn also organized a Sensitization Workshop for all the State Agricultural and Veterinary Universities and apprised them of the operations and guidelines that were in place. This has helped to further strengthen the technology base for AgIn as well as pave way for innovative partnerships in NARES’ ecosystem.

Technology Transfer

Implementation of Commercialization Guidelines: As per the commercialization guidelines, the techno-commercial assessment and expert committees were constituted to carry out a techno-commercial assessment and prepare the standard terms for potential technologies of all ICAR Institutes. AgIn had organized and conducted Techno-commercial and Expert committee meetings for select technologies of AAU (Anand) and ICAR Institutes like NDRI (Karnal), CIPHET (Ludhiana), NIAMP (Bengaluru), CIRB (Hisar), CTCRI (Thiruvananthapuram), VPKAS (Almora), IIRR (Hyderabad), NRCC (Pune), IIHR (Bengaluru), CPRI (Shimla), CISH (Lucknow), IIPR (Kanpur), NCIPM (New Delhi), IIMR (Ludhiana), IINRG (Ranchi), IVRI (Bareilly).

Central Agricultural University, Imphal

The Central Agricultural University, Imphal having 13 constituent colleges is a fully residential university covering all the North-East Hill states under its jurisdiction except Assam. The University has been placed at 25th rank in the ranking status of Agricultural

Universities for the year 2018 by Indian Council of Agricultural Research, New Delhi. Till date, 73% of the passed out students from this University are already employed/absorbed in Government departments. At present the university has 75 ongoing internally funded research projects and 112 externally funded projects including 35 All India Coordinated Research Projects (AICRPs) and 4 All India Network Research Projects (AINRPs). Farmer friendly technologies (86) and location specific recommendations (380) in the field of agriculture and allied disciplines were developed for adoption by the farmers and agripreneurs of NEH Region. The University is equipped with well-established laboratories, research and demonstration farms, 6 KVks, 6 Multi-Technology Testing Centres and 6 Vocational Training Centres in different parts of North East India in an effort for popularization of modern innovative and sustainable agriculture and agro based allied activities in the region. The university signed MoU with ICAR Research Complex for NEH Region, Umiam, Meghalaya (including Regional Centres) for facilitating students teaching, training and research under UG, PG and PhD Programme. The University also signed MOU’s with Western Sydney University, Australia; The Sustainable Environment Resource Institute (INNOVIR), New Delhi; Green Biotech Eco solutions, Manipur and Indian Institute of Governance and Leadership (IIGL), New Delhi for strengthening the academic, research and extension activities of the university. MOU with ICAR-Central Institute of Fisheries Education (CIFE), Mumbai was also renewed during the year.

Rani Lakshmi Bai Central Agricultural University, Jhansi

The Rani Lakshmi Bai Central Agricultural University, Jhansi made sustained growth in the field of education, research and extension to achieve the mandated objectives of its establishment as an institution of national importance. The University added two experiential learning resources one for Seed Production, Processing and Marketing, and another for Production of Quality Transplant and Processing of Medicinal and Aromatic Plants as a component of Student READY programme. The research work primarily focused on technology-driven production enhancement in pulses and oilseeds, particularly under moisture stress. High-yielding chickpea entries, each in Kabuli (RLBGK-1, RLBGK-2) and Desi (RLBG-1, RLBG-2) types submitted in IVT trials during 2017–18 were promoted in AVT-1 trial for 2018–19. Inoculation with *Trichoderma harzianum* + propineb was effective against *Sclerotium* rot in chickpea. The ICAR-AICRP-Rapeseed Mustard centre was started in 2018–19 to promote cultivation of this important oilseed crop in the Bundelkhand region. Indian mustard entries, MCN-TS-18-27, 18-9, and 18-18 gave seed yield of 2.32-2.45 t/ha under timely-sown irrigated conditions. The SBG entries 18-10, 18-13, 18-28, and 18-29 were tolerant to white rust, while UDN entries 18-13, 18-32, 18-33, 18-35, 18-36, 18-46 were tolerant to *Alternaria* blight. Of the 96 lines, 22 SBG entries and 35 UDN





entries showed tolerance to downy mildew under natural field conditions. The mustard variety DRMR IJ-31, with the highest oil content (42%) has the potential to be used as a donor in breeding programme.

The FLDs on chickpea (15) and rapeseed-mustard (75) improved yield of 35–36% and 27–34%, respectively, over the conventional farmers' practice. Seed-Hubs, one each for pulses and oilseeds were established to produce quality seed for its better availability to the farming community. During the reporting period, 650 q of seed of chickpea, lentil, peas, mustard, linseed, and wheat was produced at the University farm and on farmers' fields.

Dr Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar

Dr Rajendra Prasad Central Agricultural University, Pusa owes legacy of Rajendra Agricultural University, Pusa (1970) and Agricultural Research Institute and College, Pusa (1905). The university is making all efforts to develop technologies and crop varieties through 32 AICRPs, 3 international projects, 11 Government of India projects, 4 Government of Bihar Projects and 60 University Projects for farmers of different socio economical categories. The development of technology for hydroponic fodder production, improvement of productivity of challenged ecology through suitable and appropriate technology development, suitable agricultural machinery for small and marginal farmers, Gur Processing Technology, Bamboo Processer etc. and crop varieties—paddy (Rajendra Saraswati), pigeon pea (Rajendra Arhar) are some of the important milestones of the year 2019. Impressed by our success two major Lord Shiva Temples, Baidyanath Dham, Deoghar (Jharkhand) and Garib Nath, Muzaffarpur (Bihar) have started management of floral offerings in vermicompost with technical support from university.

Foreign deputations

- Dr J K Jena, DDG (Fisheries Science), ICAR, Dr S Bhaskar, ADG (AAF&CC), ICAR and Dr A Arunachalam, ADG (IR), visited Maldives as Indian Expert Delegation for cooperation in Agriculture and Allied sectors from 29 April to 1 May 2019.
- Dr Trilochan Mohapatra, Secretary (DARE) & DG (ICAR) visited Bangkok, Thailand to attend Executive Committee Meeting of Asia-Pacific Association of Agricultural Research Institutions (APAARI) on 13 June 2019.
- Dr K Srinivas, Principal Scientist, NAARM, Hyderabad visited Taipei, Taiwan to participate in the workshop on Innovation in Agribusiness for Young Entrepreneurs, organized by APO (Japan) and Asia-Pacific Association of Agricultural Research Institutions (APAARI), Bangkok during 1–5 July 2019.
- Dr J K Jena, DDG (Fisheries Science), ICAR visited National Aquatic Resources Research Centre & Development Agency (NARA),

Colombo, Sri Lanka to attend The Regional Workshop on Underutilized Fish and Marine Genetic Resources and their Amelioration organized by APAARI during 10–12 July, 2019.

- Dr Kuldeep Kumar Lal, Director, NBFGR, Lucknow visited National Aquatic Resources Research Centre & Development Agency (NARA), Colombo, Sri Lanka to attend The Regional Workshop on Underutilized Fish and Marine Genetic Resources and their Amelioration organized by APAARI during 10–12 July, 2019.
- Mr. Hicham El Ouazzani, Head of Technical Support Unit, National Agency for the Development of Aquaculture (ANDA) Morocco visited CMFRI, Kochi, Kerala during 29 July to 09 August, 2019 to attend study visit on Mariculture and open sea cage farming, under the Work Plan 2018–20 between ICAR and the Ministry of Agriculture, Marine Fisheries Rural Development and Waters and Forests of the Kingdom of Morocco.

Foreign visits

Secretary, DARE & Director General, ICAR

- Dr Trilochan Mohapatra, Secretary, Department of Agriculture Research & Education (DARE) & Director General, Indian Council of Agricultural Research (ICAR) attended the G20 Meeting of Chief Agricultural Scientists (MACS) organized by Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF) held at Tokyo, Japan from 24 April, 2019 to 26 April, 2019.
- Participated in the 51st Annual Board of Trustees (BoT) meeting of Bioversity International from 9–11 May 2018 held in Rome, Italy.
- Participated in Bioversity International and CIAT Board Meeting at Bioversity International HQ. in Rome, Italy from 20–23 May 2019 (excluding journey period).

ICAR's Scientists/Officers

- Dr Kanchan Kumar Singh, ADG (Farm Engg.), ICAR, New Delhi attended 6th Regional Forum on Sustainable Mechanization in Asia and the Pacific, during 25–28 October 2018 at Beijing and Wuhan, China.
- Dr Neeru Bhooshan, Incharge, ZTM & BPD unit, ICAR-IARI, New Delhi attended JPO/IPR Training Course Academia-Industry Collaboration and Technology Transfer from 10 to 19 December 2018 at Tokyo, Japan.
- Dr P K Chakraborty, ADG (PP), ICAR, New Delhi participated in Regional Workshop on New invasive species threats in South and South East Asia, scheduled to be held during 21–22 November 2018.
- Dr Chandish R. Ballal, Director and Dr A N Shylesha, Principal Scientist, ICAR-NBAIR,

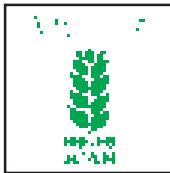




Bengaluru participated in Regional Workshop on New invasive species threats in South and South East Asia, held during 21–22 November 2018 at Kathmandu, Nepal.

- Dr A Arunanchalam, ADG (IR), ICAR Headquarters, New Delhi visited Brazil to attend the Vice Ministers of Agriculture of BRICS meeting during 17–18 July 2019.
- Dr Manish Das, Dr Adlul Islam, and Dr Dinesh Kumar, ICAR HQs, New Delhi attended training programmes organized by Centre for Agriculture, Environment and Water, Galilee International Management Institute, at Israel from 10–23 September 2019.
- Dr M Din, Project Coordinator (UAESE) and Dr Champat Raj Mehta, Project Coordinator (Farm Implements & Machinery), ICAR-CIAE, Bhopal attended 5th meeting of trainers of ANTAM in Beijing and Changsha, China during 4–11 September 2019.
- Dr Panna Lal, Principal Scientist, ICAR Headquarter, New Delhi attended 5th meeting of the Technical Working Groups (TWGs) of the Asian and Pacific Network for Testing of Agricultural Machinery (ANTAM) at Changsha, China during 9–13 September 2019.
- Dr Keshava, Pr. Scientist, ICAR HQs, New Delhi attended Training of trainers programme at German Agribusiness Alliance, Asia-Pacific Committee of German Business (APA) at Deula-Nienburg, Germany during 15–22 September 2019.
- Dr A K Singh, DDG (HS); Dr D K Yadav, ADG (Seeds); Dr Randhir Singh ADG (Ag. Extn.); Dr S N Jha, ADG (PE); Dr JP Mishra, ADG (ICT); Dr Ashok Kumar, ADG (AH); Dr G Venkateswarlu, ADG (EQ & R), ICAR HQs; Dr B P Bhatt, Director ICAR-RCER, Patna; Dr K V Prasad, Director, DFR, Pune; Dr A Pattanayak, Director VPKAS, Almora; Dr PG Patil, Director, CIRCOT, Mumbai; Dr G P Singh, Director, IIWBR, Karnal; Dr Om Prakash Yadav, Director, CAZRI; Dr N P Singh, Director, IIPR, Kanpur; Dr S K Ambast, Director, IIWM, Bhubaneswar; Dr V A Tanopi, Director, IIMR, Hyderabad; Dr R K Mathur, Director, IIOPR, Pedavegi; Dr S K Malik, Pri. Sci. Officer to DG, ICAR, ICAR HQs, Shri GP Sharma, Director (Finance), Shri V P Kothiyal, Director (Works), ICAR HQs, Dr A S Misra, Principal Scientist (TC), ICAR HQs, attended Executive Development Programme (EDP) on Developing Effective Organizational Leadership for Senior Officers of ICAR, for a period of 10 days from 21–30 September at the Netherlands, Belgium, Germany Berne.
- Dr SP Kimothi, ADG (TC), Dr VP Chahal, ADG (Ag. Extn.), Dr MK Agnihotri, ADG (HRD), Dr RS Gandhi, ADG (AP&B), Dr PK Kathia, Pr. Sc. (PIM), Dr P Ramasundram, National Coordinator, NAHEP, Smt. Seema Chopra, Director (OL), Dr NK Jain, Principal Scientist HRM & HRD Nodal officer of ICAR HQ, Dr P K Ghosh, NC, NAHEP; Dr J K Jena, DDG (AS/FS), Dr Ashok Kumar Singh, DDG (AgriL Extn.), Smt Sanjeevan Prakash, DDF –II, ICAR HQ, New Delhi; Dr Suresh Pal, Director, NIAP; Dr Gopal Krishna, Director, CIFE, Mumbai; Dr SK Singh, PD, DKMA; Dr BN Tripathi, Director, NRCE, Hisar; Dr Lakan Singh, Director, ATARI, Pune; Dr Anupam Mishra Director, ATARI zone IX, Jabalpur, attended Executive Development Programme (EDP) on “Developing Effective Organizational Leadership for Senior Officers of ICAR, for a period of 10 days from 12–21 October 2019 at Netherland, Belgium, Germany Berne.
- Dr K. Alagusundaram, DDG (Agril. Engg.), ICAR, New Delhi attended 6th Annual Meeting of the Asian and Pacific Network for Testing of Agricultural Machinery (ANTAM) on 10–12 October 2019 in Moscow.
- Dr Amol Shinde, Additional Private Secretary to MoS Agriculture attended CABI's 20th Review Conference held on 11–13 September 2019 at Egham, UK.





18.

Supporting Basic and Strategic Research

The National Agricultural Science Fund with an outlay of ₹ 164.5 crore, supports basic and strategic research in agriculture. Its main objective is to build capacity for basic, strategic and cutting edge application research in agriculture and address issues which can be solved by intensive basic and strategic research jointly by team of organizations/ institutions. The scheme has 191 funded projects, mostly in consortium mode out of which 79 are on-going projects and 76 are multi-institutional in nature. Besides supporting, reviewing, monitoring and evaluation of the ongoing projects during the year 2018–19, NASF evaluated 680 new pre-proposals and 28 new full project proposals received under different themes of Call VIII by the respective expert committee. A total of 20 new projects were approved during the period. NASF was also engaged in creating awareness for the need and nature of the basic research for agriculture among institutions within and outside the traditional NARS for prioritization of research. Six Annual Review meetings were held during the reported period to review the ongoing projects. Besides, the Empowered Committee also reviewed the progress of mega projects, viz. ‘Large scale production of multiple copies of elite buffalo bulls using animal cloning technology’ and ‘Phenomics of moisture deficit stress tolerance and nitrogen use efficiency in rice and wheat–Phase II’.

In addition to the results in terms of high impact publications, patents and technologies, a strong and sustainable platform for developing scientific capacity and culture that encompasses the extended NARS is being established. This will ensure continuous flow of knowledge, ideas and working together among different stakeholders in the basic, strategic and frontier application research for solving problems in agriculture and also forming science policy in agriculture.

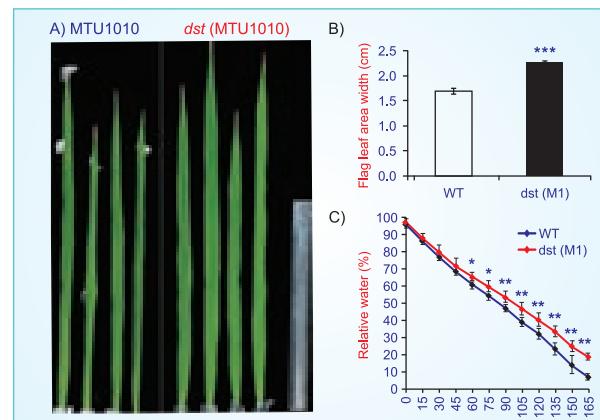
Salient achievements

During the reported period, NASF had more than 90 research publications in reputed journal, three patents and 10 technologies. The research highlights of some selected projects are as follows:

Moisture deficit stress tolerance and nitrogen use efficiency in wheat: A recombinant inbred line (RIL) population consisting of 183 RILs derived from HD 2967 × C 306 cross were phenotyped under normal and drought stress conditions to identify QTLs and superior genotypes for water use efficiency (WUE). Drought tolerant wheat cv. C 306 used 577 and 872 litres of water to produce 1 kg of grain under normal and drought stress conditions, respectively. Phenomics analysis led to the identification of RILs which use 20% less water and give 10% more yield over the both the parents under well irrigated conditions. Under drought stress conditions, RILs which

use 30% less water and give 25% more yield over both the parents were identified. These RILs and parents were genotyped. Two major QTLs for WUE with phenotypic variance of 11.57 and 13.18% were mapped on chromosome 2B and 7B, respectively. These RILs and QTLs will be useful to develop wheat varieties with high drought tolerance and WUE.

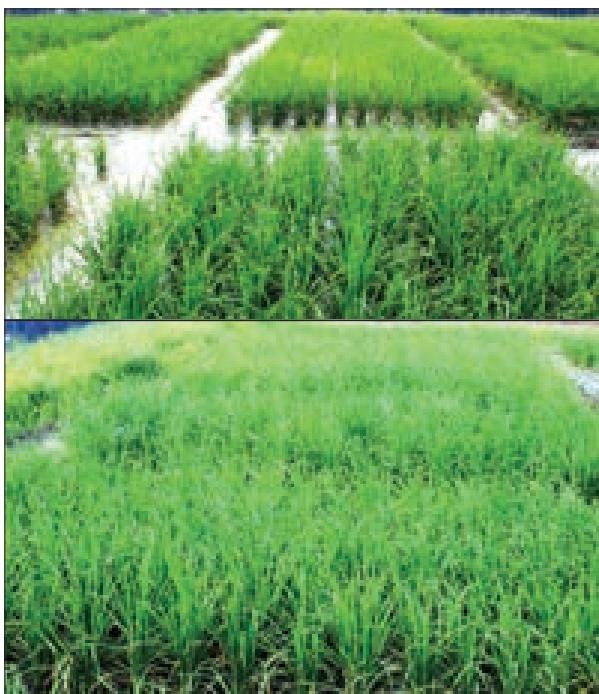
Genetic improvement of rice for yield, WUE and abiotic stress tolerance: Four genes, viz. *DEPI*, *TB1*, *CKX2* and *SPL4* were selected for genome editing to improve yield by using CRISPR-Cas9 mediated genome editing. Mutant lines for the *Dense erect panicle 1* (*dep1*) were developed in rice mega variety MTU1010 and sequence analysis identified various deletion mutations (1–50 bp) in the *DEPI* in different lines. The homozygous T2 *dep1* mutant plants produced semi-dwarf plant phenotype with increased effective tillers and panicles with high grain number. Similarly, genome edited lines for *OstB1* were generated and confirmed by sequencing. The *TB1* knockout MTU1010 indica rice cultivar produced more productive tillers and enhanced grain productivity. For improving drought and salt tolerance and yield of rice, CRISPR-Cas9 mediated editing of the *DST* (*Drought and Salt Tolerance*) gene was carried out. In T2 generation transgene free genome edited mutant of *DST* gene in indica rice cv. MTU1010 was obtained. This mutant showed broader leaf, lesser number of stomata and lower rate of leaf water loss as compared to the normal MTU1010 cultivar. This mutant will be useful for improving WUE of rice.



Genome-edited DST mutant in mega rice cv. MTU1010 background. (A, B) Enhancement of leaf area in DST mutant. (C) Reduction of excised leaf water loss in DST mutant as compared with WT MTU1010

Fungicidal and herbicidal activity of potassium phosphite: Potassium phosphite displayed dosage as well as pre-existing PO_4 dependent inhibition of organisms; complete *in vitro* inhibition of fungal pathogens was observed at 80–95 mM on *Magnaporthe oryzae* causing





Effect of potassium phosphite on blast incidence in rice on non-transgenic rice

blast disease, *Rhizoctonia solani* causing sheath blight, and *Fusarium fujikuroi* causing bakanae disease. Potassium phosphite was able to completely inhibit *X. oryzae* pv. *oryzae* at 35 mM and above. Potassium phosphite could control rice blast and bacterial blight in rice upon spray at 100–200 mM which reveals its potential as fungicide and bactericide. Potassium phosphite spray at 500–1,000 mM on rice grown on P rich soil showed little herbicidal action with phosphate starvation symptoms on weed. Neither potassium phosphite nor the recommended herbicide check, Bispyribac Na showed any carryover herbicidal effect on weeds in next season indicating the potential of phosphite as safe herbicide. While transgenic rice expressing ptxD germinated in the presence of potassium phosphite, the non-transgenic rice showed no germination indicating its pre-emergence effect. NGS based metagenomics and conventional microbiological tool based phyllosphere microbiome analysis revealed no adverse effect of ptxD gene expression on microbiome of rice as both the plants recorded identical phyllosphere microbial communities. Pattern of species distribution and their relative abundance is nearly identical in 45 and 90 days old transgenic and non-transgenic parent rice. *Rhizobium rhizogenes*, *Flavobacterium* sp IGB-4-14, *Herpetosiphon aurantiacus*, uncultured Gram positive bacterium, *Cellobibrio tontophilus*, uncultured soil bacterium, uncultured *Rickettsiales*, *Flavobacterium fontis* and uncultured proteobacterium were found on both rice types. The data revealed potential of potassium phosphite at 200–400 mM as fungicidal and bactericidal compound for use as an agroinput in rice cultivation.

