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ANNUAL REPORT 2017-18

सत्यमेव जयते

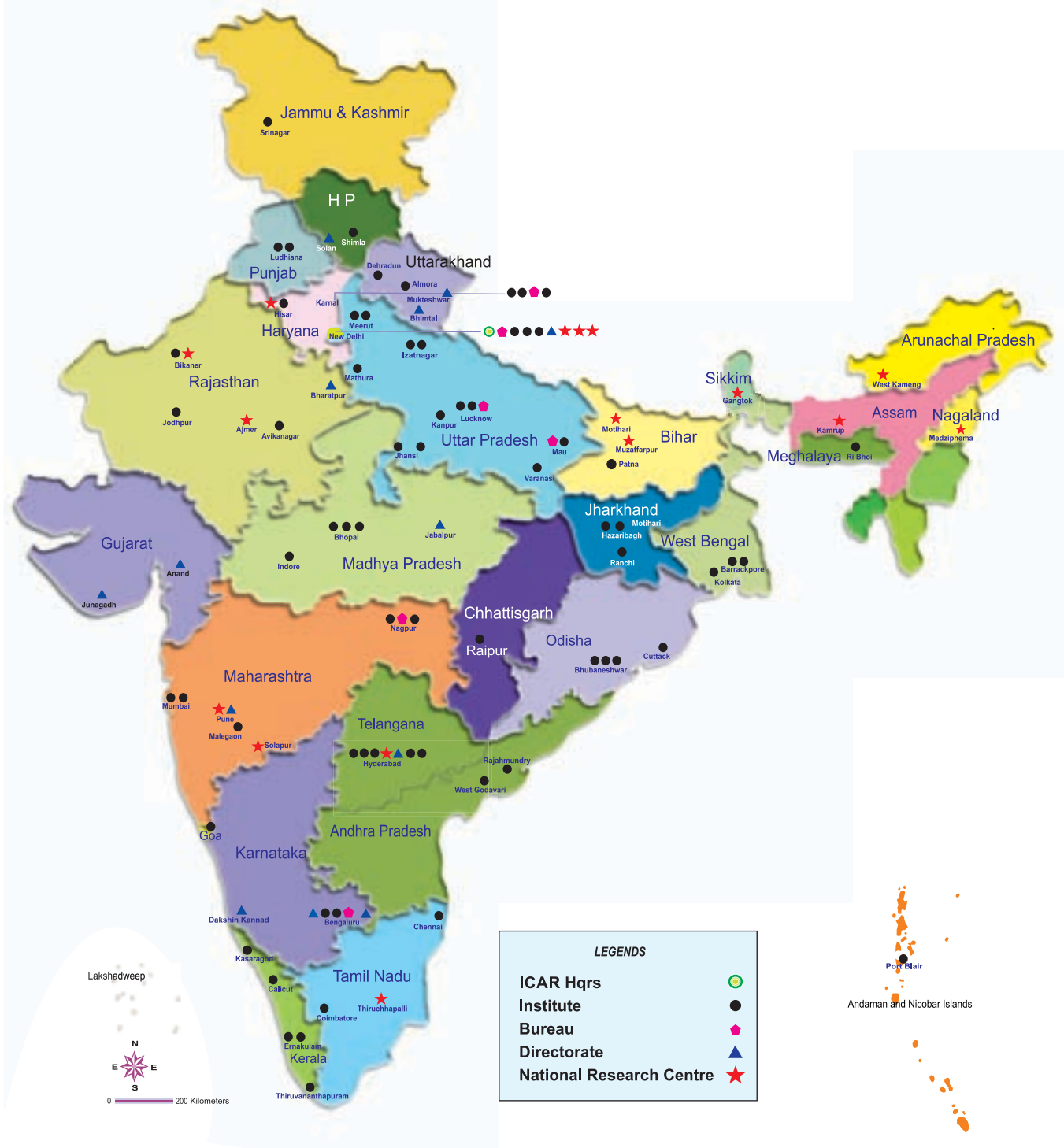
Department of Agricultural Research and Education
Ministry of Agriculture & Farmers Welfare
Government of India