Gram pod borer resistant transgenic chickpea and pigeon pea: Characters specific to chickpea (20) genotype and pigeon pea (21) articulated as per PPVFRA

Guidelines were evaluated in all the transgenic lines *vis-a-vis* parental genotype, and no significant deviation was observed. Expression of BT and NPT protein was observed in all positive transgenic lines, however the expression of BT protein dips at flowering stage. Efficacy of the transgenic lines could be correlated with the expression of BT protein and testing based on laboratory assays and *in planta* assays indicated variable resistance (up to 85% in chickpea and up to 87% in pigeon pea) in the transgenic lines tested, as compared to control. The flanking sequence information of the chickpea event IPCT3 could be identified and was localized in the gene region of chromosome 1 coding for 4-Coumarate: CoA Ligase.

Characterization, mapping and transcriptome analysis of chickpea seed: Chickpea germplasms (404) were characterized for total seed protein content, Fe, Zn and β-carotene. ICC 13461, ICC 13523, ICC 8397, T39-1, ICC 5912 and ICC 9553 genotypes showed higher (>27%) seed protein. Zinc and iron ranged from 1.10 – 5.91 mg/100 g and 0.50–8.54 mg/100 g, respectively; and are comparable to some of the best biofortified crops. High yielding chickpea cultivars contained higher seed



Field view of chickpea germplasm at ICAR-IARI, New Delhi

zinc and iron. Heera, H 82-2 and H 214 for Zn; and L 550, KGD 1168, PG 114, JG 74 and ICCV 6 for Fe are the cultivars identified with higher Zinc (>4 mg/100 g) and iron (>6 mg/100 g). Analysis of phytic acid in cultivars with higher mineral contents showed negative correlation with zinc and iron. Seed β-carotene ranged from 248.76 µg/100 g (Pusa 72 and ICC 5948) to 538.11 µg/100 g (ICC 5002). Transcriptome analysis for seed protein and zinc using contrasting cultivars identified conserved and novel miRNAs with respect to seed protein content. Large numbers of differentially expressed genes (DEG) were identified with respect to seed protein and zinc between contrasting genotypes. Validation of conserved miRNAs in two cultivars revealed presence of miR399 and miR398 exclusively in high seed protein content cultivar, i.e. ICC 8397. The expression analysis also resulted in differential expression of miRNAs in two contrasting cultivars. Six of the DEG validated in high and low seed protein genotypes through real-time PCR. Target prediction of miRNAs revealed genes encoding seed storage proteins and their sub-classes as important target genes for both conserved and novel miRNAs.

Population diversity of banana streak viruses (BSV): Banana mats/genotypes (285) collected from



Manipur, Mizoram, Nagaland, Tripura, Arunachal Pradesh, Sikkim and Assam, were characterized for endogenous banana streak viruses (eBSV). The results indicated the prevalence of distinct/novel alleles having similarity to endogenous banana streak OL virus (eBSOLV), banana streak IM virus (eBSIMV), banana streak GF virus (eBSGFV) and *Musa balbisiana* PKW type activable alleles, the allelic positions of which make them activable. Activable eBSV being harbored by banana genotypes of NE India are potential blueprints of episomal BSV diversity. Full length cloning of 14 episomal BSV isolates (sampled from Manipur, Nagaland, Sikkim, Tripura, Arunachal Pradesh and Assam) and sequencing was done. Full genome sequence of a new badnavirus banana streak MH virus (BSMVH) associated with streak disease of banana cultivar *Metei Hei* (ABB) grown in Manipur was achieved. Banana streak MY virus (BSMYV) was the most prevalent episomal badnavirus associated with streak disease of banana genotypes (AAA, AAB, ABB) in NE India.

Epigenetic regulation of host-pathogen genetics in leaf rust resistance of wheat: To understand the epigenetic component of the molecular basis of leaf rust resistance in susceptible genotype HD 2329 (S) and its resistant NIL HD 2329+*Lr28* (R) wheat, the role of miRNAs and their target genes was examined and several conserved and novel miRNAs were identified, which included 40 differentially expressed miRNAs in S0 vs S96 and R0 vs R96 treatments; qRT-PCR was also used for validation; a sugar transporter (SWEET) gene was the target for 13 miRNAs. Further several differentially binding sites (DBSs) and the associated genes for modified H3 were identified. It was discovered that susceptibility mainly involved activation of many genes and resistance was associated with both activation and repression; induced active genes differed in S and R and 27 genes were also validated using qRT-PCR.

Chemotyping of bioactive metabolites in *Hemidesmus indicus* and *Costus speciosus*: The germplasm and rhizospheric soil of 141 samples of *Costus speciosus* (rhizome) and 96 samples of *Hemidesmus indicus* (root) were collected and passport datasheets were prepared. All the GPS coordinates were documented for each collection after mapping and actual field assessment. The collected rhizome/root samples were evaluated for quality parameters. The bioactive compound in *Costus speciosus* is diosgenin and in *Hemidesmus indicus* vanillin, which have high market potential and industrial demand. These two compounds were quantified in all the collected samples for identifying the elite germplasms. Significant chemical variations were observed among the germplasms within the same phyto-geographical zone as well as within different zones also. Two elite chemotypes were identified, viz. NBCS-88 with maximum content of diosgenin (2.405%, on dry weight basis) from *Costus speciosus* and NBH-35 with maximum content of vanillin (0.0127%, on dry weight basis) from *Hemidesmus indicus*. Identified elite chemotypes are useful as quality planting material for

its commercial cultivation leading to supply of quality raw material (QRM) for herbal drug industries, in turn having huge socio-economic benefit.

Energy efficient polyhouse and aeroponic system: Increase in shoot or root zone temperature marginally affected haulm characters but a considerable decrease in tuber number was noticed when the plants were exposed to higher root and shoot zone temperatures grown under aeroponic system. The leads of this study indicated that for every 1°C rise in mean cumulative shoot temperature beyond the threshold of 19.5°C, there is a reduction of 2.3 tubers/plant. Similarly, 1°C raise in mean cumulative aeroponic chamber (root-zone) temperature beyond 18.4°C, the tuber number also reduced by 3.5. The expression of tuberization signal SP6A and positive regulator BEL5 decreased at high temperature and is correlated with tuber production (number). In polyhouse with the mean maximum temperatures of 32.83°C and mean minimum temperatures of 15.09°C of shoot zone, a significant improvement in mini tuber production was achieved by maintaining optimum aeroponic chamber temperatures (18–20°C). Using LED light panels, the plants, exposed to specific light spectra mainly in the red region achieved substantial reduction in the etiolation under polyhouse conditions with low light intensities. Marginal improvement in tuberization was achieved when plants were exposed to near far-red light (730 nm).

Improvement of salt tolerance in crops: At a salt concentration of EC 50 dS/m, total 112,218 genes were differentially expressed with 120,231 and 113,280 differentially expressed genes (DEGs) at EC 30 and 40 dS/m respectively. The Venn diagram showed that 1,065 transcripts (2.8%) were commonly upregulated at EC 30 and 40 dS/m; 11,209 (29.2%) transcripts between EC 40 and 50 dS/m; and 1627 transcripts (4.2%) were common at EC 30 and 50 dS/m in *Urochondra*. In *Dichanthium*, out of total 147,851 differentially expressed transcripts, 29,482 transcripts were upregulated and 42,425 transcripts were downregulated. In biological processes category of *Dicanthium*, responses were found to salt stress in 190 transcripts, positive and negative regulation to salt stress in 29 transcripts, oxidative stresses in 448 transcripts, cellular response oxidative stress in 35 transcripts. Validation of DEGs involved in salt tolerance pathways namely, sodium/hydrogen exchanger (NHX), dehydrin/LEA group 2-like protein, potassium transporter, catalase, peroxidase, transcription factor DREB, trehalose-6-phosphate synthase, etc. from grass halophytes confirmed the involvement of these genes in imparting tolerance at high salt concentration. The relative expression of NHX gene increased about 107% at 40 dS/m and about 1435% at 50 dS/m. NHX proteins play an important role in the ion homeostasis. Likewise, the relative expression of dehydrin also increased with increase in the salt concentration. Dehydrin protein is major protein expressed in response to drought and salt stress. The higher expression of NHX and dehydrin along with the increase in the salinity level suggested the tolerance ability of these halophytes to salt stress.





Small animal model for PPR virus: In *peste-des-petits ruminants* virus (PPRV) of sheep and goat, a laboratory animal was developed as a model to investigate anti-PPRV immunity and immune-pathology. The virus replicated and caused pathogenesis in IFN receptor knockout mice very efficiently but not at all in wild type mice. In addition, recombinant PPRV vaccine virus which has a fluorescent with GFP tag was also successfully generated which can be easily tracked in live cell culture as well as in experimentally infected small animal, even in live animals, because of being fluorescently labeled. To generate this recombinant virus, the complete genome of PPRV Sungri/96 was amplified as four overlapping fragments which was then sequentially linked through SOE-PCR. The ribozyme sequences were added on either end of the genome length cDNA. The integrity of entire genome of this recombinant virus by sequencing in entirety is already confirmed. The virus maintained the same growth kinetics as that of the parent virus. This PPR viral vector generated using this approach will be immensely useful for the development of next generation dual/combined vaccines for other viral, bacterial or parasitic diseases of animals as well.

Valorization of soybean and groundnut de-oiled meals/cakes and production of protein isolates: A physical process (based on size reduction and sieving) for removal of impurities (hulls and testa) from groundnut cake was optimized as pulverization in hammer mill. The flour samples passed through 60 BSS sieve contained 40.2% protein and 9.5% crude fibre, which was equivalent to the control cake. To optimize the process parameters for the extraction of protein from de-oiled soy and groundnut meal/cake the experimental plan was designed and executed using response surface methodology for process parameters such as: salt (sodium sulphite) concentration (0.1–0.3%), extraction temperature (40–60°C), extraction duration (40–80 min) and extraction pH (8–10) for extraction of protein from industrially produced soy meal. Maximum extraction was 65% of the total protein. In selection of biological agents, BBE4 was isolated from dairy products and its 16S rDNA sequence was registered with NCBI vide GenBank accession number KF974325 and MTCC, IMTECH, vide No: 12061. It showed survival percentage of 83% at pH 4.0.

Microbial consortia for enhancing decomposition rate and quality of bio-waste: The microbial consortia (bacterial, fungi and actinomycetes) and accelerated techniques for production of compost were developed and maturity and stability parameters were evaluated. Addition of microbial consortia achieved maturity parameters much earlier in vegetable waste compost (20 days) followed by kitchen waste (25 days), horticultural waste compost (35 days) and farm waste compost (45 days) under closed static system than un-inoculated control. Point sources segregation of domestic waste (city waste) was major factor for reducing heavy metals (12–25%) in compost. The degree of humification was 15–20% greater in microbial enriched compost and was

maximum in kitchen waste compost followed by vegetable waste compost. Increased loss rate kinetic (K) of about ~1.36 to 2-fold greater in kitchen, vegetable and horticultural waste compost as compared to crop residue compost, and maximum potential loss percentage (85.68%) in vegetable waste compost was observed. This study clearly indicated that selected thermophilic bio-inoculum addition shorten the usual period of decomposition (5–6 months by farmers practice) to 3–7 weeks (rapid composting technique).

Converting agro and food based biomass into PLA:

Cost effective solid state fermentation (SSF) process for lactic acid (LA) production was optimized. Using a *Lactobacillus plantarum* isolated under this project, L-lactic acid production, 40–45 g/100 gram rice straw was achieved. Furthermore, a novel one step method of purifying lactic acid generated during fermentation was developed using mixed solvent electrolyte system extraction containing n-butanol and ammonium sulphate. LA partitioned is recovered in organic phase with 86% yield and 93% purity. Using cottonseed cake as substrate, 19.7 g GABA (γ -Aminobutyric acid)/100 g cake was produced through fermentation by *Lactobacillus brevis*. The GABA, a biologically active compound, was obtained in purified form using silica gel column chromatography.

Synthetic anti-microbial peptide hydrogels for bovine mastitis: The lead antimicrobial peptide (AMP) molecule identified from insect secretions was chemically synthesized and initially tested for its activity against ESKAPE bacteria to determine the MIC and MBC. Stability at different temperatures, in presence of salts and serum, toxicity in *Galleria melonella* larvae, mammalian cells and haemolytic activity in RBCs of different species were determined *in vitro* prior to therapeutic evaluation in lactating Balb-c mice challenged with virulent *Staphylococcus aureus* isolate. The mice were euthanized 24 h after *S. aureus* inoculation, and mammary glands were aseptically collected for determining CFU/gland and for quantitation of pro-inflammatory cytokines using real-time PCR. It was observed that there was significant reduction in the bacterial load per gland in the AMP and antibiotic treated groups as compared to infected glands treated with sterile PBS. Further, there was significant reduction in expression of pro-inflammatory cytokines (IL-10, IL-1, IFN-Y, iNOS, TNF- α and TGF- β) in comparison to mouse infected with bacteria and treated with sterile PBS. The results of SAMAMP-1 treatment of infected mouse mammary gland were comparable with the standard antibiotic treatment group. Further, histopathological analyses showed that *S. aureus* - induced inflammatory cell infiltration, mammary alveoli thickening and edema were significantly reduced by treatment of AMP and standard antibiotic. Thus, this lead AMP can be a promising molecule for treatment of bacterial mastitis, especially caused by *S. aureus*. Further studies in bovine mastitis cases are being taken up for therapeutic evaluation of the lead compound.





Biological filter for safe wastewater irrigation: Out of 22 isolates screened for cadmium and chromium absorption, 3 highly potential mutually compatible strains were selected and grown in nutrient media supplemented with different concentrations of cadmium and chromium. Analyses of these samples revealed that the microbes were tolerant to both the metals in 20 ppm and absorbed the heavy metals provided to them during their growth. Analysis revealed that the above strains IIWM-DW-02E (1420 bases), IIWM-DW-03H (1414 bases) and IIWM-DS-01O (1432 bases) were 99.93% similar to *Pseudomonas aeruginosa*, 99.86% similar to *Actinobacter baumannii* and 100% similar to *Bacillus cereus* respectively. The microbial isolates were also immobilized in variable concentrations of calcium alginate to entrap them so that they would not mix with the flowing water when used in the filter. Shearing test of the beads in distilled water with magnetic stirrer at a constant speed revealed that maximum shearing was seen in beads prepared with 0.25% alginate followed by 0.5% which was around 1 h and 3 h, respectively, while the beads prepared with 1% alginate started shearing from the 24th hour. The total metal removal was appreciable in the bio filters. It was found to be 100%, 89.6%, 97.8%, 99%, 65.53%, 96.8%, 97%, and 90.64% for Al, Fe, Zn, Cu, Mn, Ni, Cr and Pb, respectively. Gravel biofilters performed most efficiently for total metal removal as compared to Graphite and FRP biofilters. Although, the effluent of all bio filters contained metals in parts per billion (ppb) quantity.

Automated soil nutrient sensing system: A hydraulically operated soil sampler equipped with hollow circular core cutter was developed to decide the soil sampling depth, and a proximity sensor based depth control mechanism was also developed and integrated with the soil sampler. The sensor was used to control the sampling depth of 15 cm (adjustable as per requirement) to collect soil samples without having any physical contact. The entire soil sampling unit consists of a hydraulic cylinder, core cutter, soil scrapper, soil collector, proximity sensor, controller and other



components. The hydraulic cylinder works with the help of tractor hydraulic system. The hydraulic cylinder presses the core cutter in the soil, which cuts the soil from ground and then cylinder lifts the core cutter to bring the soil sample up from the ground. A scrapper unit scraps the soil from the core cutter and places it into the soil collector. A DGPS was integrated in developed system so that the tagging of accurate location will be done for collected soil sample.

Electronic nose for optimum harvesting time in apple: One of the most important needs of fruit producers is to determine optimal harvesting time to assure the correct fruit ripening stage, high nutritional value and extended post-harvesting self-life as expected by consumers. A metal oxide hybrid transducer based E-nose sensor prototype was developed to sense the ripening stages in apple. The E-nose sensor can work independently with its own display or can be integrated with any Android mobile phone using SMART-Nose app. In addition to ripening stage, this E-nose sensor can also predict sugar, protein and polyphenol contents non-invasively under post-harvest storage conditions.

Genetic variability of milk protein in Indian goats: Goat milk proteome analysis identified 1,308 proteins in milk samples across 15 Indian goat breeds. These proteins are functional in 237 KEGG pathways including NOD-like receptor signaling pathway, HIF-1 signaling pathway, metabolic pathways, as well as disease pathways such as tuberculosis, malaria, and measles. The majority of identified proteins were localized in nucleus, cytoplasm and extracellular and involved in various biological process having transporter, binding and catalytic activities. *CSN1S1* gene was also characterized in Jamunapari goats and its effect on milk composition traits was observed. Milk protein variability at protein and DNA level was carried out. The A, B and F alleles were observed in the analyzed population with the allelic frequencies of 0.4566, 0.503 and 0.041, respectively. The direct heritability for protein %, SNF % and lactose % was 0.441, 0.294 and 0.326, respectively. The goats with AB genotype had highest protein content (3.56%) followed by AA (3.50%), BB (3.26%), BF (3.03%) and AF (2.99%) genotypes. Genetic correlation between protein % and SNF % was moderate and positive.

Effect of graded levels of nano-selenium on the performance of the broiler chicken: The body weight and cell mediated immunity in terms of cutaneous basophilic hypersensitivity response (CBH) and humoral immunity of broiler chicken at fifth week age improved when supplemented with nano-Se @ 0.30 ppm, 0.15 ppm and 0.0375 ppm in summer, rainy season and winter, respectively. Supplementation of nano Se also improved the activity of catalase, superoxide dismutase and glutathione peroxidase activity and lowered lipid peroxidation values in all the seasons. Selenium concentration in liver, breast muscle, gizzard and kidney and serum concentration of glucose, total protein, globulin concentration also improved in all the nano Se supplemented birds than control. □



Strengthening the Research System

The Agricultural Scientists Recruitment Board (ASRB) is under the administrative control of Department of Agricultural Research and Education (DARE), Ministry of Agriculture and Farmers' Welfare, Government of India. Achievements of Agricultural Scientists Recruitment Board for the year 2019–20 are discussed here.

Achievements of Agricultural Scientists Recruitment Board

Direct recruitment/lateral entry: During the period Board advertised 72 Research Management Positions. Out of these Deputy Directors General (3), Directors of National Institutes (5), Assistant Directors General (10), Directors (40), Joint Directors of National Institutes (11) and three posts were of Project Directors. The recruitment action for all the positions are under process.



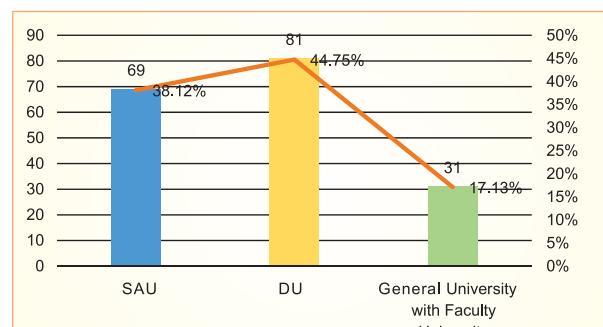
Agricultural Research Service Examination:

During the year, a combined examination for Agricultural Research Service-2017 (Prelims) and NET 2018 (I) was conducted from 6–10 April 2018 in online mode for 195 vacancies in 29 disciplines at 23 Centres across India. 28,257 candidates had registered for the examination and 21,006 candidates appeared in the examination. A total of 2,555 candidates (12.2%) qualified for the ARS (Main) Examination held on 24 June 2018 at 12 Centres across India. Out of 2,555 qualified candidates, 2,293 candidates actually appeared in the main examination.

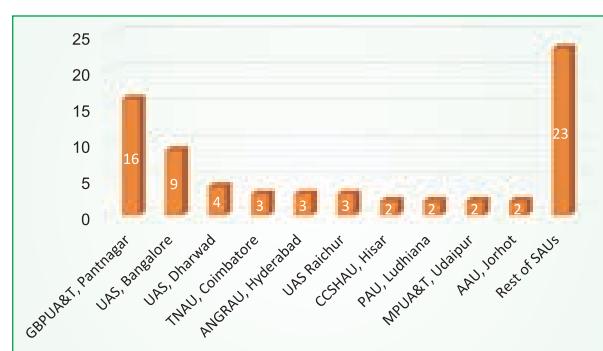
The Board usually interviews/ calls 5 candidates against each vacancy, but for the ARS-2017 Exam, 708 candidates qualified for viva voce. In eleven disciplines, the ratio of 1:5 could not be adhered to as sufficient candidates were not available in this ratio due to not scoring the minimum prescribed qualifying marks.

Analysis of data showed that out of 181 recommended candidates, 69 were from 27 State Agricultural Universities, 81 were from four ICAR Deemed to be Universities (DU) i.e. IARI, New Delhi (58); CIFE, Mumbai (04); IVRI, Izatnagar (8); NDRI, Karnal (11), 4 from BHU, Varanasi , 27 from General Universities.

Out of 181 recommended candidates about 79.56% successful candidates were from 10 states (Rajasthan, West Bengal, Karnataka, Kerala, Uttar Pradesh, Tamil



Organization-wise contribution in ARS

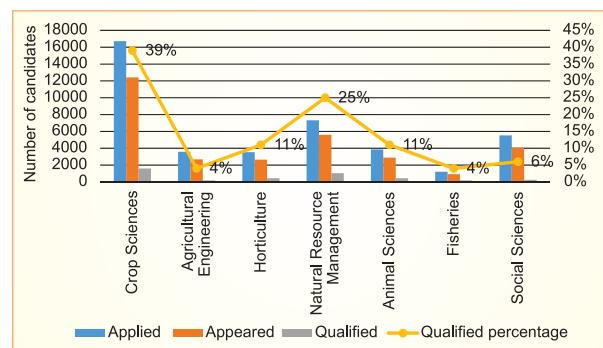


Performance of top Ten SAUs in ARS-2017

Nadu, Madhya Pradesh, Uttrakhand, Bihar, Haryana, Odisha and Telangana).

National Eligibility Test (NET) Examination-2018

(II): NET Examination 2018(II) was conducted from 27 Dec 2018 to 29 Dec 2018 in online mode. A total of 41,778 candidates had registered for NET (II)-2018 examination and 31,233 candidates appeared in the examination. A total of 4,135 candidates qualified the examination. Major discipline wise details of candidates are given below.

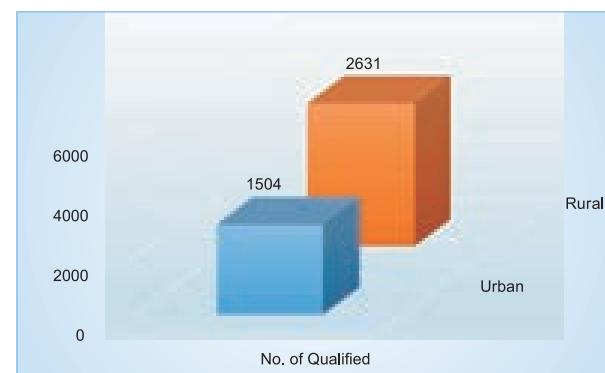


Major discipline-wise details of candidates

The highest percentage of candidates qualified is in the disciplines of Poultry Science (72.92%), Fish Health (55.74%), Animal Nutrition (49.28%), Animal Genetics and Breeding (49.06%), Spices, Plantation and Medicinal

and Aromatic Plants (46.81%), Fish Nutrition (46.15%), Veterinary Pathology (39.44%), Fish Genetics and Breeding (36.67%), Agroforestry (36.03%), Agricultural Microbiology (35.38%), Veterinary Anatomy (35.29%) and Veterinary Public Health (35.05%) and the lowest percentage of candidates qualified is in the discipline of Agricultural Business Management (0.28%), Bioinformatics (0.33%) and Agricultural Biotechnology (0.49). In eight disciplines i.e. Agricultural Entomology, Dairy Technology, Agricultural Economics, Farm Machinery and Power, Economic Botany and Plant Genetics Resources, Computer Application in Agriculture, Biotechnology (Animal Science), Food Technology the success rate was less than 5%.

Analysis of the data revealed that out of 4,135 qualified candidates, 1,068 (26%) were from 10 State Agricultural Universities (Tamil Nadu Agricultural University, Coimbatore; Kerala Agricultural University, Thrissur; Govind Ballabh Pant University of Agriculture and Technology, Pantnagar; Indira Gandhi Krishi Vishwavidyalaya, Raipur; Punjab Agricultural University, Ludhiana; University of Agricultural Sciences, Bengaluru; Orissa University of Agriculture



Area-wise details of successful candidates

Out of 4,135 qualified candidates about 67% of successful candidates were from ten states (Tamil Nadu, Uttar Pradesh, Karnataka, Kerala, Maharashtra, Rajasthan, Andhra Pradesh, Gujarat, West Bengal, Odisha).

Among 4,135 qualified candidates, 51% were female candidates and 49% were male candidates. Qualified candidates were mostly from rural area.

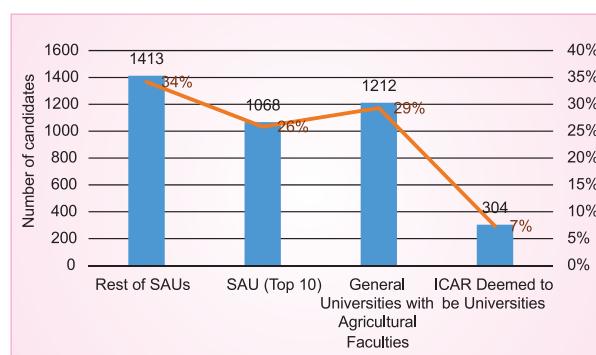
Stenographer Grade-III Examination, 2017: Out of 48,915 candidates who had appeared in the examination, 1,936 candidates were declared provisionally qualified for appearing in Skill Test. Based on the qualifying skill test held on 29.10.2018–02.11.2018, the results of 93 posts were communicated to the 48 concerned Institutes/ Krishi Vigyan Kendras (KVKs) for appointment as Stenographer Grade-III.

Common Written Examination for Technician (T-1): Out of 9,204 candidates who had appeared in the examination, results of 527 candidates who have been selected for T-1 post were communicated to the concerned Institutes.

Limited Departmental Competitive Examinations: During this period, Limited Departmental Competitive Examination was held on 16.11.2018 to fill up for the posts of Upper Division Clerk (UDC). Details are as follows:

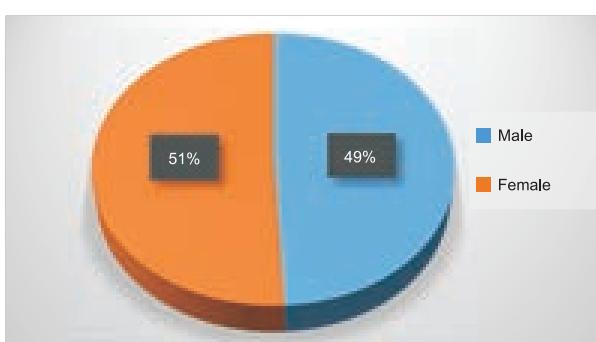
Post	Vacancies	Candidates applied	Candidates appeared	Selected
Upper Division Clerk (UDC)	07	03	01	01
Total	07	03	01	01

Career Advancement Scheme (CAS): Proposals (102) received from different ICAR Institutes were assessed for placement from Senior Scientists to the grade of Principal Scientists under the revised Career Advancement Scheme (CAS) in 41 discipline and one review case in the Plant Breeding was assessed. The outcome of this assessment indicated that 85% candidates got promotions from due date and 10% deferred promotions to the next higher grade.

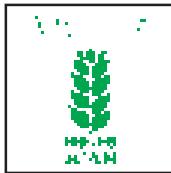


Organization-wise performance of candidates

and Technology, Bhubaneshwar; Acharya NG Ranga Agricultural University, Hyderabad; Dr Panjabrao Deshmukh Krishi Vidyapeeth Akola; Navsari Agricultural University, Navsari), 1,413 (34%) were from rest of SAUs, 1,212 (29%) were from General Universities with Agriculture Faculties and 304 (7%) were from DU (IARI, New Delhi; IVRI, Izatnagar; NDRI, Karnal; and CIFE, Mumbai).



Gender-wise details of successful candidates



20.

Training and Capacity Building

Human Resource Management Unit at ICAR Headquarters is promoting systematic approach to training in ICAR since 2016–17. The highlights of Training and Capacity Building of ICAR employees of all categories during 2018–19 are enumerated below.

New Initiatives

Field/exposure visit

It was realized that there should be a provision of field/exposure visit of Skilled Support Staff (SSS) category who have never visited other ICAR-Institutes even in the same state. Keeping this in view, it was decided that all ICAR-Institutes/HQs shall try to include 1–2 days field/exposure visit of SSS to the ICAR-Institute within the same state or nearby state in case of Delhi and NE states as an integral part of the training programme. Since January 2019, ICAR-Institutes/HQs have organized field/exposure visit of 181 SSS to other ICAR-Institute.

Specialized training programme for caretakers/guest house: First time, a specialized training programme on Hospitality Management in collaboration with Institute of Hotel Management, Catering Technology and Applied Nutrition (IHMC&AN), Hyderabad was organized by ICAR-NAARM, Hyderabad for Caretakers/Incharges of guest house. In the said training programme, 29 Caretakers/Incharges of guest house of various ICAR-Institutes participated, out of which, 96% attended first time, such training programme after joining ICAR service.

New training programme for vigilance officers: Most of the Vigilance Officers of ICAR-Institutes are scientists. Keeping this in view, two-day Training Workshop for Vigilance Officers of ICAR was organized by ICAR-NAARM, Hyderabad. Vigilance Officers (35) of 35 Institutes participated. None of them had such type of training in the past.

Development and launching of training management information system (TMIS): As per ICAR HRM Policy, Training Management Information System (TMIS) for ICAR employees was launched on 31 January 2019. It has been made mandatory for all ICAR-Institutes/Headquarters to submit the Annual training Plan (ATP) and applications for attending Training program in ICAR/Non-ICAR Institutes w.e.f. 1 April 2019. TMIS is hosted on <https://hrm.icar.gov.in>.

In order to effectively coordinate, implement, monitor and evaluate trainings and to get feedback of human resource related activities, the framework of TMIS for ICAR was developed by NAARM, Hyderabad, in consultation with IASRI, New Delhi, and HRM Unit of ICAR. It was designed, developed, tested and

implemented by IASRI, New Delhi in consultation with HRM Unit, ICAR. This system facilitates (i) training needs assessment, (ii) training application process, (iii) training feedback process, and (iv) training evaluation process.

Other Initiatives

Annual training plan (ATP): It is essential for all the Institutes/HQs to develop Annual Training Plan (ATP) based on training need assessment (TNA) as per ICAR HRM Policy. The implementation of ATP was assessed at the end of the year and appropriate feedbacks were given to all the ICAR-Institutes for better implementation in future.

Organization of Training Programmes

Scientific staff: During the reporting period, ICAR-Institutes organized 252 training programmes for scientific staff (1,098) for enhancing their competency in various fields.

Management Development Programme: For effective and efficient implementation of training functions in the Institutes, a Management Development Programme on Effective Implementation of Training Functions by HRD Nodal Officers of ICAR was organized in which 23 officials participated. They were exposed to learn various training functions including developing a system of training in the institute; pursuing systematic approach to training; performing training needs analysis (TNA) of all categories of employees; developing Annual Training Plan (ATP) based on TNA; evaluation of Trainings; monitoring and impact assessment of trainings; and maintaining database of training and trained manpower, etc.

Training programme for PME Cell Incharges: To acquaint the PME Cell Incharges with the techniques for research prioritization, monitoring and evaluation, six-day MDP on Priority Setting, Monitoring and Evaluation (PME) of Agricultural Research Projects, for PME Cell Incharges of ICAR was organized during the reporting period. In the said MDP, 30 PME Cell Incharges of 30 Institutes participated.

Technical staff: During 2018–19, ICAR-Institutes organized 109 training programmes for Technical Staff (816) for enhancing their competency in various aspects.

Training programmes for farm/farm manager: In order to manage the research/livestock farms more effectively and efficiently, a specially designed and developed training programme on Farm Management, was successfully organized in two batches. Farm Managers (51 from ICAR + 3 Non-ICAR Institutes) participated in the programme.



**Table 1. SMD-wise number of employees undergone training**

SMDs/HQs	No. of employees undergone training					% Employees undergone training				
	Scientist	Tech.	Admin	SSS	Total	Scientist	Tech.	Admin	SSS	Total
Crop Sciences	301	258	161	180	900	18.1	18.6	18.9	13.6	17.2
Horticultural Sciences	200	166	126	114	606	26.9	23.3	31.0	18.5	24.4
NRM	150	102	100	33	385	18.8	9.8	22.3	5.2	13.1
Agricultural Education	15	16	24	33	88	22.1	10.1	17.7	6.8	12.5
Agricultural Engineering	41	58	26	17	142	20.5	20.7	18.2	12.2	18.6
Animal Sciences	172	75	95	99	441	32.2	25.1	42.0	21.3	29.3
Fisheries Sciences	194	134	132	93	553	10.9	15.2	20.9	53.2	21.0
Agricultural Extension	8	4	18	2	32	22.9	13.3	31.0	22.2	24.2
ICAR HQs	17	3	51	59	130	23.0	3.7	12.1	89.4	20.2
Total	1098	816	733	630	3277	21.8	16.6	22.2	13.3	18.2

Training programme for library staff: Technical staff (34 from ICAR and 3 from SAUs) associated with library work in various ICAR Institutes/HQs were nominated by the ICAR HQs for Training Programme organised by KOHA.

Administrative staff: ICAR-Institutes/HQs organized 35 training programmes for administrative including finance staff for improving their competency and 733 administrative staff of ICAR of various grades participated.



Refresher course on Administration and Finance Management for Section Officer, AAOs, AFAOs, and Assistants of ICAR Headquarters and Institutes

Training programme for drivers: A specialized and updated training programme on ‘Automobile Maintenance, Road Safety and Behavioural Skills’ was organized for regular drivers of ICAR. In this programme, 93 regular drivers participated in three batches, out of which about 88% got first time opportunity after joining ICAR service.

Training programme for stenographers: During the reporting period a training programme on ‘Enhancing

Efficiency and Behavioural Skills’ was organized in three batches. In this programme, 75 stenographers in various grades participated, out of which about 95% stenographers got training first time after joining ICAR services.

Training programme for skilled support staff: Based on the identified training needs, ICAR-Institutes/HQs are now organising trainings for skilled support staff (SSS) after the creation of HRM Unit at ICAR HQs. During reporting period, 53 training programmes were organized for Skilled Support Staff by 53 ICAR-Institutes/HQs, and 630 SSS were trained.



Visit of SSS, ICAR HQs at IISR, Lucknow

Employees Trained

During the reporting period, 3,277 employees underwent various types of training and capacity building programmes, out of which scientists, technical, administrative including finance, and skilled support staff (SSS) were 1,098, 816, 733 and 630, respectively (Table 1). Compared to 2013–14, there was considerable improvement in number of employees undergone trainings particularly in case of Technical, Administrative and Skilled Support Staff, where improvement was 120.5, 21.0 and 1475.0%, respectively, along with overall improvement of 36.0% in all the categories of employees during 2018–19.

During the reporting period, Crop Science Division depoted highest number of Scientists (301), Technical staff (258), Administrative staff (161) and Skilled Support Staff (180) for various capacity building programmes (Table 1). Thus, overall, maximum number of employees were trained in Crop Science Division (900) followed





by Horticultural Science Division (606), out of 3,277 employees trained in the ICAR system.

In terms of per cent employees trained under each category, Scientists (21.8%), Technical (16.6%), Administrative including Finance (22.2%) and Skilled Support Staff (13.3%) were trained in various aspects as per their training needs with overall 18.2% employees across the categories got opportunity for capacity building (Table 1). This is evident that 9.3, 5.7 and 12.6% more Technical, Administrative including Finance and Skilled Support Staff, respectively, got training opportunities during this period as compared to 2013–14 with overall improvement of 5.5% in capacity building of all the categories of employees.

The training programmes organised for scientists, technical, administrative including finance, and skilled support staff were 252, 109, 35 and 53, respectively (Table 2). Compared to 2013–14, ICAR-Institutes/HQs organized 62.7 and 960.0% more training programmes for Technical and Skilled Support Staff, respectively, during 2018–19. It is also being emphasised to give more opportunities outside ICAR.

Trainings organized by various ICAR-Institutes/HQs

Crop Science Division organised maximum number of trainings for all the categories of employees, viz. scientists (55), technical staff (49), administrative staff (9) and skilled support staff (24).

Impact assessment of training programmes

ICAR-Institutes (106) submitted Impact Assessment Report for 2,191 trainees who had attended training

Table 2. Number of trainings organized by various SMDs

SMDs/HQs	Scientists staff	Technical staff	Administrative	SSS	All employees
Crop science	55	49	9	24	137
Horticultural science	13	17	3	8	41
NRM	45	2	1	1	49
Agricultural education	54	8	9	1	72
Agricultural Engineering	21	18	0	2	41
Animal Science	25	1	6	7	39
Fisheries Science	13	8	5	7	33
Agricultural Extension	26	6	2	1	35
ICAR HQs	0	0	0	2	2
Total	252	109	35	53	449

programmes with an average age of 43.8 years and average experience of 17.1 years. Out of 2,191 participants, 548 were the female participants. The proforma developed by DoPT for this purpose was used.

Based on the feedback of trainees received from different ICAR-Institutes, the overall impact of training was Considerable-Great Extent with average rating of 3.72/5. 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 an average rating of 3.66/5.00.



(A) DEPARTMENT OF AGRICULTURAL RESEARCH AND EDUCATION

APPENDIX I

SUBJECTS ALLOCATED TO DEPARTMENT OF AGRICULTURAL RESEARCH AND EDUCATION (KRISHI ANUSANDHAN AUR SHIKSHA VIBHAG)

Part I

The following subjects which fall within List I of the Seventh Schedule to the Constitution of India:

1. International cooperation and assistance in the field of agricultural research and education including relations with foreign and international agricultural research and educational institutions and organizations.
2. Fundamental, applied and operational research and higher education including coordination of such research and higher education in agriculture, agro-forestry, animal husbandry, dairying, fisheries, agricultural engineering and horticulture including agricultural statistics, economics and marketing.
3. Coordination and determination of standards in institutions for higher education or research and scientific and technical institutions in so far as they relate to food and agriculture including animal husbandry, dairying and fisheries. Development of Human Resources in Agricultural Research/Extensions and Education.
4. Cess for financing to the Indian Council of Agricultural Research and the Commodity Research Programmes other than those relating to tea, coffee and rubber.
5. Sugarcane research.

Part II

For Union Territories the subjects mentioned in Part I above, so far as they exist in regard to these Territories and in addition the following subject which falls within List II of the Seventh Schedule to the Constitution of India:

6. Agricultural Education and Research.

Part III

General and Consequential:

7. Plant, animal and fish introduction and exploration.
8. All India Soil and Land Use Survey relating to research training, correlation, classification, soil mapping and interpretation.
9. Financial assistance to State Governments and Agricultural Universities in respect of agricultural research and educational schemes and programmes.
10. National Demonstrations.
11. Indian Council of Agricultural Research and its constituent Institutes, National Research Centres, Project Directorates, Bureaux and All India Coordinated Research Projects.
12. Research and Development on production and improvement of bio-fuels plants.