भाकृअनुप
ICAR

Indian Council of Agricultural Research
New Delhi

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Institutes, Bureaux, National Research Centres and Directorates



• 69 Research Institutes • 6 Bureaux • 12 Directorates • 14 National Research Centres

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Foreword

The Indian Council of Agricultural Research (ICAR) is nearing nine decades of its service to the nation and as a vibrant organization continues to generate technologies for sustainable development of agriculture. I am pleased to place on record that Department of Agricultural Research and Education (DARE) and ICAR is working towards enabling 'Doubling of Farmers' Income by 2022' on a mission mode. We strongly believe that science-led development of agriculture is the basis for transformed Indian agriculture enabling the country to sustain its food grain production.

Towards increasing the productivity, production and quality of field and horticultural crops, we have developed 209 new varieties/hybrids with potential for higher yields and enhanced tolerance/resistance to various stresses across different agro-ecological regions of the country. Our landmark varieties such as Pusa Basmati 1121 in rice and HD 2697 in wheat have transformed production and trade scenario both within the country and at international level that today India is amongst the leading exporters of basmati rice. The Council has developed 12 biofortified crop varieties that would help the nation to address the prevalent malnutrition in the country. We prepared and submitted a strategy paper for achieving self-sufficiency in pulses to the Government, followed by establishment of seed hubs across the country have resulted in a big success story during 2016-17.

As part of lab-to-land programme, our efforts to reach out to the farmers/villages is gaining momentum through frontline demonstration by KVKs and also village adoption under '*Mera Gaon Mera Gaurav*' initiative. The Council has constituted State Level Coordination Committees with a mission to doubling farmers' income that are preparing strategy documents highlighting Science-led Approaches to Double Farmers' Income in respective states. To enable personalized decision support systems, the Council has developed several digital platforms both in web portal mode as well as mobile *apps* that help the farmer to integrate scientific inputs in their farming practices. Further, the Council has also established 100 centres for promoting sustainable agriculture through its *Pandit Deen Dayal Upadhyaya Unnat Bharat Krishi Sikhsa Yojana*.

Changing climate is a concern and the Council is doing all to enable Indian agriculture climate resilient. Vulnerability Atlas for the country has been prepared to identify 100 most critically vulnerable districts for appropriate interventions. Several climate resilient crop varieties and animal breeds along with efficient NRM technologies have been successfully introduced in NICRA villages (151 nos.) spread across the country for enabling climate smart agriculture. District level contingency plans have been updated that are being adopted by the state governments. Some of the state governments – Maharashtra and Odisha have also come forward to up-scale the NICRA Village concept.

Improvement of indigenous cattle breeds was conceptualized for the genetic improvement of Gir, Kankrej and Sahiwal cattle in their home tracts. Protocol for organic sheep production has been developed, and recently organic livestock certification has also been obtained from Organic India. Further, the Council is actively popularizing the integrated farming system models for small-holders in different agro-climatic conditions and also organic farming system models developed for different crops through KVKs and SAUs.

Towards strengthening agricultural education in the country, the Council has adopted the Fifth Deans' Committee Report. Several reforms such as guidelines to maintain minimum standards in higher agricultural education has been issued to all the agricultural universities. For the first time, we introduced online student counselling system for admissions to UG and PG programmes. As part of personnel management in ICAR, a digital platform personnel management information systems along with posting and transfer modules have been introduced. The Council has just implemented the National Higher Agicultural Education Project for providing world class education within the country in the State Agricultural Universities.

Global outreach of the Council has been visible being a member of the CGIAR System Council. As an active member of BRICS, DARE is hosting the Coordination Unit of BRICS Agricutlural Platform in New Delhi. DARE is also hosting the 4thIndia-ASEAN Agricutlure Ministers' Meeting in New Delhi in January, 2018. Further, several MoUs and international

cooperation for strengthening agricultural education in our neighboring countries such as Myanmar and Afghanistan are proving to be fruitful.