APPENDIX II

TOTAL NUMBER OF POSTS AND NAMES OF IMPORTANT FUNCTIONARIES

Group	Designation	Sanctioned strength
A	Secretary (DARE) and DG (ICAR)	1
A	Additional Secretary and Financial Advisor	1
A	Additional Secretary (DARE) and Secretary (ICAR)	1
A	Director	1
A	Deputy Secretary	2
A	Senior Principal Private Secretary/Principal Staff Officer	1
A	Joint Director	1
A	Under Secretary	7
A	Principal Private Secretary	3
B	Assistant Director (Official Language)	1
B	Private Secretary	3
B	Section Officer	8
B	Assistant Section Officer	5
B	Personal Assistant/Steno Grade 'C'	4
C	Junior Hindi Translator	1
C	Senior Secretariat Assistant (UDC)	1
C	UDC-cum-Cashier	1
C	UDC-Hindi Typist	1
C	Stenographer Grade 'D'	3
C	Staff Car Driver	1
C	Junior Secretariat Assistant (LDC)	1
D	Daftry	1
D	Peon/MTS	5
Total		54

NAMES OF THE IMPORTANT FUNCTIONARIES

S. No.	Name	Designation
1.	Dr Trilochan Mohapatra	Secretary (DARE) and DG (ICAR)
2.	Shri Sushil Kumar	Additional Secretary (DARE) and Secretary (ICAR)
3.	Shri Bimbardhar Pradhan	Additional Secretary and Financial Advisor
4.	Shri Shaleen Agrawal	Director
5.	Shri Mohinder Kumar	Principal Staff Officer
6.	Shri A.R.Sengupta	Deputy Secretary
7.	Shri Uday Shanker Pandey	Deputy Secretary
8.	Shri Jitendra Misra	Under Secretary
9.	Shri Prem Prakash Maurya	Under Secretary
10.	Shri A.G.Subramanian	Under Secretary
11.	Shri Rajesh Kumar	Under Secretary
12.	Shri Surjeet Saha	Under Secretary
13.	Shri P. Ramamoorthy	Under Secretary
14.	Shri Shailendra Kumar Upadhyay	Under Secretary
15.	Smt. Meena Balani	Principal Private Secretary



APPENDIX III

ACTIVITY PROGRAMME CLASSIFICATION

Budget Estimates (BE) and Revised Estimates (RE) for the year 2018-19 and BE 2019-20 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

Items		(Rupees in Lakh)		
		Budget Estimates	Revised Estimates	Budget Estimates
		2018-19	2018-19	2019-20
		Unified Budget	Unified Budget	Unified Budget
Major Head '3451'				
090	Secretariat-Economic Services	816.00	770.00	805.00
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	400.00	361.00	405.00
020035	Grants for creation of Capital Assets	3800.00	3800.00	6992.00
020036	Grants in Aid Salaries	500.00	155.00	500.00
03	Grant-in-Aid Central Agricultural University Bihar			
030031	Grants in Aid General	1000.00	900.00	1010.00
030035	Grants for creation of Capital Assets	360.00	4536.00	10000.00
030036	Grants in Aid Salaries	7540.00	7520.00	8000.00
05	Grants-in-Aids to National Academy of Agricultural Sciences and Indian Agricultural Universities Association			
050031	Grants in Aid General	156.00	196.00	156.00
050035	Grants for creation of Capital Assets	-	-	-
050036	Grants in Aid Salaries	-	-	-
06	Agricultural Scientists' Recruitment Board			
060031	Grants in Aid General	-	391.00	1570.00
060035	Grants for creation of Capital Assets	-	275.00	1490.00
060036	Grants in Aid Salaries	-	126.00	900.00
80.798	International Co-operation (Minor Head)			
01	India's Membership Contribution to Commonwealth Agricultural Bureau			
010032	Contribution	25.00	22.85	25.35
02	India's Membership Contribution to Consultative Group on International Agricultural Research			
020032	Contribution	525.75	590.00	590.00
04	Asia Pacific Association of Agricultural Research Institutions			
040032	Contribution	14.60	8.50	9.00
05	N.A.C.A.			
050032	Contribution	44.00	46.00	46.00
07	International Seed Testing Association, Zurich, Switzerland			
070032	Contribution	4.25	4.25	4.25
08	International Society for Horticulture Science, Belgium			
080032	Contribution	0.40	0.40	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	2366.00	2131.00	2393.00
010035	Grants for creation of Capital Assets	1650.00	7664.00	6700.00
010036	Grants in Aid Salaries	9384.00	9325.00	9500.00
	TOTAL	28586.00	38822.00	51096.00



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 2017-2018			Budget 2018-2019			Revised 2018-2019			Budget 2019-2020		
	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
CENTRE'S EXPENDITURE												
I. Establishment Expenditure of the Centre												
1. Secretariat	6989.92	... -47.00	6989.92 7800.00	... -47.00	... 8.06	7800.00 7952.73	... 8.06	... 7.60	7952.73 8078.76	... 7.60	... 7.95	8078.76
Gross Recoveries	6942.92 6942.92	6942.92 7800.00 7800.00 7952.73 7952.73 7952.73 7952.73 8078.76 8078.76 8078.76	8078.76
Receipts	6942.92 6942.92	6942.92 7800.00 7800.00 7952.73 7952.73 7952.73 7952.73 8078.76 8078.76 8078.76	8078.76
Net	6942.92 6942.92	6942.92 7800.00 7800.00 7952.73 7952.73 7952.73 7952.73 8078.76 8078.76 8078.76	8078.76
II. Central Sector Schemes/Projects												
2. Agricultural Extension	2415	6.28	6.28	6.24	... 6.75	6.24 8.06	... 13.03	6.24 8.06	... 14.30	6.82 7.60	... 14.42	6.82 7.95
Total-Secretariat	3451	6.75	6.75	6.75	... 13.03	6.75 14.30	... 14.30	6.75 14.30	... 14.42	6.85 14.80	... 14.80	6.85 7.95
III. Total -Agricultural Extension	2415	232.51	232.51	228.17 42.68	228.17 13.64 241.81 98.12	... 13.64 241.81 98.12	228.17 13.64 241.81 98.12	... 13.64 205.53 57.90	193.94 11.59 205.53 57.90	... 11.59 205.53 57.90	193.94 12.48 221.15 62.30
IV. Agricultural Engineering	2552	42.68	42.68	42.68 42.68	42.68 100.00	... 100.00	42.68 100.00	... 100.00	1.88 1.60	... 1.60	1.88 1.72
V. Total -Agricultural Engineering	42.68	42.68	42.68	42.68 42.68	42.68 100.00	... 100.00	42.68 100.00	... 100.00	59.50	... 59.50	59.50 64.02
VI. Management of Natural Resources	2415	167.68	167.68	144.69 50.00	167.68 174.39	... 174.39	167.68 174.39	... 174.39	144.69 29.70	... 29.70	144.69 25.25
VII. Natural Resource Management Institutes including Agro Forestry Research	2552	167.68	167.68	167.68 50.00	167.68 174.39	... 174.39	167.68 174.39	... 174.39	122.99	... 122.99	122.99 132.32
VIII. Total-Natural Resource Management Institutes including Agro Forestry Research	50.00	50.00	50.00	50.00 50.00	50.00 52.00	... 52.00	50.00 52.00	... 52.00	148.24	... 148.24	148.24 159.48
IX. Climate Resilient Agriculture Initiative	2415	50.00	50.00	44.30 50.00	50.00 7.70	... 7.70	50.00 7.70	... 7.70	37.66 6.55	... 6.55	37.66 40.52
X. Total-Climate Resilient Agriculture Initiative	2552	50.00	50.00	50.00 50.00	50.00 52.00	... 52.00	50.00 52.00	... 52.00	44.21	... 44.21	44.21 47.56
XI. Crop Sciences	2415	399.66	399.66	746.25 154.90	399.66 800.00 194.68 200.00	... 800.00 194.68 200.00	399.66 800.00 194.68 200.00	... 800.00 194.68 200.00	606.84 45.15	... 45.15	606.84 48.59
XII. Total-Crop Science	2552	399.66	399.66	53.75 154.90	399.66 800.00 194.68 200.00	... 800.00 194.68 200.00	399.66 800.00 194.68 200.00	... 800.00 194.68 200.00	651.99	... 651.99	651.99 701.53
XIII. Horticultural Science	2415	154.90	154.90	5.32 154.90	154.90 200.00	... 200.00	154.90 200.00	... 200.00	4.52	... 4.52	4.52 4.87
XIV. Total -Horticultural Science	2552	154.90	154.90	154.90 154.90	154.90 200.00	... 200.00	154.90 200.00	... 200.00	165.75	... 165.75	165.75 178.34

Contd...

Schemes	Actual 2017–2018			Budget 2018–2019			Revised 2018–2019			Budget 2019–2020		
	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
8. National Agricultural Science Fund	2415	36.55	36.55	50.75	50.75	50.75	50.75	50.75	50.75	54.60	...	54.60
Animal Sciences												
9. Animal Science	2552	271.97	271.97	388.61	388.61	388.61	279.31	279.31	279.31	300.55	...	300.55
Total -Animal Science		271.97		400.00		400.00	9.67		9.67	10.43	...	10.43
10. Fisheries Science	2415	115.85	115.85	169.59	169.59	169.59	131.40	131.40	131.40	141.38	...	141.38
Total-Fisheries Science		115.85		115.85		170.69		170.69		1.01	...	1.01
Agricultural Education												
11. Agricultural Universities and Institutions	2415	658.37	658.37	651.70	651.70	651.70	497.54	497.54	497.54	535.35	...	535.35
Total -Agricultural Universities and Institutions		658.37		658.37		684.70		684.70		525.59		565.51
12. Economic Statistics and Management	2415	31.29	31.29	32.54	32.54	32.54	27.66	27.66	27.66	29.76	...	29.76
13. National Agricultural Higher Education Project	5.00	5.00	5.00	7.89	7.89	7.89	155.27	155.27	155.27
14. National Agricultural Higher Education Project (EAP)												
Total -Central Sector Schemes/Projects												
III Other Central Sector Expenditure												
b Autonomous Bodies												
15. ICAR Headquarters	2552	4574.09	4574.09	4467.37	4467.37	4467.37	4920.64	4920.64	4920.64	4711.75	...	4711.75
16. Central Agricultural Universities	2415	4574.09	4574.09	4599.37	4599.37	4599.37	132.00	132.00	132.00	135.44	157.05	157.05
2552	234.93	234.93	234.93	136.00	136.00	136.00	172.72	172.72	172.72	4868.80	...	4868.80
2415	234.93	234.93	234.93	134.00	134.00	134.00	191.20	191.20	191.20	172.72	269.07	269.07
2552	1.41	1.41	1.41	270.00	270.00	270.00	363.92	363.92	363.92	185.93	455.00	455.00
2415							1.56	1.56	1.56	1.96	1.56	1.56
17. National Academy of Agricultural Sciences												
18. Agricultural Scientists Recruitment Board												
Total -Autonomous Bodies												
f Others												
19. Actual Recoveries	3451	-46.96	-46.96
		-0.04	-0.04
		-47.00	-47.00
Grand Total -												
B. Developmental Heads												
Economic Services												
1. Agricultural Research and Education	6936.21	6.71	6.71	7368.46	7368.46	7368.46	7485.17	7485.17	7485.17	7584.37	...	7584.37
2. Secretariat-Economic Services	6942.92		6942.92	7376.52		7376.52	7492.77		7492.77	7.95	...	7.95
Total -Economic Services												
Others												
3. North Eastern Areas												
Total -Others												
Total -		6942.92		6942.92	7800.00		7800.00	7952.73		7952.73	8078.76	8078.76

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 maintenance and improvement of standard of agricultural education through (i) accreditation of educational institutions, (ii) providing International/national fellowships both at post and undergraduate levels, (iii) organization of training and capacity building programmes for the scientists/faculty of National Agricultural Research System in cutting-edge areas.
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. The provision is for 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 the global agriculture education standards.
14. 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.
15. **ICAR Headquarter**—provision is primarily for the salaries, pensions and expenses on administrative and logistic support to different schemes under ICAR due to implementation of 7th CPC. The provision in RE 2018–19 goes up dramatically because of revision of pay scales and pension to Scientific personnel of ICAR due to implementation of 7th CPC.
16. **Central Agricultural Universities**—The provision is to strengthen the regional education, research and extension capabilities based on local agro-climatic situation.
17. **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.
18. **Agricultural Scientists Recruitment Board**—The provisions are for the creation of an 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.



(B) INDIAN COUNCIL OF AGRICULTURAL RESEARCH

APPENDIX 1

INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

4(i)	<i>Minister-in-charge of the portfolio of Agriculture in the Union Cabinet-President of the Society.</i>			
1.	Shri Narendra Singh Tomar Minister of Agriculture & Farmers' Welfare, Rural Development and Panchayati Raj, Government of India, Krishi Bhavan, New Delhi-110 001	Ex-officio	10. Sh. Mopidevi Venkata Ramana Rao Minister for Animal Husbandry & Fisheries, Government of Andhra Pradesh, A.P. Secretariat, Valagapudi, Hyderabad, Andhra Pradesh-500 022	Ex-officio
4(ii)	<i>Minister of State in the Union Ministry of Agriculture & Farmers Welfare dealing with ICAR</i>			
2.	Shri Kailash Choudhary Minister of State for Agriculture & Farmers' Welfare, Government of India, Krishi Bhavan, New Delhi-110 001	Ex-officio	11. Shri Tage Taki Minister for Agriculture, Animal Husbandry, Horticulture & Fisheries, Government of Arunachal Pradesh, CM Secretariat, Itanagar, Arunachal Pradesh-791 111	Ex-officio
4(iii)	<i>Union Ministers holding charge of Finance, Planning, Science & Technology, Education and Commerce (in case the Prime Minister is holding any of these portfolios, the Minister of State in the Ministry / Department concerned).</i>			
3.	Smt. Nirmala Sitharaman Minister of Finance and Corporate Affairs, Government of India, North Block, New Delhi-110 001	Ex-officio	12. Shri Atul Bora Minister for Agriculture & Horticulture & Animal Husbandry, Government of Assam, Assam(Civil) Secretariat, Dispur, Guwahati -781006, Assam	Ex-officio
4.	Shri Rao Inderjit Singh Minister of State for Planning Government of India, Room No. 132, NITI Aayog, New Delhi-110 001	Ex-officio	13. Shri Parimal Suklabhaiya Minister of Fisheries, Government of Assam, Assam(Civil) Secretariat, Dispur, Guwahati -781006, Assam	Ex-officio
5.	Dr Harsh Vardhan Minister of Science & Technology and Earth Science, Health and Family Welfare, Government of India, CSIR Building, 2 Rafi Marg, New Delhi-110 001	Ex-officio	14. Dr Prem Kumar Minister for Agriculture, Animal & Fisheries Resources, Government of Bihar, Vikas Bhawan, New Secretariat, Bailey Road, Patna, Bihar-800 015	Ex-officio
6.	Shri Ramesh Pokhriyal 'Nishank' Minister of Human Resource Development, Government of India, Shastri Bhavan, New Delhi-110 001	Ex-officio	15. Shri Ravindra Choubey Minister of Agriculture, Animal Husbandry & Fisheries, Government of Chhattisgarh, Mahanadi Bhawan, Mantralaya Naya Raipur-492 002, Chhattisgarh	Ex-officio
7.	Shri Piyush Goyal Minister of Commerce & Industry Government of India, Udyog Bhavan, New Delhi-110 001	Ex-officio	16. Shri Gopal Rai Minister for Development Delhi Secretariat, I.P. Estate, New Delhi-110 002	Ex-officio
4(iv)	<i>Other Ministers in the Union Ministry of Agriculture & Farmers Welfare.</i>			
8.	Shri Parshottam Rupala, Minister of State for Agriculture & Farmers' Welfare, Government of India, Krishi Bhavan, New Delhi-110 001	Ex-officio	17. Shri Chandrakant Kavalekar Minister of Agriculture Government of Goa, Secretariat, Panaji, Goa-403 001	Ex-officio
9.	Shri Kurasula Kanna Babu Minister for Agriculture and Cooperation, Government of Andhra Pradesh, A.P. Secretariat, Valagapudi, Hyderabad, Andhra Pradesh-500 022	Ex-officio	18. Shri Pramod Sawant Minister of Animal husbandry Government of Goa, Secretariat, Panaji, Goa-403 001	Ex-officio
ANDHRA PRADESH				
4(v)	<i>Ministers in the States in-charge of Agriculture/ Horticulture/Animal Husbandry/ Fisheries.</i>			
9.	Shri Kurasula Kanna Babu Minister for Agriculture and Cooperation, Government of Andhra Pradesh, A.P. Secretariat, Valagapudi, Hyderabad, Andhra Pradesh-500 022	Ex-officio	19. Shri Filipe Rodrigues Minister of Fisheries Government of Goa, Secretariat, Panaji, Goa-403 001	Ex-officio



GUJARAT			KERALA		
20. Shri Ranchhodhai Chanabhai Faldu Minister for Agriculture & Horticulture, Government of Gujarat, Swarnim Sankul-I, New Sachivalaya, Gandhinagar, Gujarat-382 010	Ex-officio		30. Shri V. S. Sunil Kumar Minister for Agriculture & Horticulture, Government of Kerala, Secretariat Annexe Thiruvananthapuram, Kerala-695 001	Ex-officio	
21. Shri Jayash Radhadia Minister of Animal Husbandry & Fisheries, Government of Gujarat, Swarnim Sankul-I, New Sachivalaya, Gandhinagar, Gujarat-382 010	Ex-officio		31. Shri K. Raju Minister for Animal Husbandry Government of Kerala Secretariat Annexe Thiruvananthapuram, Kerala-695 001	Ex-officio	
HARYANA			MADHYA PRADESH		
22. Shri Jai Prakash Dalal Minister for Agriculture and Farmers Welfare, Animal Husbandry and Dairying and Fisheries Government of Haryana, Haryana Civil Secretariat, Chandigarh, Haryana	Ex-officio		33. Shri Sachin Subhash Yadav Minister of Agriculture Development & Horticulture, Government of Madhya Pradesh, Vallabh Bhavan, Bhopal, Madhya Pradesh-423 006	Ex-officio	
HIMACHAL PRADESH			34. Shri Lakhan Singh Yadav Minister of Animal Husbandry & Fisheries Government of Madhya Pradesh, Vallabh Bhavan, Bhopal, Madhya Pradesh -423 006	Ex-officio	
23. Shri Virender Kanwar Minister for Animal Husbandry & Fisheries, Government of Himachal Pradesh, H.P. Secretariat, Shimla, Himachal Pradesh-171 002	Ex-officio		MAHARASHTRA		
24. Shri Ram Lal Markanda Minister for Agriculture, Government of Himachal Pradesh, H.P. Secretariat, Shimla, Himachal Pradesh-171 002	Ex-officio		35. Shri Vijay alias Balasaheb Bhasaheb Thorat Minister for Animal Husbandry, Dairy and Fisheries, Government of Maharashtra Mantralaya, Mumbai Maharashtra-400 032	Ex-officio	
25. Shri Mahender Singh Thakur Minister for Horticulture, Government of Himachal Pradesh, H.P. Secretariat, Shimla, Himachal Pradesh-171 002	Ex-officio		JAMMU & KASHMIR		
JAMMU & KASHMIR President Rule	Ex-officio		36. Shri Subhash Rajaram Desai Minister for Agriculture and Horticulture Government of Maharashtra Mantralaya, Mumbai Maharashtra-400 032	Ex-officio	
JHARKHAND			MANIPUR		
26. Shri Randhir Kumar Singh Minister of Agriculture, Animal Husbandry & Fisheries, Government of Jharkhand, Project Building HEC, Dhurva, Ranchi, Jharkhand-834 002	Ex-officio		37. Shri V. Hangkhanlian Minister for Agriculture & Animal Husbandry, Government of Manipur, Secretariat, Imphal, Manipur-795 001	Ex-officio	
KARNATAKA			38. Shri Thounaojam Shyamkumar Minister for Horticulture Government of Manipur, Secretariat, Imphal, Manipur-795 001	Ex-officio	
27. Sh. Laxman Savadi Deputy Chief Minister and Minister of Agriculture & Horticulture, Government of Karnataka, Vidhan Soudha, Bengaluru Karnataka-560 001	Ex-officio		39. Shri N. Kayisii Minister for Fisheries Government of Manipur, Secretariat, Imphal, Manipur-795 001	Ex-officio	
28. Shri Prabhu Chauhan Minister of Animal Husbandry Government of Karnataka, Vikasa Soudha, Vidhan Soudha, Bengaluru, Karnataka-560 001	Ex-officio		MEGHALAYA		
29. Shri Kota Srinivas Poojary Minister of Fisheries, Government of Karnataka, Vikasa Soudha, Vidhan Soudha, Bengaluru, Karnataka-560 001	Ex-officio		40. Sh. Banteidor Lyngdoh Ministry of Agriculture & Horticulture Government of Meghalaya, Meghalaya Secretariat (C), Shillong, Meghalaya-793 001	Ex-officio	
			41. Shri Prestone Tynsong Minister for Animal Husbandry Government of Meghalaya, Meghalaya Secretariat (C), Shillong, Meghalaya-793 001	Ex-officio	



42. Sh. Comingone Ymbon Minister for Fisheries Government of Meghalaya, Meghalaya Secretariat (C), Shillong, Meghalaya-793 001	Ex-officio	54. Shri Malladi Krishna Rao Minister for Fisheries Government of Puducherry, Puducherry-605 001	Ex-officio
MIZORAM		RAJASTHAN	
43. Shri Pu Zoramthanga Chief Minister & holding the charge of Ministry for Horticulture, Government of Mizoram, Aizawl, Mizoram-796 001	Ex-officio	55. Shri Lal Chand Kataria Minister for Agriculture, Animal Husbandry & Fisheries, Government of Rajasthan, Rajasthan Secretariat, Mantralaya Bhawan, Jaipur, Rajasthan - 302 005.	Ex-officio
44. Shri K. Beichhua Minister of State for Animal Husbandry, Government of Mizoram, Aizawl, Mizoram-796 001	Ex-officio	SIKKIM	
45. Shri Pu C Lalrinsanga Minister for Agriculture, Government of Mizoram, Aizawl, Mizoram-796 001		56. Shri Lok Nath Sharma Minister for Agriculture Development & Horticulture, Animal Husbandry, Fisheries, Government of Sikkim, New Secretariat, Development Area, Gangtok, Sikkim-737 101	Ex-officio
46. Pu K.Lalrinliana Minister of State for Fisheries, Government of Mizoram, Aizawl, Mizoram-796 001	Ex-officio	TAMIL NADU	
NAGALAND		57. Shri Thiru R. Doraikannu Minister for Agriculture & Horticulture Government of Tamil Nadu, Chennai, Tamil Nadu-600 009	Ex-officio
47. Sh. 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	58. Shri Thiru D. Jayakumar Minister for Fisheries, Government of Tamil Nadu, Chennai, Tamil Nadu-600 009	Ex-officio
48. Shri G. Kaito Aye Minister of Agriculture, Government of Nagaland, Civil Secretariat Complex Kohima, Nagaland-797 004	Ex-officio	59. Shri Udamalai Radhakrishnan Minister for Animal Husbandry, Government of Tamil Nadu, Chennai, Tamil Nadu-600 009	Ex-officio
ODISHA		TELANGANA	
49. Shri Arun Kumar Sahoo Minister for Agriculture, Fisheries & Animal Resource Development, Government of Odisha, Odisha Secretariat, Bhubaneswar, Odisha-751 001	Ex-officio	60. Shri Singireddy Niranjan Reddy Minister of Agriculture Room No.261,D-Block Government of Telangana, Telangana Secretariat Hyderabad - 500 022, Telangana	Ex-officio
PUNJAB		61. Shri Talasani Srinivas Yadav Minister of Animal husbandry & Fisheries, Room No.261,D-Block, Government of Telangana, Telangana Secretariat Hyderabad - 500 022, Telangana	Ex-officio
50. Captain Amarinder Singh Chief Minister holding the Charge of Ministry of Agriculture & Horticulture, Government of Punjab, Punjab Civil Secretariat, Chandigarh, Punjab	Ex-officio	TRIPURA	
51. Sh. Tript Rajinder Singh Bajwa Ministry for Animal husbandry & Fisheries, Government of Punjab, Punjab Civil Secretariat, Chandigarh, Punjab	Ex-officio	62. Shri Pranajit Singha Roy Minister for Agriculture & Horticulture, Government of Tripura, Civil Secretariat, Agartala, Tripura-799 001	Ex-officio
PUDUCHERRY		63. Shri Narendra Chandra Debbarma Minister for Fisheries Government of Tripura, Civil Secretariat, Agartala, Tripura-799 001	Ex-officio
52. Shri. R. Kamalakkannan Minister for Agriculture Minister Government of Puducherry, Puducherry-605 001	Ex-officio	64. Smt. Santana Chakma Minister for Animal Resource Development, Government of Tripura, Civil Secretariat, Agartala, Tripura-799 001	Ex-officio
53. Shri A. Namassivayam Minister for Animal Husbandry Government of Puducherry, Puducherry-605 001	Ex-officio		



UTTARAKHAND		
65. Shri Subodh Uniyal Minister for Agriculture & Horticulture Government of Uttarakhand, Uttarakhand Vidhan Sabha Bhawan, Dehradun, Uttarakhand	Ex-officio	4(vii) <i>Six Members of Parliament-four elected by Lok Sabha and two elected by Rajya Sabha.</i> 75. VACANT
66. Smt. Rekha Arya Minister for Animal Husbandry & Fisheries, Government of Uttarakhand, Uttarakhand Vidhan Sabha Bhawan, Dehradun, Uttarakhand	Ex-officio	76. VACANT 77. VACANT 78. VACANT 79. VACANT 80. VACANT
UTTAR PRADESH		
67. Shri Surya Pratap Shahi Minister of Agriculture Government of Uttar Pradesh, UP Civil Secretariat, Lucknow, Uttar Pradesh	Ex-officio	4(viii) <i>Director-General, Indian Council of Agricultural Research.</i> 81. Dr T. Mohapatra Secretary, DARE & DG, ICAR, Krishi Bhavan, New Delhi-110 001
68. Shri Laxmi Narayan Chaudhary Minister of Animal Husbandry & Fisheries Government of Uttar Pradesh, UP Civil Secretariat, Lucknow, Uttar Pradesh		82. Ex-officio 83. Ex-officio 4(ix) All Secretaries in the Ministry of Agriculture & Farmers Welfare. 82. Shri Sanjay Agarwal Secretary, Deptt. of Agriculture, Cooperation & Farmers Welfare Ministry of Agriculture & Farmers Welfare, Krishi Bhavan, New Delhi-110 001
69. Shriram Chauhan Minister of State for Horticulture (Independent Charge) Government of Uttar Pradesh, UP Civil Secretariat, Lucknow, Uttar Pradesh	Ex-officio	4(x) CEO, NITI Ayog 83. Shri Amitabh Kant CEO, Niti Ayog, Yojana Bhavan, Sansad Marg, New Delhi-110 001
WEST BENGAL		
70. Dr Ashish Banerjee Minister for Agriculture, Government of West Bengal, "NABANNA", HRBC Building, 3rd Floor, 325, Sarat Chatterjee Road, Howrah-711 102 Kolkata, West Bengal	Ex-officio	4(xi) Secretary, Department of Bio-Technology. 84. Ex-officio 84. Dr Renu Swarup Secretary, Department of Biotechnology, Block 2, 7th Floor, CGO Complex, Lodhi Road, New Delhi-110 003
71. Sri Swapna Debnath Minister of State for Animal Resources Development (Independent Charge), Government of West Bengal, Prani Sampad Bhavan, LB-2, Sector-III, Salt Lake, Kolkata-700 091, West Bengal	Ex-officio	4(xii) <i>Director-General, Council of Scientific and Industrial Research</i> 85. Ex-officio 85. Dr Shekhar C. Mande Director General, Council of Scientific and Industrial Research, Anusandhan Bhavan, 2-Rafi Ahmed Kidwai Marg, New Delhi-110 001
72. Sri Chandranath Sinha Minister for Fisheries Department, Government of West Bengal, Benfish Tower, 8th Floor, GN Block, Salt Lake, Sector-V, Kolkata-700 091, West Bengal	Ex-officio	4(xiii) <i>Chairman, University Grants Commission.</i> 86. Ex-officio 86. Dr D. P. Singh Chairman, University Grants Commission Bahadur Shah Zafar Marg, New Delhi-110 002
73. Sri Janab Abdur Rezzak Mollah Minister for Horticulture Government of West Bengal, Mayukh Bhavan, 2nd Floor, Sector-I, Salt Lake, Kolkata-700 091, West Bengal	Ex-officio	4(xiv) <i>Chairman, Atomic Energy Commission (or Director, Bhabha Atomic Research Centre, if nominated by the Chairman, Atomic Energy Commission)</i> 87. Ex-officio 87. Sh. Kamlesh Nilkanth Vyas Chairman, Atomic Energy Commission Department of Atomic Energy, Anushakti Bhavan, Chhatrapati Shivaji Maharaj Marg, Mumbai-400 001
4(vi) <i>Member, NITI Ayog, In-charge of Agriculture.</i> 74. Dr Ramesh Chand Member (Agriculture) NITI Ayog, Niti Bhawan, New Delhi-110 001	Ex-officio	4(xv) <i>Member, Finance (Secretary/ Additional Secretary) in the Ministry of Finance, Government of India.</i> 88. Ex-officio 88. Additional Secretary (Expenditure) Department of Expenditure, Ministry of Finance, North Block New Delhi-110 001



89.	<i>Alternative member for Ministry of Finance - AS & FA (DARE/ICAR)</i> Shri B. Pradhan AS & FA (DARE/ICAR), Krishi Bhawan, New Delhi-110 001	Ex-officio	102. Dr T. V. R. S. Sharma (Emeritus Scientist) Former Head, Field Crops, ICAR-Central Agricultural Research Institute, Garacharma-744 101, Port Blair, Andman-Nicobar Island, India	07.02.2021
4(xvi)	<i>Five Vice-Chancellors of Agricultural Universities, nominated by the President.</i>			
90.	Dr Ramesh Chandra Srivastava Vice Chancellor, Dr Rajendra Prasad Central Agricultural University, Pusa, Samastipur-848 125, Bihar	13.11.2020	103. Dr P.S. Rathore Former Vice Chancellor, SKN Agricultural University, Jobner (Jaipur), Rajasthan	07.02.2021
91.	VACANT		104. Dr Prakash Shastri Professor (Plant Pathology), College of Agriculture (RVSKV), Khandwa-450 001 (MP)	07.02.2021
92.	VACANT		105. Pro. Arun Kumar Das Agricultural university Bhubaneswar, Odisha Residence-159/3907, Bhakt Madhunagar, Gundamunda, Khandagiri, Bhubaneswar, Odisha-751 030	07.02.2021
93.	VACANT		106. Dr M. Premjeet Singh Vice Chancellor, Central Agricultural University, Imphal, Manipur	07.02.2021
94.	VACANT		107. Dr Jitendra kumar Chauhan Professor & Chairman, School of Social Science, College of Post Graduate Studies, Barapani (Umiam), Shilong-Meghalaya-793 103	07.02.2021
4(xvii)	<i>Five Technical Representatives, namely Agricultural commissioner, Horticultural Commissioner, animal Husbandry Commissioner, fisheries Development commissioner, and Inspector-General of forests, Government of India</i>		108. Dr K. P. Viswanatha Vice Chancellor, Mahatma Phule Agricultural University, Rahuri, Maharashtra	07.02.2021
95.	Dr S.K. Malhotra Agriculture Commissioner, Dept. of Agriculture & Cooperation, Ministry of Agriculture & Farmers Welfare, Krishi Bhavan, New Delhi-110 001	Ex-officio	109. Dr C. J. Dangria Vice Chancellor, Navsari Agricultural University, Navsari-396 450, Gujarat	07.02.2021
96.	Dr B. N. S. Murthy Horticulture Commissioner, Dept. of Agriculture & Cooperation, Ministry of Agriculture & Farmers Welfare, Krishi Bhavan, New Delhi-110 001	Ex-officio	110. Dr P. M. Salimath Former Vice Chancellor (UAS, Raichur), 405, Raya Residency, Savmati Nagar, Dharwad-580 001, Karnataka	07.02.2021
97.	Dr Praveen Malik Animal Husbandry Commissioner, Dept. of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture & Farmers Welfare, Krishi Bhavan, New Delhi-110 001	Ex-officio	111. Dr K. P. Singh Vice Chancellor, Chaudhary Charan Singh Agricultural University, Hisar-125 004, Haryana	07.02.2021
98.	Dr P. Paul Pandian Fisheries Development Commissioner Dept. of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture & Farmers Welfare, Krishi Bhavan, New Delhi-110 001	Ex-officio	112. Dr M. S. Nataraju Director of Extension, University of Agricultural Science, GKV, Hebbal, Bengaluru-560 065, Karnataka	07.02.2021
99.	Dr Pankaj Asthana Inspector General of Forests (NAEB) Ministry of Environment & Forests, Paryavaran Bhawan, B-Block CGO Complex, Lodi Road, New Delhi-110 003	Ex-officio	113. Dr Bharat S. Sontakki Head, Extension Systems Management Division, ICAR-National Academy of Agricultural Research Management (ICAR-NAARM), Rajendranagar, Hyderabad-500 030 201, Soumya Homes, RKN Colony, Behind Eeshwar Theatre, RKN Colony, Hyderabad (Attapur)-500 048	07.02.2021
4(xviii)	<i>Fifteen scientists from within and outside the Council including one representative from the Indian Council of Medical Research</i>			
100.	Dr N.C. Gautam Vice-Chancellor, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidhyalaya Chitrakoot, Satna-485 334, MP	07.02.2021		
101.	Dr Kamala Kanta Saharia Professor (Extension Education.) Department of Extension Education, College of Veterinary Science, AAU, Khanpara, Guwahati, Assam-781 022	07.02.2021		



<i>Representative from the Indian Council of Medical Research</i>		
114. Dr Raman R. Gangakhedkar Scientist-G & Head, Division of Epidemiology(ECD), ICMR Hqrs., Ansari Nagar, New Delhi-110 029.	30.09.2022	4(xx) <i>Four Directors of the Indian Council of Agricultural Research Institutes, nominated by the President.</i>
115. Sh. Rajendra Prasad Gupta Harsidhi, East Champaran, Bihar-845 422	07.03.2022	129. VACANT
116. Sh. Anil Rao 967, Sector - 14, Gurgaon, Haryana	07.03.2022	130. VACANT
117. VACANT		131. VACANT
4(xix) <i>Three representatives of commerce and industry, nominated by the President.</i>		132. VACANT
118.		4(xxii) <i>Four representatives of State Governments to be nominated zone-wise on a rotational basis by Director General, ICAR</i>
119.		133. Shri Amitabh Avasthi Principal Secretary, (Horticulture) Room No. A-331, Government of Himachal Pradesh, H.P. Secretariat, Shimla-171 002
120.		134. Shri Alan Gonmei Secretary, Veterinary & Animal Husbandry Thizama Road, New Secretariat Nagaland, Kohima-797 001
121.		135. Shri K.S. Pannu Secretary, Agriculture 5th Floor, Mini Secretariat Punjab, Sector 9, Chandigarh-160 001
122.		136. Shri Vijay Kumar Addl. Chief Secretary, Agriculture and Marketing Department (Additional Charge) Government of Maharashtra, Agriculture Dept., Room no. 509, 5th floor, Annex Bldg., Mantralaya, Mumbai-400 032
123.		4(xxiii) <i>One representative of Agro and Agro-Processing Industries nominated by President</i>
124.		137. Mr. Kanwal Singh Chauhan Shimla Farm, Village - Aterna district Sonipat (Haryana)
4 <i>Representatives of Rural Interests</i>		05.02.2022
125. Shri Sudhir Kumar Bhargava Director, Agroman Systems Pvt. Ltd. 25/2, Tardeo AC Market, Tardeo, Mumbai, Maharashtra-400 034	8 June, 2020	4(xxiv) <i>One representative from a distinguished Non-Governmental Organization dealing with Agriculture/ Extension nominated by President</i>
126. Shri Pushp Jain Ex-Member of Parliament, 53/54, Maa Kripa Housing Society, Circuit House Road, Pali (Rajasthan)	11 April, 2021	138.
127. Shri Suresh Chandel Ex-Member of Parliament, Village-Gandhi Ropa, Post-Beri Ropa, Distt. & Tehsil-Bilaspur-174 001, Himachal Pradesh	11 April, 2021	4(xxv) <i>Secretary, Indian Council of Agricultural Research- Member Secretary</i>
Shri Suresh Chandel Ex-member of Parliament, House No. 70/5, Roura, Sector-3, Bilaspur-174 001, Himachal Pradesh		139. Shri Sushil Kumar Addl. Secy., DARE & Secy., ICAR, Krishi Bhavan, New Delhi-110 001
128. Shri Akhilesh Kumar Shyama Bhavan, Mathiya Zirat, Motihari, East Champaran, Bihar	11 April, 2021	Ex-Officio



APPENDIX 2

**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

Ex-Officio

9. Vacant
10. Vacant
11. Vacant
12. Vacant

Rule 35(ii)**Member, Finance, Alternate member-Financial Adviser
(DARE/ICAR)**

2. Additional Secretary (Expenditure)
Department of Expenditure,
Ministry of Finance, North Block
New Delhi-110 001

*Ex-Officio***Rule 35(iii)****Secretary, Niti Ayog**

3. Shri Amitabh Kant,
CEO, Niti Ayog,
Yojana Bhavan, Sansad Marg,
New Delhi - 110 001

*Ex-Officio***Rule 35(viii)****Three Members of Parliament nominated by the President-
(Two from Lok Sabha and one from Rajya Sabha)**

13. Vacant (MP from Lok Sabha)
14. Vacant (MP from Lok Sabha)
15. Vacant (one MP from Rajya Sabha)

Rule 35(ix)**Four Farmers/Representatives of Rural Areas nominated by
the President**

16. Shri Sudhir Kumar Bhargava, 08.6.2020
Director, Agroman Systems Pvt. Ltd.

25/2, Tardeo AC Market,
Tardeo, Mumbai
Maharashtra-400 034

17. Shri Pusp Jain 11.04.2021
Ex-MP, Pali (Rajasthan)

53/54, Maa Kripa Housing Society,
Circuite House Road, Pali (Rajasthan)

18. Shri Suresh Chandel, 11.04.2021
Ex-Member of Parliament,
Village-Gandhi Ropa,
P.O. Beri,
Tehsil & District, Bilaspur, Himachal Pradesh

Preferred Contact Address:
Shri Suresh Chandel,
Ex- Member of Parliament,
House No. 70/5, Roura Sector-3,
Bilaspur, Himachal Pradesh

19. Shri Akhilesh Kumar 11.04.2021
Shyama Bhavan, Mathiya Zirat, Motihari,
East Champaran,
Bihar-845 401

Rule 35(x)**Three Directors of Research Institutes of the Council
nominated by the President**

20. Vacant
21. Vacant
22. Vacant

Rule 35(xi)**Four representatives of State Governments to be nominated
zone-wise on a rotational basis by Director General, ICAR**

23. Shri Amitabh Avasthi 15.6.2020

Principal Secretary(Horticulture)
Room No. A-331,
Government of Himachal Pradesh
H.P. Secretariat, Shimla-171 002

Rule 35 (vii)**Five Vice-Chancellors of Agricultural Universities-nominated
by the President**

8. Dr Ramesh Chandra Srivastava 13.11.2020
Vice Chancellor,
Dr Rajendra Prasad Central Agricultural University,
Pusa, Samastipur, Bihar-848 125



24. Shri Alan Gonmei, Secretary, Veterinary & Animal Husbandry Thizama Road, New Secretariat Nagaland, Kohima-797 001	15.6.2020	Rule 35(xii) One representative of Agro and Agro-Processing Industries to be nominated by President 27. Shri Kanwal Singh Chauhan, R/o Shimla Farm, Village-Aterna, District Sonipat, Haryana-131 023	05.02.2022
25. Shri K.S. Pannu, Secretary Agriculture Punjab, Mini Secretariat, 5th Floor Mini Secretariat Punjab, Sector 9, Chandigarh-160 001	15.6.2020	Rule 35(xiii) One representative from a distinguished Non-Governmental Organization dealing with Agriculture/Extension nominated by President 28. Vacant	
26. Shri Vijay Kumar Addl., Chief Secretary, Agriculture and Marketing Department, Additional Charge Government of Maharashtra, Agriculture Dept., Room No. 509, 5th floor, Annex Bldg., Mantralaya, Mumbai-400 032	15.6.2020	Rule 35(xiv) Secretary, ICAR-Member Secretary 29. Shri Sushil Kumar Additional Secretary, DARE & Secretary, ICAR, Krishi Bhawan, New Delhi-110 001	



APPENDIX 3**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 Sushil Kumar

Secretary, ICAR and Additional Secretary to Government of India,
Department of Agricultural Research and Education

Deputy Directors General

1. Dr K. Alagusundaram (Agricultural Engineering)
2. Dr A.K. Singh (Agricultural Extension)
3. Dr R.C. Agarwal (Agricultural Education)
4. Dr Joykrushna Jena (Fisheries Science)
5. Dr Anand Kumar Singh (Horticultural Science)
6. Dr K. Alagusundaram (Acting) (NRM)
7. Dr Joykrushna Jena (Acting) (Animal Sciences)
8. Dr Anand Kumar Singh (Acting) (Crop Sciences)

Assistant Directors General**Crop Science**

1. Dr Rajan (PP&B) (Acting)
2. Dr Dinesh Kumar (F&FC) (Acting)
3. Dr R.K. Singh (CC)
4. Dr S K Jha (OP) (Acting)
5. Dr D.K. Yadava (Seed) (Acting)

Horticultural Science

1. Dr T. Janakiram (Hort.Sci.-I)
2. Dr W.S. Dhillon (Hort.Sci.-II)

Natural Resource Management

1. Dr S.K. Chaudhari (S&WM)
2. Dr S. Bhaskar (AAF&CC)

Agricultural Engineering

1. Dr Kanchan Kumar Singh (FE) (Acting)
2. Dr S.N. Jha (PE)

Animal Sciences

1. Dr R.S. Gandhi (AP&B) (Acting)
2. Dr Ashok Kumar (AN&P) (Acting)
3. Dr Ashok Kumar (AH)

Fisheries Science

1. Dr P. Pravin (MF)
2. Dr P. Pravin (IF) (Acting)

Agricultural Extension

1. Dr V.P. Chahal
2. Dr Randhir Singh

Agricultural Education

1. Dr G. Venkateshwarlu (EQA&R)
2. Dr M.K. Agnihotri, ADG (HRD) (Acting)
3. Dr P.S. Pandey (EP&HS)

Others

1. Dr J P Mishra (PIM) (Acting)
2. Dr Shiv Prasad Kimothi (Cdn.)
3. Dr A.K. Vyas (HRM)
4. Dr Sanjeev Saxena (IPTM&PME)
5. Dr A Arunachalam (IR) (Acting)

National Agricultural Science Fund (NASF)

1. Dr Sanjeev Saxena, ADG (Acting)

Principal Scientists**Crop Science**

1. Dr Rajan
2. Dr S.K. Jha
3. Dr Dinesh Kumar
4. Dr Y.P. Singh
5. Dr P.R. Chaudhary

Horticultural Science

1. Dr B.K. Pandey
2. Dr Manish Das
3. Dr Vikramaditya Pandey

Natural Resource Management

1. Dr R.K. Tomar
2. Dr Adlul Islam

Agricultural Education

1. Dr M.K. Agnihotri
2. Dr (Mrs.) Vanita Jain
3. Dr (Mrs.) Nidhi Verma
4. Dr K.P. Tripathi
5. Dr Neeraj 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

Animal Sciences

1. Dr Rajan Gupta
2. Dr Vineet Bhasin
3. Dr (Mrs.) Jyoti Misri

Agri. Extension

1. Dr P. Adhiguru
2. Dr Keshava
3. Dr Naresh Girdhar

Others

1. Dr A. Arunachalam
2. Dr S.K. Malik
3. Dr N.K. Jain (HRM)
4. Dr M. K. Tripathi (PIM)
5. Dr P.K. Katiba (PIM)
6. Dr A.S. Mishra (Tech. Cdn.)
7. Dr Sanjeev Panwar (Tech. Cdn.)
8. Dr Shiv Datt (IPTM)
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 J.P. Mishra

National Agricultural Higher Education Project (NAHEP)

1. Dr P. Ramasundaram, PS & NC
2. Dr R.B. Sharma, PS & NC
3. Dr P.K. Ghosh, PS & NC
4. Dr Prabhat Kumar, PS & NC



Agricultural Scientists' Recruitment Board

1. Prof. (Dr.) A.K. Misra, Chairman
2. Prof. (Dr.) A.K. Srivastava
3. Dr P.K. Chakraborty
4. Dr K.K. Singh

Directorate of Knowledge Management in Agriculture

1. Dr S.K. Singh, Project Director (Acting)

2. Sh Jitendra Kumar Meena, Under Secretary
3. Dr Himanshu, Scientist SS, AKMU
4. Dr V.K. Bharti, Chief Production Officer
5. Dr Aruna T Kumar, Incharge, English Editorial Unit
6. Sh Ashok Singh, Incharge, Hindi Editorial Unit
7. Sh V.S. Kaushik, Incharge, ARIC
8. Sh S.K. Joshi, Business Manager & I/c CeRA
9. Sh Anil Sharma, CP & PRO