Further, the DARE/ICAR has got good number of new initiatives such as Farmer FIRST, Student READY, ARYA, Consortia Research Platforms, etc. to facilitate agricultural research through innovation and integration. I hope that the *DARE/ICAR Annual Report 2017-18* will provide useful information to the diverse stakeholders and prove to be helpful literature for planning future programmes in agriculture research for development.

(RADHA MOHAN SINGH)
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**
Union Ministers of State for Agriculture	:	**Shri Parshottam Rupala (Since 8 July 2016)** **Shri Gajendra Singh Shekhawat (Since 4 September 2017)** **Smt Krishna Raj (Since 3 September 2017)** **Shri S S Ahluwalia (up to 3 September 2017)** **Shri Sudarshan Bhagat (up to 3 September 2017)**
Secretary, DARE, and Director General, ICAR	:	**Dr Trilochan Mohapatra (Since 22 February 2016)**
Additional Secretary and Financial Adviser, DARE/ICAR	: :	**Shri Sunil Kumar Singh (up to 24 August 2017)** **Shri Surendra Nath Tripathi (Since 5 September 2017)**
Additional Secretary, DARE and Secretary, ICAR	:	**Shri Chhabilendra Roul**

The Mandate of the Indian Council of Agricultural Research

- Plan, Undertake, Coordinate and Promote Research and Technology Development for Sustainable Agriculture.
- Aid, Impart and Coordinate Agricultural Education to enable Quality Human Resource Development.
- Frontline Extension for technology application, adoption, knowledge management and capacity development for agri-based rural development.
- Policy, Cooperation and Consultancy in Agricultural Research, Education and Extension.

1. Overview

In India, new records are being established in the agriculture sector. India's foodgrain production for the 2016-17 is estimated at record 275.68 million tonnes, which is over 4% higher than the previous record production achieved in the country during 2013-14. In this endeavour, the Indian Council Agricultural Research (ICAR) has played a vital role by way of technology development, demonstration and transfer in India.

The National Agricultural Research System (NARS) of the country has taken up number of activities through Krishi Vigyan Kendras (KVKs) and other programmes for application of farm technologies in farmers'field. Besides, taking up technology assessment, refinement, demonstration and capacity development programmes during the year, the other initiatives such as Farmers FIRST, Attracting and Retaining Youth in Agriculture (ARYA), Climate Resilient Integrated Farming Systems (IFS), Cluster Frontline Demonstration (CFLD) of pulses and oilseeds, Cereal Systems Initiatives for South Asia (CSISA), documentation and registration of farmers' varieties under PPV&FRA, Pulses Seed Hubs, KVK Portal, *Mera Gaon Mera Gaurav* and awareness creations about mega government schemes, etc. were also implemented to espouse the cause of farming community through technology application with their active participation.

Mobile advisory was provided for timely and need based information to the farming community. Information on weather, market, various farm operations, outbreak of pest and disease incidences and their control measures were provided to farmers through Short Message Service (SMS). On ICAR's 89th Foundation Day Hon'able Minister for Agriculture and Farmers Welfare launched the flagship educational initiative in the form of a National Agricultural Higher Education Project (NAHEP).

To sustain agricultural production, food security of the nation, and agriculture-dependent rural livelihoods in the face of changing climate, it is very pertinent to evolve adaptation strategies to minimize the adverse effect of climate change and also initiate mitigation strategies to reduce greenhouse gases (GHGs) emissions from agriculture and allied sectors. The ICAR launched a prestigious project, National Initiative on Climate Resilient Agriculture, which metamorphosed into the National Innovations in Climate Resilient Agriculture (NICRA). One of the major achievements so far in the NICRA project is development and standardization of state-of-the-art infrastructure for climate change research, such as High Throughput Plant Phenomics facilities, Free Air Temperature Environment (FATE), Carbon Dioxide Temperature Gradient (CTGC), Eddy Covariance Towers, Automatic Weather Stations, Satellite Data Reception System, Rainout shelter facility, Animal Calorimeter, CO_2 Environmental Chambers, Custom designed animal shed, Research Shipping Vessel etc.