APPENDIX 4
ICAR INSTITUTES AND THEIR DIRECTORS

National Institutes

1. Dr A.K. Singh (Acting)
Indian Agricultural Research Institute,
New Delhi 110 012
2. Dr Raj Kumar Singh
Indian Veterinary Research Institute,
Izatnagar 243 122, Uttar Pradesh
3. Dr R.R.B. Singh (Acting)
National Dairy Research Institute,
Karnal 132 001, Haryana
4. Dr Gopal Krishna
Central Institute of Fisheries Education,
Jaiprakash Road, Seven Bungalow (Versova)
Mumbai 400 061, Maharashtra
5. Dr Ch. Srinivasa Rao
National Academy of Agricultural Research Management,
Rajendranagar, Hyderabad 500 030,
Telangana
6. Dr Jagdish Rane
National Institute of Abiotic Stress Management,
Malegaon, Baramati, Pune 413 115, Maharashtra
7. Dr T.R. Sharma (Acting)
Indian Institute of Agricultural Biotechnology,
Ranchi, Jharkhand
8. Dr Jagdish Kumar (Acting)
National Institute of Biotic Stress Management,
Raipur, Chhattisgarh
9. Dr D. Maity, OSD, IARI, Jharkhand

Agricultural Sciences

10. Dr B. Gangaiah (Acting)
Central Island Agricultural Research Institute,
Post Box No. 181, Port Blair 744 101
Andaman & Nicobar Islands
11. Dr O.P. Yadav
Central Arid Zone Research Institute,
Jodhpur 342 003, Rajasthan
12. Dr P.S. Tiwari (Acting)
Central Institute of Agricultural Engineering,
Nabi Bagh, Berasia Road,
Bhopal 462 038, Madhya Pradesh
13. Dr P.L. Saroj
Central Institute of Arid Horticulture,
Bikaner 334 006, Rajasthan
14. Dr V.N. Waghmare (Acting)
Central Institute for Cotton Research
Post Bag No. 2, Shankar Nagar P.O.
Nagpur 440 010, Maharashtra
15. Dr Shailendra Rajan
Central Institute for Sub-tropical Horticulture,
Rehmankhera, PO Kakori,
Lucknow 227 107, Uttar Pradesh
16. Dr Desh Beer Singh
Central Institute of Temperate Horticulture
Old Air Field, Rangreth 190 007 Jammu & Kashmir
17. Dr R.K. Singh (Acting)
Central Institute of Post Harvest Engg. and Technology,
P.O. PAU Campus, Ludhiana 141 004, Punjab
18. Dr P.K.G. Patil
Central Institute for Research on Cotton Technology,
Adenwala Road, Matunga,
Mumbai 400 019, Maharashtra
19. Dr Anita Karun (Acting)
Central Plantation Crops Research Institute,
Kasaragod 671 124, Kerala
20. Dr S.K. Chakrabarty
Central Potato Research Institute
Shimla 171 001, Himachal Pradesh

21. Dr G. Ravindrachari (Acting)
Central Research Institute for Dryland Agriculture,
Santoshnagar, Saidabad P.O., Hyderabad 500 059,
Andhra Pradesh
22. Dr Nimai Chandra Pan (Acting)
National Institute of Natural Fibre Engineering &
Technology,
12, Regent Park, Kolkata 700 040, West Bengal
23. Dr Himanshu Pathak
National Rice Research Institute,
Cuttack 753 006, Orissa
24. Dr Parbodh Chander
Central Soil Salinity Research Institute,
Zarifa Farm, Kachhwa Road, Karnal 132 001, Haryana
25. Dr P.R. Ojasvi (Acting)
Indian Institute of Soil & Water Conservation,
218, Kaulagarh Road, Dehradun 248 195, Uttarakhand
26. Dr D. Damodar Reddy
Central Tobacco Research Institute,
Rajahmundry 533 105, Andhra Pradesh
27. Dr V. Ravi (Acting)
Central Tuber Crops Research Institute,
Sreekariyam, Thiruvananthapuram 695 017, Kerala
28. Dr E.B. Chakurkar (Acting)
Central Coastal Agricultural Research Institute, Ela,
Old Goa, North Goa 403 402, Goa
29. Dr B.P. Bhatt
ICAR Research Complex for Eastern Region,
ICAR Parisar, P.O. Bihar Veterinary College, Patna 800 014,
Bihar
30. Dr Basant Kumar Kandpal (Acting)
ICAR Research Complex for NEH Region,
Umroi Road, Umiam, Ri-Bhoi, Meghalaya 793 103
31. Dr Tauqueer Ahmad (Acting)
Indian Agricultural Statistics Research Institute,
Library Avenue, Pusa Campus, New Delhi 110 012
32. Dr Vijay Kumar Yadav (Acting)
Indian Grassland & Fodder Research Institute, Pahuj Dam,
Gwalior Road, Jhansi 284 003, Uttar Pradesh
33. Dr M.R. Dinesh
Indian Institute of Horticulture Research
Hessaraghatta Lake Post, Bengaluru 560 089,
Karnataka
34. Dr Narendra Pratap Singh
Indian Institute of Pulses Research,
Kanpur 208 024, Uttar Pradesh
35. Dr Ashok Kumar Patra
Indian Institute of Soil Sciences, Nabi Bagh,
Berasia Road, Bhopal 462 038, Madhya Pradesh
36. Dr K. Nirmal Babul Indian
Institute of Spices Research, Marikunnu P.O.,
Calicut 673 012, Kerala
37. Dr A.D. Pathak
Indian Institute of Sugarcane Research,
Rai Bareilly Road, P.O. Dilkusha, Lucknow 226 002,
Uttar Pradesh
38. Dr K.K. Sharma
Indian Institute of Natural Resins and Gums, Namkum,
Ranchi 834 010, Jharkhand
39. Dr Jagdish Singh
Indian Institute of Vegetable Research,
PB No. 01, PO Jakhini, Shahanshapur
Varanasi 221 005, Uttar Pradesh
40. Dr Bakshi Ram
Sugarcane Breeding Institute,
Coimbatore 641 007, Tamil Nadu



41. Dr A. Pattanayak
Vivekanand Parvatiya Krishi Anusandhan Sansthan,
Almora 263 601, Uttarakhand
42. Dr Jiban Mitra (Acting)
Central Research Institute for Jute & Allied Fibres,
Barrackpore, Kolkata-700120,
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 141004, Punjab
45. Dr Ravi Kumar Mathur
Indian Institute of Oil Palm Research,
Pedavegi 534 450, West Godavari, Andhra Pradesh
46. Dr A.V. Reddy
Indian Institute of Oilseeds Research,
Rajendranagar, Hyderabad 500 030, Telangana
47. Dr S.R. Voleti (Acting)
Indian Institute of Rice Research,
Rajendranagar, Hyderabad 500 030, Telangana
48. Dr G.P. Singh
Indian Institute for Wheat & Barley Research
P. Box No. 158, Agrasain Marg,
Karnal 132 001, Haryana
49. Dr S.K. Ambast
Indian Institute of Water Management,
Opposite Rail Vihar, Chandersekharpur
Bhubaneshwar 751 023, Odisha
50. Dr S.K. Srivastava (Acting)
Central Institute for Women in Agriculture,
Plot No.50, Mauza-Jokalandi,
P.O. Baramunda, Bhubaneswar-751 003, Odisha
51. Dr Anil Kumar (Acting)
Central Agro-Forestry Research Institute,
Near Pahuj Dam, Jhansi 284 003, Uttar Pradesh
52. Dr M.S. Ladaniya
Central Citrus Research Institute, P.B. No. 464,
Shankar Nagar P.O., Amravati Road,
Nagpur 440 010, Maharashtra
53. Dr Suresh Pal
National Institute of Agricultural Economics
and Policy Research,
P.B. No. 11305, DPS Marg, Pusa,
New Delhi 110 012.
54. Dr Dinesh Kumar Agarwal (Acting)
Indian Institute of Seed Science P.B. No. 11,
Kusmaur, P.O. Kaithauli,
Mau Nath Bhanjan 275 101, Uttar Pradesh
55. Dr Vilas A. Tonapi
Indian Institute of Millets Research,
Rajendranagar, Hyderabad 500 030, Telangana
56. Dr V.S. Bhatia
Indian Institute of Soybean Research,
Khandwa Road, Indore 452 017, Madhya Pradesh
57. Dr N.K. Singh (Acting),
ICAR-NIPB (earlier NRCPB), LBS Centre,
Pusa Campus, New Delhi 110 012
58. Dr Hans Raj Sardana (Acting)
National Research Centre for Integrated Pest Management,
LBS Building, New Delhi 110 012
59. Dr B.P. Bhatt, OSD
Mahatma Gandhi Integrated Farming Research Institute,
Piprakothi, Motihari,
East Champaran, Bihar
- Animal Sciences and Fisheries**
60. Dr V.K. Saxena (Acting)
Central Avian Research Institute,
Izatnagar, Bareilly 243 122, Uttar Pradesh
61. Dr S.S. Dahiya (Acting)
Central Institute for Research on Buffaloes,
Sirsa Road, Hisar 125 001, Haryana
62. Dr Manmohan Singh Chauhan
Central Institute of Research on Goats,
Makhdoom, Mathura 281 122, Uttar Pradesh
63. Dr Basant Kumar Das
Central Inland Fisheries Research Institute,
Barrackpore 700 120, West Bengal
64. Dr K.K. Vijayan
Central Institute of Brackishwater Aquaculture,
75, Santhome High Road, Raja Annamalai Puram,
Chennai 600 028, Tamil Nadu
65. Dr Ravishankar C.N.
Central Institute of Fisheries Technology,
Willingdon Island, Matsyapuri P.O.,
Cochin 682 029, Kerala
66. Dr (Mrs) B.R. Pillai (Acting)
Central Institute of Freshwater Aquaculture,
Kausalyaganga, Bhubaneshwar,
Khurda 751 002, Odisha
67. Dr A. Gopalakrishnan (Acting)
Central Marine Fisheries Research Institute,
P.B. No. 1603, Ernakulam North P.O.,
Kochi 682 018, Kerala
68. Dr Artabandu Sahoo (Acting)
Central Sheep & Wool Research Institute,
Avikanagar 304 501, Distt. Tonk, Rajasthan
69. Dr Raghevendra Bhatta,
National Institute of Animal Nutrition & Physiology,
Adugodi, Bengaluru 560 030, Karnataka
70. Dr Vijendra Pal Singh,
National Institute of High Security Animal Diseases,
Anand Nagar, Bhopal 462 021
71. Dr N V Patil (Acting)
Central Institute for Research on Cattle, P.B. No. 17,
Grass Farm Road, Meerut Cantt. 250 001, Uttar Pradesh
72. Dr Parimal Roy
National Institute of Veterinary Epidemiology and
Disease Informatics,
H.A. Farm Post, Hebbal, Bengaluru 560 024, Karnataka



APPENDIX 5**NATIONAL BUREAUX AND THEIR DIRECTORS****Agricultural Sciences**

1. Dr (Mrs.) C.R. Ballal
National Bureau of Agricultural Insect Resources,
P.B. No. 2491, H.A. Farm Post,
Bengaluru 560 024, Karnataka
2. Dr Anil Kumar Saxena
National Bureau of Agriculturally Important
Micro-organisms,
P.B. No. 6, Kusmaur,
Maunath Bhanjan 275 101, Uttar Pradesh
3. Dr Kuldeep Singh
National Bureau of Plant Genetic Resources,
Pusa Campus, New Delhi 110 012

4. Dr P. Chandran (Acting)

National Bureau of Soil Survey and Land Use Planning,
Shankar Nagar, P.O. Amravati Road,
Nagpur 440 010, Maharashtra

Animal Sciences

5. Dr R.K. Vij (Acting)
National Bureau of Animal Genetic Resources,
P.B. No. 129, G.T. Road Bye Pass,
Karnal 132 001, Haryana
6. Dr Kuldeep Kumar
Lal National Bureau of Fish Genetic Resources,
Canal Ring Road, P.O. Dilkusha, Lucknow 226 002,
Uttar Pradesh



APPENDIX 6

**PROJECT DIRECTORATES, AGRICULTURAL TECHNOLOGY APPLICATION
RESEARCH INSTITUTES AND THEIR DIRECTORS**

Agricultural Sciences

1. Dr Radhakrishnan T.
Directorate of Groundnut Research, Post Box No. 5,
Ivnagar Road, Junagadh 362 001, Gujarat
2. Dr P.K. Rai (Acting)
Directorate of Rapeseed - Mustard Research,
Sewar, Bharatpur 321 303, Rajasthan
3. Dr P.K. Singh (Acting)
Directorate of Weed Research,
Maharajpur, Adhartal, Jabalpur 482 004, Madhya Pradesh
4. Dr M.G. Nayak (Acting)
Directorate of Cashew Research,
Darbe, P.O. Puttur 574 202,
Dakshina Kannada, Karnataka
5. Dr K. V. Prasad
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
Directorate of Mushroom Research, Chambaghat,
Solan 173 213, Himachal Pradesh
8. Dr Major Singh
Directorate on Onion & Garlic Research,
Rajgurunagar, Pune 410 505, Maharashtra

Animal Sciences

9. Dr R.K. Singh (Acting)
Directorate of Foot and Mouth Disease,
IVRI Campus, Mukteshwar 263138, Uttarakhand
10. Dr R.N. Chatterjee (Acting)
Directorate of Poultry Research,
Rajendranagar, Hyderabad 500 030,
Telangana
11. Dr D. Sharma (Acting)
Directorate of Coldwater Fisheries Research,
Anusandhan Bhawan, Industrial Area,
Bhimtal 263 136, Uttarakhand

Agricultural Technology Application Research Institutes

12. Dr Rajbir Singh
Agricultural Technology Application Research Institute,
Zone-I, PAU Campus, Ludhiana 141 004, Punjab
13. Dr Sati Shankar Singh
Agricultural Technology Application Research Institute,
Zone-II, Bhumi Vihar, Block-GB, Sector-III,
Salt Lake, Kolkata 700 097, West Bengal
14. Dr B.C. Deka
Agricultural Technology Application Research Institute,
Zone-III, TOP, Umroi Road, Barapani 793 103, Meghalaya
15. Dr Atar Singh (Acting)
Agricultural Technology Application Research Institute,
Zone-IV,G.T. Road, Rawatpura, Near Vikas Bhawan,
Kanpur 208 002, Uttar Pradesh
16. Dr Y.G. Prasad
Agricultural Technology Application Research Institute,
Zone-V, CRIDA Complex, Santoshnagar,
Hyderabad 500 059, Telangana
17. Dr S.K. Singh
Agricultural Technology Application Research Institute,
Zone-VI, CAZRI Campus, Jodhpur 342 003, Rajasthan
18. Dr Anupam Mishra
Agricultural Technology Application Research Institute,
Zone-VII, JNKVV Campus, Jabalpur 484 002
Madhya Pradesh
19. Dr M.J. Chandre Gowda (Acting)
Agricultural Technology Application Research Institute,
Zone-VIII,ICAR Transfer of Technology Project,
MRS HA Farm Post, Hebbal, Bengaluru 560 030
Karnataka
20. Dr Anjani Kumar
Agricultural Technology Application Research Institute,
Patna, Bihar
21. Dr Lakan Singh
Agricultural Technology Application Research Institute,
Pune, Maharashtra
22. Dr A.K. Tripathi
Agricultural Technology Application Research Institute,
Guwahati, Assam



APPENDIX 7

NATIONAL RESEARCH CENTRES AND THEIR DIRECTORS

Agricultural Sciences

1. Dr (Mrs) S. Uma
National Research Centre for Banana,
Thogamalai Road, Thayanur Post,
Thiruchirapalli 620 102, Tamil Nadu
2. Dr Indu Sawant (Acting)
National Research Centre for Grapes,
P.B. No. 3, Manjri Farm Post,
Solapur Road, Pune 412 307, Maharashtra
3. Dr Vishal Nath
National Research Centre for Litchi
Mushahari Farm, Mushahari,
Muzaffarpur 842 002, Bihar
4. Dr D.R. Singh
National Research Centre for Orchids,
Pakyong, Gangtok 737 106, Sikkim
5. Dr Jyotsana Sharma (Acting)
National Research Centre on Pomegranate,
NH-9, Byepass Road,
Shelgi Sholapur 413 006, Maharashtra
6. Dr Gopal Lal
National Research Centre on Seed Spices
Tabiji, Ajmer 305 206, Rajasthan

Animal Sciences and Fisheries

7. Dr R.K. Sawal (Acting)
National Research Centre on Camel
Jorbeer, P.B. No. 07, Bikaner 334 001,
Rajasthan
8. Dr B.N. Tripathi
National Research Centre for Equines,
Hisar 125 001, Haryana
9. Dr S. Vaithianathan (Acting)
National Research Centre on Meat,
Chengicherla, P.B. No. 19, Uppal PO,
Hyderabad 500 039, Telangana
10. Dr Abhijit Mitra
National Research Centre for Mithun
Jharnapani, P.O. Medziphema 797 106,
Nagaland
11. Dr S. Rajkhowa (Acting)
National Research Centre on Pig,
Rani, Guwahati 781 131, Assam
12. Dr Prithviraj Chakravarty (Acting)
National Research Centre on Yak,
Dirang, West Kameng 790 101,
Arunachal Pradesh



APPENDIX 8**ALL INDIA CO-ORDINATED RESEARCH PROJECTS AND NETWORK PROGRAMMES**

1. AICRP on Micro Secondary and 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 Research, 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. All India Coordinated Rice Improvement Project, Hyderabad
 18. AICRP on Wheat and Barley, Karnal
 19. AICRP on Maize, Ludhiana
 20. AICRP Sorgum, Hyderabad
 21. AICRP on Pearl Millets, Jodhpur
 22. AICRP on Small Millets, Bengaluru
 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, Junagadh
 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, Tiruvanthapuram
 45. AICRP Palms, Kasargod
 46. AICRP on Cashew, Puttur
 47. AICRP Arid Zone Fruits, Bikaner
 48. AICRP Spices, Calicut
 49. AICRP on Medicinal and Aromatic Plants, Anand
 50. AICRP on Cattle Research, Meerut
 51. AICRP on Goat Improvement, Mathura
 52. AICRP on Nutritional and Physiological Intervention for Enhancing Reproductive Performance in Animal (including outreach methane)—Earlier Feed Sources
 53. AICRP ADMAS, Bengaluru
 54. AICRP Foot and Mouth, 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 (new in EFC)
 4. Network Project on Harvesting, Processing and Value Addition of Natural Resins and Gums, Ranchi
 5. Network Project on Conservation of Lac Insect Genetic Resources, Ranchi
 6. AIC Research Network on Potential Crops, New Delhi
 7. Application of Micro-organisms in Agriculture and Allied Sectors (AMAAS) + Microbial Genomic Resources Repository Network, Mau
 8. Network Project on Transgenics
 9. AINP on Arid Legumes, Kanpur
 10. All India Network Research Project on Tobacco, Rajamundry
 11. AINP on Jute and Allied Fibres, Barrackpore
 12. AINP on Soil Arthropod Pests, Durgapura, Rajasthan
 13. AINP on Agricultural Acarology
 14. AINP on Pesticides Residues, New Delhi
 15. AINP on Vertebrate Pest Management, Jodhpur
 16. Network O & G (included in Directorate)
 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 Animal (NNM), 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 9

AGRICULTURAL UNIVERSITIES

State Agricultural Universities

1. Acharya N.G. Ranga Agricultural University, Lam, Guntur (Andhra Pradesh) 522 034
2. Agriculture University, Jodhpur (Rajasthan) 342 304
3. Agriculture University Kota (Rajasthan) 324 001
4. Anand Agricultural University Anand (Gujarat) 388 110
5. Assam Agricultural University Jorhat (Assam) 785 013
6. Banda University of Agriculture and Technology Banda (Uttar Pradesh) 210 001
7. Bidhan Chandra Krishi Viswavidyalaya Mohanpur (West Bengal) 741 252
8. Bihar Agricultural University, Sabour Bhagalpur (Bihar) 813 210
9. Bihar Animal Sciences University, Patna
10. Birsa Agricultural University Ranchi (Jharkhand) 834 006
11. Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana) 125 004
12. Ch. Sarwan Kumar Krishi Vishvavidyalaya Palampur (Himachal Pradesh) 176 062
13. Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh) 208 002
14. Chhattisgarh Kamdhenu Vishvavidyalaya Durg (Chhattisgarh) 491 001
15. Dr Panjabrao Deshmukh Krishi Vidyapeeth Akola (Maharashtra) 444 104
16. Dr Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli (Maharashtra) 415 712
17. Dr Y.S. Parmar University of Horticulture and Forestry, Nauni-Solan (Himachal Pradesh) 173 230
18. Dr Y.S.R. Horticultural University Venkataramannagudem (Andhra Pradesh) 534 101
19. G.B. Pant University of Agriculture and Technology Pantnagar (Uttarakhand) 263 145
20. Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana (Punjab) 141 004
21. Indira Gandhi Krishi Vishwavidyalaya Raipur (Chhattisgarh) 492 006
22. Jawaharlal Nehru Krishi Viswavidyalaya Jabalpur (Madhya Pradesh) 482 004
23. Junagadh Agricultural University Junagadh (Gujarat) 362 001
24. Kamdhenu University Amreli (Gujarat) 382 010
25. Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar (Karnataka) 585 401
26. Kerala Agricultural University Thrissur (Kerala) 680 656
27. Kerala University of Fisheries and Ocean Studies Panangad (Kerala) 682 506
28. Kerala Veterinary and Animal Sciences University Wayanad (Kerala) 673 576
29. Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar (Haryana) 125 001
30. Maharana Pratap Horticultural University, Karnal (Haryana)
31. Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan) 313 001
32. Maharashtra Animal and Fishery Sciences University, Nagpur (Maharashtra) 440 001
33. Mahatma Phule Krishi Vidyapeeth Rahuri (Maharashtra) 413 722
34. Nanaji Deshmukh Veterinary Science University Jabalpur (Madhya Pradesh) 482 001