The country level programme named as *Sankalp-se-Siddhi* aimed at creating mass awareness about Government of India's Commitment for doubling farmer's income by the year 2022 was organized. As per the guidelines of ICAR and Ministry of Agriculture and Farmers Welfare, Government of India, pre-*kharif* and pre-*rabi* campaigns were organized by 438 KVKs for better planning and farmers' participation ensuring timely dissemination of knowledge and information, flow of technological inputs and effective crop management strategy. The KVKs created awareness about *Pradhan Mantri Fasal Beema Yojana* (PMFBY) across the country for protecting farmers from production risks that may occur through crop loss/ damage due to unforessen natural vagaries and to stabilize the income of farmers by adopting innovative and modern agricultural practices. The overview presents a brief account of salient achievements.

Soil and water productivity: The National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) developed NBSS BHOOMI Geo-portal to access various thematic information on major physiographic regions, sub-physiographic regions of India, agro-ecological regions (1992), agro-ecological regions (2015) and agro-ecological sub-regions of the country. Area/region-specific efficient and remunerative crops and cropping sequences were delineated based on soils, landforms, rainfall, temperature, length of growing period and irrigability. The NBSS&LUP developed an android-based mobile application on GIS platform to facilitate web-based decision support system (DSS) for land use planning and dissemination of soil health cards information at village and farm level for Gujarat. App will display details of soil map unit information and suggested land use plan for that survey number. The NBSS&LUP has so far prepared Land Resource Inventory (LRI) of 99 blocks. These digitized maps of micronutrients status would be helpful in providing site-specific variable rate application of micronutrients prescription for sustainable agricultural productivity. Application of *Leucaena* biochar, significantly reduced ammonium content of soil, whereas increased nitrate N.

Check dams, constructed using two thickness of sheets for 1.2 m high head wall with MS angle frame, saved 30-47% on cost without any effect on life and performance of the check dam. Such constructions will be very useful for installation of quick and low

cost check dam structures in remote areas. The sub-surface drainage (SSD) system was installed in waterlogged saline soils at 2 locations of Bharuch district of Gujarat. Local communities are being sensitized for the active participation for successful operation of these projects. Determination of lead and cadmium concentration limits in agricultural soil and municipal solid waste compost through an approach of zero tolerance to food contamination was developed. Bilingual (Marathi and English) STCR mobile App for fertilizer recommendations of Maharashtra, helps realize the targeted yield of crops. Using National Aeronautics and Space Administration's (NASA) Gravity Recovery and Climate Experiment (GRACE) data, groundwater storage changes in India were assessed, and the results were validated for the first time using *in-situ* observation. The AICRP on Integrated Farming Systems (IFS) is operational in 24 states and 1 union territory covering all the 15 Agro-climatic regions of country. Region specific IFS models, developed in 14 agro-climatic regions along with business model (Bankable projects), indicated 2-3 times higher income than existing farming systems. The model with field crops, horticultural crops, livestock, fishery, and other components like vermicompost, biogas unit and composting unit developed in lower Gangetic plains agro-climatic region in Kalyani, West Bengal, recorded higher sustainability yield index (SYI) of 0.78, followed by a model with cropping systems, dairy, horticulture, vermicompost and water harvest in SK Nagar, Gujarat with 0.66 SYI. A negative correlation between SYI and coefficient of variation (CV) of annual rainfall, showed that inter-annual rainfall variation has visible impact on sustainability of integrated farming systems.

Under Network Project on Organic Farming (NPOF), best performing varieties of crops for organic farming were identified in 16 states. A database Management System was developed including district level data on land use classification (9 fold), source-wise net irrigated area, indicators of extent of irrigated area, fertilizer consumption (N, P and K), monthly rainfall and crop-wise area sown, production and yield and area sown with irrigation (for 20 crops) etc. The Decision Support System (DSS) was developed accommodating 15 rainfed crops, viz. rice, sorghum, pearlmillet, maize, fingermillet, chickpea, pigeonpea, blackgram, greengram, groundnut, soybean, sunflower, sesame, castor and cotton. Synthesised Nanoclay, developed using matured coconut water as capping material, will reduce the seepage from ponds, and can play very important role in using poor quality soil for aquaculture.

Climate change and resilient agriculture: The study on most conducive weather conditions for the spread of aphids in mustard at Anand, Gujarat, revealed that window from 10 to 20 October was the most ideal for sowing to avoid high aphid infestation in mustard. Real time pest dynamics (RTPD) data were recorded for development of forewarning model of mango pests under climate change scenario through a better understanding of host-pest interaction and dynamics in mango. High level of fruit fly catches coincided with marble stage of mango fruits. A process-based climatic phenology model (ILCYM), revealed that the changing climates will be more favorable for *Bactrocera zonata*, and its damage potential will progressively increase in all mango-producing regions of India where the pest already prevails. The spatial and temporal changes in voltinism of three major mango fruit fly species, viz. *Bactrocera dorsalis*, *Bactrocera correcta* and *Bactrocera zonata* were estimated in major mango regions of India. Increased number of generations across 10 mango-growing locations of India suggested that incidence of fruit flies may increase due to projected increase in temperatures in future climate change scenario.

Under balanced fertilization in soybean and wheat, change in soil organic C in soil depth of 0-15 cm and 15-30 cm was nonsignificant in all RCPs and time slices. This result agreed well with the change in grain yield of soybean and wheat. In year 2050, soybean yield will increase by 12, 17, 15 and 22% in RCPs 2.6, 4.5, 6.0 and 8.5, respectively. The result showed that soybean yield increase will be more in year 2080 than that in year 2050. The increase in wheat yield would be 2-4% over base in year 2050, whereas 1-6% in the year 2080.

Supplementation of tamarind seed husk alone or in combination with soapnut significantly reduced *in vivo* methane emission (22-24%) and decreased the population of rumen protozoa and methanogens. Feeding of tree leaves (*Leucenea leucocephala* and *Ficus*) based complete feed resulted in 9.8-18.93% reduction in enteric methane emission (g/day) in goats in comparison to traditional complete feed. A herbal crude powder based bolus, consisting of three plant materials, reduced climatic stress in goats. Examination of the whole transcriptome changes in indigenous (Mali) and exotic (Hampshire) pigs during summer and winter, revealed that indigenous Mali pigs recorded only 14 upregulated and 45 downregulated genes in response to change in ambient temperature indicating better adaptation in them.

Genetic resources: Total 21 explorations were undertaken and 1,532 germplasm accessions were collected comprising 1,095 of cultivated plants and 437 wild accessions. The explorations were undertaken two each in Andhra Pradesh, Asom, Chhattissgarh, Maharashtra, Tamil Nadu, Uttar Pradesh, West Bengal and one each in Andaman and Nicobar, Arunachal Pradesh, Karnataka, Nagaland, Odisha, Tripura and Uttarakhand. The population of *Momordica cochinchinensis*, collected from the middle Andaman Island, was described as a new subspecies *Momordica cochinchinensis* subsp. *andamanica*, which was subsequently validated through DNA barcoding. During the period, 411 herbarium specimens were added to the National Herbarium of Cultivated Plants. Out of 28,516 accessions, imported from 39 countries, 2,911

were screened against biotic and 787 against abiotic stresses, and 7,343 were supplied for research use and crop improvement programme within the country. Ten phytosanitory certificates were issued for export of germplasm.

The genetic resource of horticultural crops was strengthened by collecting germplasm accessions, viz. banana (55), citrus (20), grape (13), guava (23), jackfruit (29), litchi (12) and mango (44). Besides, genotypes of date palm and grapefruit (1 each), acid lime (11), mandarin (8), sweet orange (11), different species of *Citrus* rootstocks (17) and guava (5) were added to field gene bank. Twenty-seven mushroom specimens were collected from forest of Himachal Pradesh and Tripura and 21 were identified up to genus level. About 20 rare orchid species were collected from the Himalayan Ecosystem. Breeding material and parental lines of hybrids were assigned national identity—okra (23), tomato (2), pointed gourd (1), radish (9), carrot (16), *bathua* (4), French bean (10) and ridge gourd (1). In potato, 14 germplasm accessions were imported from the Netherlands and the USA and 4 accessions were added to the gene bank after quarantine clearance.