35. Narendra Deva University of Agriculture Technology, Faizabad (Uttar Pradesh) 224 229
36. Navsari Agricultural University Navsari (Gujarat) 396 450
37. Orissa University of Agriculture and Technology Bhubaneswar (Odisha) 751 003
38. P.V. Narsimha Rao Telangana Veterinary University Rajendranagar, Hyderabad (Telangana) 500 030
39. Professor Jayashankar Telangana State Agricultural University, Hyderabad (Telangana) 500 030
40. Punjab Agricultural University Ludhiana (Punjab) 141 004
41. Rajasthan University of Veterinary and Animal Sciences, Bikaner (Rajasthan) 334 001
42. Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya Gwalior (Madhya Pradesh) 474 002
43. Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (Uttar Pradesh) 250 110
44. Sardarkrushinagar Dantiwada Agricultural University Sardarkrushinagar (Gujarat) 385 506
45. Sher-e-Kashmir University of Agricultural Science and Technology of Jammu, Jammu (Jammu and Kashmir) 180 009
46. Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar (Jammu and Kashmir) 190 025
47. Sri Karan Narendra Agriculture University Jobner (Rajasthan) 303 329
48. Sri Konda Laxman Telangana State Horticultural University, Rajendra Nagar Campus Hyderabad (Telangana) 500 030
49. Sri Venkateswara Veterinary University Tirupati (Andhra Pradesh) 517 502
50. Swami Keshwanand Rajasthan Agricultural University Bikaner (Rajasthan) 334 006
51. Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu) 641 003
52. Tamil Nadu Veterinary and Animal Sciences University, Chennai (Tamil Nadu) 600 051
53. Tamil Nadu Fisheries University, Nagapattinam (Tamil Nadu) 611 001
54. U.P. Pt. Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwa Vidyalaya Even Go Anusandhan Sansthan, Mathura (Uttar Pradesh) 281 001
55. University of Agricultural and Horticultural Sciences Shimoga (Karnataka) 577 204
56. University of Agricultural Sciences Bengaluru (Karnataka) 560 065
57. University of Agricultural Sciences Dharwad (Karnataka) 580 005
58. University of Agricultural Sciences Raichur (Karnataka) 584 102
59. University of Horticultural Sciences Bagalkot (Karnataka) 587 103
60. Uttar Banga Krishi Viswavidyalaya Coochbehar (West Bengal) 736 165
61. V.C.S.G. Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal (Uttarakhand) 246 123
62. Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani (Maharashtra) 431 402
63. West Bengal University of Animal and Fishery Sciences, Kolkata (West Bengal) 700 037

Deemed Universities

1. ICAR-Indian Agricultural Research Institute New Delhi-110 012
2. ICAR-Indian Veterinary Research Institute Izatnagar, Bareilly (Uttar Pradesh) 243 122



3. ICAR-Central Institute of Fisheries Education, Mumbai (Maharashtra) 400 061
4. ICAR-National Dairy Research Institute, Karnal (Haryana) 132 001

Central Agricultural Universities

1. Central Agricultural University, Imphal (Manipur) 795 004
2. Dr Rajendra Prasad Central Agricultural University, Pusa, Samastipur (Bihar) 848 125
3. Rani Laxami Bai Central Agricultural University, Jhansi (Uttar Pradesh) 284 003

Central Universities with Agriculture Faculty

1. Aligarh Muslim University, Aligarh (Uttar Pradesh) 202 002
2. Banaras Hindu University, Varanasi (Uttar Pradesh) 221 005
3. Nagaland University, Lumani (Nagaland) 798 620
4. Visva Bharti University, Shanti Niketan, Birbhum (West Bengal) 731 235

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APPENDIX 10

Total number of employees in the ICAR and its Research Institutes and number of employees of Scheduled Castes, Scheduled Tribes and Other Backward Classes

S.No.	Class of post	Total posts sanctioned	Total employees in position	SC employees		ST employees		OBC employees	
				No.	% to total employees	No.	% to Total employees	No.	% to total employees
1 Scientist Posts									
a	Scientist	4229	3708	542	14.62	212	5.72	1047	28.24
b	Senior Scientist	1364	913	64	7.01	16	1.75	114	12.49
c	Pr. Scientist	776	377	14	3.71	3	0.80	28	7.43
d	RMP	177	95	1	1.05	0	0	2	2.11
	Total	6546	5093	621	12.19	231	4.54	1191	23.39
2 Technical Posts									
a	Category I	3696	2554	494	19.34	269	10.53	451	17.65
b	Category II	2456	1669	285	17.07	123	7.36	346	20.73
c	Category III	437	238	37	15.54	16	6.72	42	17.64
	Total	6589	4461	816	18.29	408	9.14	839	18.80
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	333	259	41	15.83	13	5.02	30	11.58
b	Category 'B' posts: AF&AO/AAO/SO/PS/LO/ ALA/Assistant/PA/JAO	2747	1973	323	16.37	141	7.15	229	11.61
c	Category 'C' posts: UDC/Steno/LDC	1687	1043	198	18.98	77	7.38	240	23.01
	Total	4767	3275	562	17.16	231	7.05	499	15.24
4 Supporting Skilled Staff									
	Total	7984	4131	1199	29.02	309	7.48	725	17.55



APPENDIX 11

ICAR AWARDS 2018

AWARDS	AWARDEES
Sardar Patel Outstanding ICAR Institution Award 2018	<p>Large Institute 1. Central Institute of Fisheries Technology, Kochi, Kerala</p> <p>Small Institute 1. Indian Institute of Millets Research, Hyderabad, Telangana 2. Indian Institute of Soil Science, Bhopal, Madhya Pradesh</p> <p>University 1. Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh</p>
Chaudhary Devi Lal Outstanding All India Coordinated Research Project Award 2018	<p>Best AICRP 1. All India Coordinated Research Project on Farm Implements & Machinery, Bhopal, Madhya Pradesh 2. All India Coordinated Research Project on Wheat & Barley Improvement, Karnal, Haryana</p>
Vasant Rao Naik Award for Research Application in Agriculture 2018	<p>1. Dr B V Asewar (Team Leader) Chief Scientist, AICRP on Dryland Agriculture-Parbhani Centre, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra</p> <p>2. Dr M S Pendke (Associate) Agricultural Engineer (SWC), Dryland Research Centre, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra</p> <p>3. Prof. S B Chouluwar (Associate) Chief Scientist (Additional Charge), AICRP On Dryland Agriculture-Parbhani Centre, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra</p> <p>4. Dr A K Gore (Associate) Senior Scientist(Agronomy), AICRP On Dryland Agriculture-Parbhani Centre, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra</p> <p>5. Dr G K Gaikwad (Associate) Assistant Professor (Soil Science) Dryland Research Centre, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra</p> <p>6. Dr (Mrs) M W Suryawanshi (Associate) Assistant Professor Dryland Research Centre, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra</p> <p>7. Dr (Mrs) P H Gourkhede (Associate) Assistant Professor Dryland Research Centre, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra</p> <p>8. Dr G Ravindra Chary (Associate) Project Coordinator (Dryland Research)Project Coordination Unit, AICRP On Dryland Agriculture, ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, Telangana</p>
Rafi Ahmed Kidwai Award for Outstanding Research in Agricultural Sciences 2018	<p>Crop & Horticultural Sciences</p> <p>1. Dr Bakshi Ram Director, ICAR-Sugarcane Breeding Institute, Coimbatore</p> <p>2. Dr A T Sadashiva Principal Scientist & Head, Division of Vegetable Crops, ICAR-Indian Institute of Horticultural Research, Hesaraghatta Lake Post, Bengaluru-560089, Karnataka</p>



AWARDS	AWARDEES
	<p>Natural Resource Management & Agricultural Engg.</p> <p>1. Dr M L Jat Principal Scientist/ Systems Agronomist, CIMMYT India, NASC Complex, Pusa, New Delhi</p> <p>2. Dr Himanshu Pathak Director, ICAR-National Rice Research Institute, Cuttack, Odisha</p> <p>3. Dr G Taru Sharma Principal Scientist & Head, Division of Physiology & Climatology, ICAR-Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh</p>
Lal Bahadur Shastri Outstanding Young Scientist Award 2018-	<p>Crop & Horticultural Sciences</p> <p>1. Dr P Suresh Kumar Senior Scientist, NRC for Banana, Trichy, Tamil Nadu</p>
Panjabrao Deshmukh Outstanding Women Scientist Award 2018	<p>Natural Resource Management & Agricultural Engg.</p> <p>1. Dr Dibyendu Sarkar Bidhan Chandra Krishi Vishwavidyalaya, Nadia, West Bengal</p> <p>Animal & Fisheries Sciences</p> <p>1. Dr Deepak Kumar Scientist, Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh</p> <p>Social Sciences</p> <p>1. Dr R Sendhil Scientist, Indian Institute of Wheat and Barley Research, Karnal</p> <p>Professor Dr (Mrs) Parveen Chhuneja</p> <p>1. Senior Molecular Geneticist cum Director, School of Agricultural Biotechnology, Punjab Agricultural University, Ludhiana, Punjab</p> <p>Dr Anju Manuja</p> <p>1. Principal Scientist, ICAR-NRC on Equines, Hisar, Haryana</p>
Bharat Ratna Dr C. Subramaniam Award for Outstanding Teachers 2018	<p>Crop & Horticultural Sciences</p> <p>1. Dr Shelly Praveen Head, Division of Biochemistry, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi</p> <p>Natural Resource Management & Agricultural Engineering</p> <p>1. Dr Yashbir Singh Shivay Principal Scientist, Division of Agronomy, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi</p> <p>Animal & Fisheries Sciences</p> <p>1. Dr Sudhir Kumar Tomar Principal Scientist (Dairy Microbiology) and Academic Coordinator, ICAR-National Dairy Research Institute, Karnal, Haryana</p> <p>Social Sciences</p> <p>1. Dr Med Ram Verma Principal Scientist, Division of Livestock Economics, Statistics and Information Technology, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh</p>
Fakhruddin Ali Ahmed Award for Outstanding Research in Tribal Farming Systems 2018	<p>1. Dr Kamal Singh Kirad (Team Leader) Principal Scientist & Head, Krishi Vigyan Kendra, Mandu Link Road, Dhar, Madhya Pradesh</p> <p>2. Dr G S Gathiye (Associate) Scientist (Crop Science), Krishi Vigyan Kendra, Mandu Link Road, Dhar, Madhya Pradesh</p> <p>3. Dr S S Chauhan (Associate) Scientist (Soil Science), Krishi Vigyan Kendra, Mandu Link Road, Dhar, Madhya Pradesh</p>



AWARDS	AWARDEES
	<p>4. Dr J S Rajpoot (Associate) Scientist (LPM), Krishi Vigyan Kendra, Mandu Link Road, Dhar, Madhya Pradesh</p>
	<p>5. Dr R Kiruba Sankar (Team Leader) Scientist (Fish & Fisheries), ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman & Nicobar Islands</p>
	<p>6. Dr V Baskaran (Associate) Principal Scientist (Floriculture), Division of Horticulture and Forestry, ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman & Nicobar Islands</p>
	<p>7. Dr Raj Kumar Gautam (Associate) Principal Scientist (Plant Breeding), Division of Field Crop Improvement and Protection, ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman & Nicobar Islands</p>
	<p>8. Dr Sakthivel Krishnan (Associate) Scientist (Plant Pathology), Division of Field Crop Improvement and Protection, ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman & Nicobar Islands</p>
	<p>9. Dr K Abirami (Associate) Scientist (Fruit Science), Division of Horticulture & Forestry, ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman & Nicobar Islands</p>
	<p>10. Dr Arunava Pattanayak (Team Leader) Director, ICAR- Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, Uttarakhand</p>
	<p>11. Dr Rajesh Kumar Khulbe (Associate) Senior Scientist (Plant Breeding), ICAR- Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, Uttarakhand</p>
	<p>12. Dr Brij Mohan Pandey (Associate) Principal Scientist (Agronomy), ICAR- Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, Uttarakhand</p>
	<p>13. Dr (Ms) Kushagra Joshi (Associate) Scientist (Home/Family Resource Management), ICAR- Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, Uttarakhand</p>
	<p>14. Dr Tsering Stobdan (Team Leader) Scientist 'E', Defence Institute of High Altitude Research (DIHAR), Leh Ladakh, Jammu & Kashmir</p>
	<p>15. Dr Anand Kumar Katiyar (Associate) Scientist 'D', Defence Institute of High Altitude Research (DIHAR), Leh Ladakh, Jammu & Kashmir</p>
	<p>16. Sh Tsewang Tamchos (Associate) Technical Officer, Defence Institute of High Altitude Research (DIHAR), Leh Ladakh, Jammu & Kashmir</p>
	<p>17. Sh Desyong Namgail (Associate) Senior Technical Assistant, Defence Institute of High Altitude Research (DIHAR), Leh Ladakh, Jammu & Kashmir</p>
Crop Sciences	
<p>1. Dr Rajkumar Uttamrao Zunjare Scientist, Division of Genetics, ICAR-Indian Agricultural Research Institute, New Delhi</p>	
<p>2. Dr A Radhika Ramya S S Colony, Pathapatnam Vill, Mandal & Post, Srikakulam, Andhra Pradesh-532213</p>	

**Jawaharlal Nehru Award for P.G.
Outstanding Doctoral Thesis Research in
Agricultural and Allied Sciences 2018**



AWARDS	AWARDEES
	Biotechnology <ol style="list-style-type: none"> 1. Dr Hake Anil Arjun Post Shedgewadi, Taluka Khandala, Dist. Satara, Maharashtra 2. Dr Om Prakash Gupta Scientist (Sr. Scale), Division of Quality & Basic Sciences, ICAR-Indian Institute of Wheat & Barley Research, Post Box-158, Agrasain Marg, Karnal-132 001, Haryana
	Crop Protection <ol style="list-style-type: none"> 1. Dr A S Vidyashree Janatha Quarters, 5th Cross, Champaka Nagar, Sakleshpur, Hassan Distt., Karnataka-573 134 2. Dr Vinod Kumar Ramachandran Odiyanthal Village, Kadambur Post, Sankarapuram TK, Villupuram-605 802, Tamil Nadu
	Natural Resource Management <ol style="list-style-type: none"> 1. Dr Sandeep Kumar Malyan Room No.121, CESCRA, NRL Building, Pusa, IARI, New Delhi-110 012 2. Dr Ejaz Ahmad Dar House No.14, Lassipora Budgam, Jammu & Kashmir-191 111
	Agricultural Engineering <ol style="list-style-type: none"> 1. Dr Narendra Singh Chandel Scientist , Agricultural Mechanization Division, ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh-462 038 2. Dr Jitendra Kumar Scientist (Land & Water Management Engineering), ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, Uttarakhand, Pin-263 602
	Animal Sciences <ol style="list-style-type: none"> 1. Dr D. Senthil Kumar Scientist, ICAR-National Institute of High Security Animal Diseases, Anand Nagar, Bhopal 2. Dr Anju Kala Rumen Microbiology Laboratory, Animal Nutrition Division, ICAR-Indian Veterinary Research Institute, Izatnagar-243 122, Uttar Pradesh
	Social Sciences <ol style="list-style-type: none"> 1. Dr Mrinmoy Ray Scientist (Division of Forecasting & Agricultural Systems Modelling), ICAR-Indian Agricultural Statistics Research Institute, Library Avenue, Pusa, New Delhi-110 012 2. Dr Sivaraman Iyemperumal Scientist, ICAR-Central Institute of Freshwater Aquaculture, Indian Council of Agricultural Research, Kausalyaganga, Bhubaneswar, Odisha-751 002
	Horticulture <ol style="list-style-type: none"> 1. Dr Gograj Singh Jat Scientist (Horticulture-Vegetable Science), ICAR-Indian Agricultural Research Institute, Pusa, New Delhi 2. Dr Ravindra Kumar Kurimella Scientist (Horticulture), Dr YSR Horticultural University, Horticultural Research Station, Kovvur, West Godavari Distt., Andhra Pradesh-534 350



AWARDS	AWARDEES
	<p>Fisheries</p> <p>1. Dr Madhusmita Nayak Sector-1, Plot No.139, Niladri Vihar, Chandrasekharpur, Bhubaneswar, Odisha-751 021</p> <p>2. Dr Bini Thilakan Neeruketty House, Engandiyur P.O., Thrissur, Kerala-680 615</p>
Jagjivan Ram Abhinav Kisan Puruskar/ Jagjivan Ram Innovative Farmer Award (National/ Zonal) 2018	<p>National</p> <p>1. Sh Raghupat Singh Vill.-Samathal, The.-Bilari, Distt.-Muradabad, Uttar Pradesh</p> <p>2. Sh Simran Rang 236-B, Rajguru Nagar, Ludhiana, Punjab</p>
	<p>Zone I</p> <p>1. Sh Prem Chand Sharma Vill. & P O Hatal, The.-Tyuni, Block-Chakrata, Dehradun, Uttarakhand</p>
	<p>Zone II</p> <p>1. Sh Jagdish Prasad Pareek Vill.-Ajitgarh, Ward No.08, The.-Srimadhopur, Distt.-Sikar, Rajasthan</p>
	<p>Zone III</p> <p>1. Sh Rajendra Singh Vill.-Barsaon, P.O.-Pakdi Bakhtawar, Duboulia, Distt.-Basti, Uttar Pradesh</p>
	<p>Zone IV</p> <p>1. Sh Srawan Kumar Gupta C-92, Harmu Housing Colony, Behind Sahajanand Chowk, Thana- Argora, Ranchi, Jharkhand</p>
	<p>Zone VIII</p> <p>1. Sh Samir Mohanrao Dombe A/p-Khor, Tal.-Daund, Distt.-Pune, Maharashtra</p>
	<p>Zone IX</p> <p>1. Sh Ashwini Singh Chauhan P.O.-Pipliyahama, The.-Ghattiya, Distt.-Ujjain, Madhya Pradesh</p>
	<p>Zone X</p> <p>1. Sh. C M Mohamed Chundan Veetil, Mandayapurathu House, Vettom PO, Malappuram Distt., Kerala</p>
N.G. Ranga Farmer Award for Diversified Agriculture 2018	<p>1. Sh Uddhav Asaram Khedekar At. Shivani, P.O.-Ner, Taluk & District-Jalna, Maharashtra</p>
Swami Sahajanand Saraswati Outstanding Extension Scientist Award 2018	<p>1. Dr Sanjay Kumar Das Principal Scientist & I/C Head, Division of Fisheries, ICAR Research Complex for NEH Region, Umiam, Umroi Road, Barapani, Meghalaya-793 103</p> <p>2. Dr Gouranga Kar Principal Scientist, ICAR-Indian Institute of Water Management, P O - Rail Vihar, Chandrasekharpur, Bhubaneswar, Odisha- 752 023</p> <p>3. Dr Birbal Sahu, Senior Scientist & Head, Krishi Vigyan Kendra, Kanker, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh-492012</p>
NASI-ICAR Award for Innovation and Research on Farm Implements-2018	<p>1. Dr P Rajkumar Professor & Head, Department of Processing & Food Engineering, Agricultural Engineering College & Research Institute, Kumulur, Trichy, Tamil Nadu</p>

AWARDS	AWARDEES
Dr Rajendra Prasad Puruskar for technical books in Hindi in Agricultural and Allied Sciences 2018-	<p>2. Dr Narendra Singh Chandel Scientist, Agricultural Mechanization Division, ICAR-CIAE, Bhopal, Madhya Pradesh</p> <p>Crop & Horticultural Sciences</p> <p>1. Dr Ram Chet Chaudhary Chairman, PRDF Gorakhpur, Uttar Pradesh</p> <p>Natural Resource Management & Agricultural Engineering</p> <p>1. Dr Cherukumalli Srinivasa Rao (Team Leader) Director, ICAR-National Academy of Agricultural Research and Management, Hyderabad</p> <p>2. Dr Ashok Kumar Indoria (Associate) Scientist, ICAR-Central Research Institute for Dryland Agriculture, Hyderabad</p> <p>3. Dr Kishori Lal Sharma (Associate) Principal Scientist, ICAR- Central Research Institute for Dryland Agriculture, Hyderabad</p> <p>4. Dr Sushil Kumar Yadav (Associate) Principal Scientist, ICAR- Central Research Institute for Dryland Agriculture, Hyderabad</p> <p>5. Dr Kotha Sammi Reddy (Associate) Director(I/C), ICAR- Central Research Institute for Dryland Agriculture, Hyderabad</p> <p>6. Dr Sant Ram Yadav (Associate) Director(OL), ICAR- Central Research Institute for Dryland Agriculture, Hyderabad</p> <p>7. Dr G Prabhakar (Associate), Sr. Technical Officer, ICAR- Central Research Institute for Dryland Agriculture, Hyderabad</p> <p>Social Sciences</p> <p>1. Dr U S Gautam (Team Leader) VC, Banda University of Agriculture & Technology, Banda, Uttar Pradesh</p> <p>2. Dr Atar Singh (Associate) Director, ICAR-ATARI, Kanpur</p> <p>3. Dr S K Dubey (Associate) Principal Scientist, ICAR-ATARI, Kanpur</p> <p>4. Sh S N Yemul (Associate) CTO, ICAR-ATARI, Kanpur</p> <p>5. Dr Bhupendra Kumar Singh (Associate) SMS(PP), KVK, Kannauj</p>
Hari Om Ashram Trust Award 2016-17	<p>Crop & Horticultural Sciences</p> <p>1. Dr R Viswanathan Acting Head, Division of Crop Protection, ICAR-SBI, Coimbatore, Tamil Nadu-641007</p> <p>2. Dr Swarup Kumar Chakrabarti (Team Leader) Director, ICAR-Central Potato Research Institute, Shimla, H.P.-171001</p> <p>3. Dr Jagesh Kumar Tiwari (Associate) Senior Scientist, Horticulture (Vegetable Science), ICAR-Central Potato Research Institute, Shimla, H.P.-171001</p> <p>4. Dr Sundaresha Siddappa (Associate) Scientist (Senior Scale), Plant Pathology, ICAR-Central Potato Research Institute, Shimla, H.P.-171001</p>



AWARDS	AWARDEES
	<p>Natural Resource Management & Agricultural Engineering</p> <p>1. Dr Sudhir Singh Principal Scientist, ICAR-Indian Institute of Vegetable Research, Varanasi, Post Bag No.1, Jakhini (Shahanshapur), Varanasi, Uttar Pradesh-221305</p>
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	<p>Social Sciences</p> <p>1. Dr G. Govindaraj Senior Scientist, ICAR-National Institute of Veterinary Epidemiology & Disease Informatics, Bengaluru, Karnataka</p>
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AWARDS	AWARDEES
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	Zone IV 1. Krishi Vigyan Kendra, Rohtas, Bihar Agricultural University, Sabour, Bhagalpur, Bihar
	Zone V 1. Krishi Vigyan Kendra, Angul, ICAR-Orissa University of Agriculture & Technology, Odisha
	Zone VI 1. Krishi Vigyan Kendra, East Sikkim, ICAR-National Organic Farming Research Institute, East Sikkim, Sikkim, Ranipool
	Zone VII 1. Krishi Vigyan Kendra, Khowai, Tripura
	Zone VIII 1. Krishi Vigyan Kendra, Nandurbar, Maharashtra
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	Zone XI 1. Krishi Vigyan Kendra, Davanagere, Karnataka 1. Smt. Lalita Mukati Borlay, Barwani, Madhya Pradesh 2. Th P Saravanan Muthuvelthottam, Ariyagoundampatti, Rasipuram, Namakkal, Tamil Nadu
Haldhar Organic Farmer Award 2018	
Nanaji Deshmukh ICAR Award for Outstanding Interdisciplinary Team Research in Agricultural and Allied Sciences 2018	<p>Crop & Horticultural Sciences</p> <p>1. Dr Krishnendu Chattopadhyay (Team Leader) Principal Scientist, ICAR-National Rice Research Institute, Cuttack, Odisha</p> <p>2. Dr Srigopal Sharma (Associate) Former Principal Scientist (Biochemistry) And Professor Emeritus Biochemistry, Govind Ballabh Pant University Agriculture and Technology, Pantnagar, Uttarakhand, ICAR-National Rice Research Institute, Cuttack, Odisha</p> <p>3. Dr Torit Baran Bagchi (Associate) Senior Scientist (Biochemistry), ICAR-National Rice Research Institute, Cuttack, Odisha</p> <p>4. Dr Avijit Das (Associate) Principal Scientist (Biochemistry), ICAR-National Rice Research Institute, Cuttack, Odisha</p> <p>5. Dr Bishnu Charan Marndi (Associate) Scientist S.G. (Plant Genetic Resource), ICAR-National Rice Research Institute, Cuttack, Odisha</p> <p>Natural Resource Management & Agricultural Engineering</p> <p>1. Dr Ramesh Singh (Team Leader) Principal Scientist, ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh</p> <p>2. Dr Inder Dev (Associate) Principal Scientist (Agronomy), ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh.</p>



AWARDS	AWARDEES
	<p>3. Dr R K Tewari (Associate) Principal Scientist (Horticulture), ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh.</p> <p>4. Dr S K Dhyani (Associate) Senior Agroforestry Specialist, South Asia Regional Programme, ICRAF, New Delhi & Ex-Director, ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh</p> <p>5. Dr O P Chaturvedi (Associate) Ex-Director, ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh</p> <p>6. Dr R P Dwivedi (Associate) Principal Scientist (Extension), ICAR-Central Agroforestry Research Institute, Jhansi Uttar Pradesh</p> <p>7. Dr R H Rizvi (Associate) Principal Scientist (Computer Application), ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh</p> <p>8. Dr K B Sridhar (Associate) Scientist, (Forestry), ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh</p> <p>9. Sh Rajendra Singh (Associate) Chief Technical Officer, ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh</p> <p>10. Sh Shishupal Singh (Associate) Senior Technical Officer, ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh</p> <p>11. Dr C K Bajpai (Associate) Chief Technical Officer, ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh</p>
Chaudhary Charan Singh Award for excellence in Journalism in Agricultural Research and Development 2018	<p>Print Media-Hindi Journalism</p> <p>1. Sh Tarun Kumar Jain Vaigyanik Drishtikon, 123/83, Mansarovar, Jaipur, Rajasthan-302020</p> <p>Print Media-Regional Language</p> <p>1. Sh Bhagwan Dass Special Agriculture Correspondence1, Sirhind Road, Opposite Govt. Press, Patiala, Punjab-147 004</p> <p>Electronic Media-Television</p> <p>1. Shri Om Prakash Yadav Editor News, DD News, Doordarshan Bhawan, Copernicus Marg, New Delhi-110 003</p>
Cash Awards Scheme 2018	<p>Administrative Category</p> <p>1. Smt K K Rukmani Ammal P.A., ICAR-National Academy of Agricultural Research and Management, Hyderabad</p> <p>2. Sh Sunil Kumar Das F&AO, ICAR-National Rice Research Institute, Cuttack</p> <p>3. Sh Fayaz Ahmad Dar AF&AO, Central Institute of Tropical Horticulture, Srinagar, J&K</p> <p>Technical Category</p> <p>1. Sh Arvind Kumar Ahlawat ACTO, ICAR-Indian Agricultural Research Institute, New Delhi</p> <p>2. Sh Subodh Kumar ACTO, ICAR-Indian Institute of Wheat & Barley Research, Karnal</p> <p>3. Sh Anil Kumar Sharma CP&PRO, ICAR, Krishi Bhawan, New Delhi</p> <p>Supporting Category</p> <p>1. Sh Mewa Singh ICAR-National Dairy Research Institute, Karnal</p> <p>2. Smt V Saroja ICAR- National Academy of Agricultural Research and Management, Hyderabad</p>



Acronyms

AARDO	: African-Asian Rural Development Organization	CIAE	: Central Institute of Agricultural Engineering
ABI	: Agri-business Incubation	CIARI	: Central Island Agricultural Research Institute
ACI	: Adaptive Capacity Index	CIMMYT	: Centro International de Mejoramiento de Maize Trigo
AER	: Agro-ecological Region	CLA	: Conjugated Linoleic acid
AES	: Agriculture Expert System	CP	: Crude Protein
AESR	: Agro-ecological Sub-region	CPE	: Cumulative Pan Evaporation
AFC	: Age at First Calving	CPP	: Caseinophosphopeptides
AFLP	: Amplified Fragment Length Polymorphism	CRD	: Chronic respiratory disease
AGID	: Agar Gel Immunodiffusion	CSFV	: Classical Swine Fever Virus
AI	: Avian Influenza	CVM	: Congenital Vascular Malformation
AICRP	: All India Coordinated Research Project	DAS	: Days After Sowing
AINP	: All India Network Project	DAT	: Days After Transplanting
AKAP4	: A-kinase Anchor Protein 4	DEs	: Directorates of Extension
AKMU	: Agricultural Knowledge Management Unit	DG	: Distillers' Grains
ALV	: Avian Leukosis Virus	DHA	: Docosahexanoid acid
AMAAS	: Application of Micro-organisms in Agriculture and Allied Sectors	DI	: Drip Irrigation
AMPs	: Antimicrobial Peptides	DSn	: Diagnostic sensitivity
ANASTU	: Afghan National Agricultural Sciences and Technology Unit	DSS	: Decision Support System
APCTT	: Asia-Pacific Centre for Technology Transfer	DSWP	: Defatted Silkworm Pupae Meal
ARYA	: Attracting and Retaining Youth in Agriculture	EAS	: Extension and Advisory Services
ASAM	: Alkaline Sulfite Anthraquinone Methanol	ECPI	: Empowerment of Crop Production Index
ASEAN	: Association of South-East Asian Nations	EEE	: Eastern Equine Encephalitis
ASRB	: Agricultural Scientists' Recruitment Board	EHV	: Equine Herpes Virus
ATARI	: Agricultural Technology Application Research Institutes	EIA	: Enzyme Immuno Assay
ATIC	: Agricultural Technology Information Centre	EIV	: Equine Influenza Virus
ATP	: Annual Training Programme	ELISA	: Enzyme-linked Immunosorbent Assay
BAT	: BAIT Application Technique	EPA	: Eicosapentanoic acid
BOD	: Biochemical Oxygen Demand	EPN	: Entomopathogenic Nematode
BoHV	: Bovine Herpes Virus	ETL	: Economic Threshold Level
BRICS	: Brazil, Russia, India, China and South Africa	EXPSS	: Expert System on Seed Spices
BTV	: Blue Tongue Virus	FAO	: Food and Agriculture Organization
BVDV	: Bovine Viral Diarrhoea Virus	FCR	: Feed Conversion Rate
BVS	: Bovine Vaccinate Serum	FEC	: Faecal Egg Count
CA	: Conservation Agriculture	FFP	: Farmers FIRST Project
CAFT	: Centres of Advanced Faculty Training	FINE	: Festival of Innovation and Entrepreneurship
CAU	: Central Agricultural University	FLD	: Frontline Demonstrations
CAZRI	: Central Arid Zone Research Institute	FMD	: Foot-and-Mouth Disease
CC	: Cellular Component	FPT	: Field Progeny Testing Project
CCA	: Climate Change adaptation	FSH	: Follicle-stimulating Hormone
CeRA	: Consortium for e-Resources in Agriculture	FWKGS	: Farm Women Knowledge Groups
CFL	: Current Fallow Land	FYM	: Farmyard Manure
CFLD	: Cluster Frontline Demonstration	GADVASU	: Guru Angad Dev Veterinary and Animal Sciences University
CFT	: Complement Fixation Test	GBNV	: Groundnut Bud Necrosis Virus
CGIAR	: Consultative Group on International Agricultural Research	GBPUAT	: Govind Ballabh Pant University of Agriculture and Technology
CHC	: Custom Hiring Centres	GDP	: Gross Domestic Production
		GEF	: Global Environmental Facility
		GHGs	: Greenhouse Gases
		GIS	: Geographical Information System
		GO	: Gene Ontology
		GPA	: Global Plan of Action
		GPS	: Global Positioning System
		HAB	: Hyper Ammonia Producing Bacteria



ACRONYMS

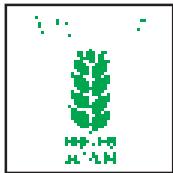
HAPA	: Hybridization-supplemented Apomixis Components Partitioning Approach	NARS	: National Agricultural Research System
HPAI	: Highly Pathogenic Avian Influenza	NASF	: National Agricultural Science Fund
HPNA	: Highly Pathogenic Notifiable Avian Influenza	NBSS&LUP	: National Bureau of Soil Survey and Land Use Planning
HPTLC	: High Performance Thin Layer Chromatography	NDF	: Non-detergent Fibre
HRR	: Head Rice Recovery	NDMI	: Normalized difference moisture index
HS	: Haemorrhagic Septicaemia	NDVI	: Normalized difference vegetation index
HSP	: Heat Shock Protein	NDWI	: Normalized difference water index
IAA	: Integrated Agri-aquaculture	NEH	: North-Eastern Hills
IBR	: Infectious Bovine Rhinotracheitis	NET	: National Eligibility Test
ICARDA	: International Centre for Agricultural Research in Dry Areas	NGOs	: Non-Government Organizations
ICMV	: Indian Cassava Mosaic Virus	NIABI	: Network of Indian Agri-business Incubators
ICRISAT	: International Crops Research Institute for Semi-Arid Tropics	NICRA	: National Innovations in Climate Resilient Agriculture
ICT	: Information and Communication Technologies	NISAGENET	: National Information System on Agricultural Education Network
IDM	: Integrated Disease Management	NLS	: Nano-lignocellulosic
IDS	: Integrated Drying System	NRC	: National Research Centre
IFS	: Integrated Farming System	NSP-Ab	: Non Structural Protein Antibody
IHC	: Immuno-histochemistry	NSSO	: National Sample Survey Office
IPM	: Integrated Pest Management	NTM	: Non-tuberculous <i>Mycobacterium</i>
IPNS	: Integrated Plant Nutrient System	NTS	: National Talent Scholarship
IPR	: Intellectual Property Rights	NUE	: Nitrogen Uptake
IRES	: Internal Ribosomal Entry Site	OAS1	: Oligoadenylylate Synthase 1
IRR	: Internal Rate of Return	ODR	: Overall Discomfort Rating
ITK	: Indigenous Technical Knowledge	OMF	: Organo-mineral Fertilizer
IWMI	: International Water Management Institute	OTC	: Open Top Chamber
JE	: Japanese Encephalitis	PBMCS	: Peripheral Blood Mononuclear Cells
JNKVV	: Jawaharlal Nehru Krishi Vishwa Vidyalaya	PCA	: Principal Component Analysis
KKA	: Krishi Kalyan Abhiyan	PCR	: Polymerase Chain Reaction
KVAFSU	: Kerala Veterinary, Animal Sciences and Fisheries University	PCZ	: Potentila Crop Zone
KVK	: Krishi Vigyan Kendra	PDDUUKSY	: Pandit Deen Dayal Upadhyay Unnat Krishi Shiksha Yojana
LAMP	: Loop Mediated Isothermal Amplification	PFA	: Psychological First Aid
LAT	: Latency Associated Transcript	PGDTMA	: Post-graduate Diploma in Technology Management in Agriculture
LC-MS/MS	: Liquid chromatographs/ Mass spectrometry	PGFM	: Prostagladin F2 Alpha Metabolite
LD	: <i>Longissimus dorsi</i>	PGRC	: Plant Germplasm Registration Committee
LDF-Mobile App	: Livestock Disease Forewarning-Mobile App	PIADC	: Plum Island Animal Disease Center
LEU	: Landscape Ecological Unit	PID	: Participating Technology Development
LFA	: Lateral Flow Assay	PME	: Priority Setting, Monitoring and Evaluation
LRI	: Land Resource Inventory	PMIS	: Personal Management Information System
MABB	: Marker Assisted Backcross Breeding	PPGSE	: Plausible Potato Growing Seasons Estimator
MAS	: Molecular Marker-assisted Selection	PPR	: <i>Peste des Petits Ruminants</i>
MAT	: Macroscopic Agglutination Test	PPV and FRA	: Protection of Plant varieties and Farmers' Rights Authority
MAT	: Male Annihilation Technique	PPV	: Porcine Parvovirus
MF	: Molecular Function	PRRSV	: Porcine Reproductive and Respiratory Syndrome Virus
MGMG	: Mera Gaon Mera Gaurav	PSVs	: Peer Support Volunteers
MOU	: Memorandum of Understanding	PUFAs	: Polyunsaturated fatty acids
MPP	: Methane Production Potential	QPM	: Quality Protein Maize
MS	: Mass Spectrometry	QTL	: Quantitative Trait Loci
MW	: Molecular Weight	RAWE	: Rural Agricultural Work Experience
NABG	: National Agricultural Bioinformatics Grid	RDF	: Recommended Dose of Fertilizers
NADRES	: National Animal Disease Referral Expert System	RE	: Revised Estimate
NAE	: Niche Area of Excellence	RFD	: Results-Framework Document
NAEAB	: National Agricultural Education Accreditation Board	RFLP	: Restricted Fragment Length Polymorphism
NARD	: National Agricultural Research Database	RH	: Relative Humidity
		RIL	: Recombinant Inbred Line



Risk MAP	: Risk Mapping, Assessment and Planning	TLR-1	: Toll Like Receptor-1
RMP	: Research Management Positions	TNA	: Training Needs Analysis
RNFE	: Rural Non-farm Employment	ToT	: Transfer of Technology
RVF	: Rift Valley Fever	TSP	: Tribal Sub-Plan
SAARC	: South Asian Association for Regional Co-operation	TSS	: Total Soluble Solids/Sugars
SAH	: Solar Air Heater	TTV	: Transfusion Transmitted Virus
SAUs	: State Agricultural Universities	UAN	: Urea Ammonium Nitrate
SCC	: Somatic Cell Count	UGC	: University Grants Commission
SCS-CN	: Soil conservation Service-Curve Number	USST	: Udder Skin Surface Temperature
SCSMV	: Sugarcane Streak Mosaic Virus	UV	: Ultra Violet
SNP	: Single Nucleotide Polymorphism	VACV	: Vaccinia Virus
SPR	: Surface Plasmon Resonance	VNTR	: Variable Number Tandem Repeats
SRF	: Senior Research Fellowship	VPKAS	: Vivekananda Parvatiya Krishi Anusandhan Sansthan
SRI	: System of Rice Intensification	VRFA	: Variable Rate Granular Fertilizer Applicator
SSD	: Surface and Subsurface Drainage	VS	: Vesicular Stomatitis
SSLUP	: Small Scale Lac Processing Units	VTCC	: Veterinary Type Culture Centre
SSR	: Simple Sequence Repeat	WB	: Western Blot
SWYMOD	: Surface-Water Yield Model	WBUFAS	: West Bengal University of Fisheries and Animal Sciences
TDC	: Technology Demonstration Component	WCL	: Whole Cell Lysate
TEM	: Transmission Electron Microscope	WDCM	: World Data Centre for Microorganisms
TFP	: Total Factor Productivity	WSSV	: White Spot Syndrome Virus
TiLv	: Tilapia Lake Virus	WUE	: Water Use Efficiency
TKP	: Tamarind Kernel Powder		
TLCV	: Tomato Leaf Curl Virus		

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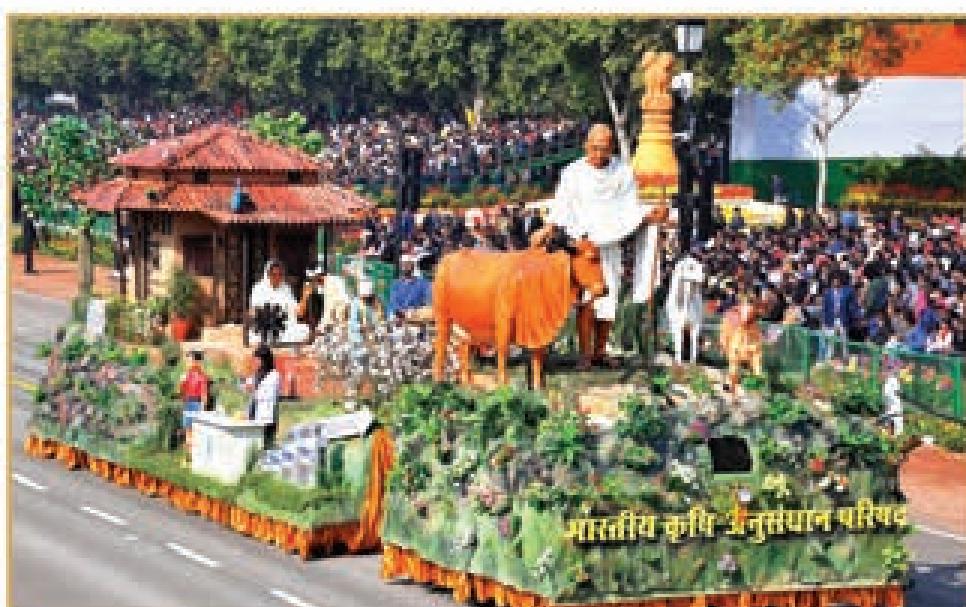


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The ICAR was awarded First Prize for its Tableau, '**Kisan Gandhi**' in the Republic Day Parade – 2019. The ICAR tableau displayed the importance of dairy farming, use of indigenous breeds and livestock based organic agriculture for rural prosperity.