Nine new populations of livestock and poultry have been registered as breeds, which include cattle, Badri (Uttarakhand); goats, Teressa (Andaman and Nicobar Islands) and Kodi Adu (Tamil Nadu); sheep, Chevaadu (Tamil Nadu) and Kendrapada (Odisha); pig, Tenyi Vo (Nagaland), Nicobari (Andaman and Nicobar Islands), Doom (Asom); and chicken, Kaunayen (Manipur). Phenotypic characterization was completed for the cattle of Sikkim, Meghalaya and Nagaland states; Konkan cattle; Burgur buffalo; Mouli sheep of Karnataka; Yalaga sheep and Nagaland goats. Measures of diversity which forms the basis for planning utilization and/or conservation were calculated for seven different species, viz. Dharwadi buffalo; Hazara birds; Poonch, Tibetain sheep; Bhakarwal goat; Rajasthani donkey; Arunachali yak; Kosali cattle; and Jalori and Mewari camel. The diversity indices pointed towards diminished genetic diversity and declining population in the *Tibetain,* a valuable Himalayan sheep breed. A faster and economic genotyping protocol was developed for congenital vascular malformation (CVM) and the same was registered for an Indian Patent. The FCGRT gene in Murrah buffaloes showed association with exon-3; which was significant between the high and the low colostral IgG groups. Viral load of CSF virulent virus was significantly higher in macrophages of crossbred pigs than that in indigenous pigs. Evaluation of immune competence traits revealed that Ghagus has better expression profile of genes linked to innate immunity.

Whole genome sequencing of *Clarias magur* and *Tenualosa ilisha,* was carried out, which will help in fast selection of economically important adaptive traits and improvement of organisms. Mitochondrial genome sequencing of the highly esteemed edible oyster, *Crossostrea madrasensis,* will help in identification of stocks for future production programmes. Genome sequencing of *Aphanomyces invadens,* causal agent of mass-scale mortalities in cultured and wild fish, was carried out. The study will help in understanding the pathway of *A. invadens* infection syndrome in fish.

Crop improvement: Major emphasis was to develop new varieties/hybrids tolerant to various biotic and abiotic stresses with enhanced quality. During the reported period, total 209 varieties were developed: 117 high-yielding varieties/hybrids of cereals comprising 65 of rice, 14 of wheat, 24 of maize, 5 of finger millet, 3 of pearl millet, 1 each of sorghum, barley, foxtail millet, kodo millet, little millet and proso millet and released for cultivation in different agro-ecological regions of the country. Twenty eight high-yielding varieties of oil seeds, 32 of pulses, 24 of commercial crops (cotton, sugarcane and jute) and eight of forage crops were released for cultivation in different agro-ecologies. Biofortified varieties of crops, viz. wheat (WB 2 and HPBW 01), maize (Pusa Vivek QPM 9, Pusa HM 4, Pusa HM 9 Improved), pearl millet (HHB 299, AHB 1200), Indian mustard (Pusa Double Zero Mustard 31) and lentil [Pusa Ageti Masoor (L 4717)], were developed for improved nutrition and health of consumers. Lipoxygenase-2 free soybean NRC 109 was developed and commercialized. A leaf rust resistant stock Selection 12 in wheat was developed from the cross between bread wheat line CM 108-31 × *T. timopheevii*. To identify co-dominant marker, large number of microsatellite markers representing long arm of chromosome 1 were synthesized and used in analyzing segregating generation and RILS developed from a cross between Nap Hal and UP 2425 in wheat. Three brown midrib genes useful for lignocellulosic biofuel production pyramided into two sorghum cultivars, CSV 20 and CSV 27. A new genic SSR marker Sb-bmr12 was developed for effective marker-assisted gene pyramiding. A high-density intraspecific consensus linkage map of 11 pigeonpea chromosomes comprising 932 markers that span a total map length of 1,411.83 cM was developed. Profiling of 23 varieties of *Brassica rapa,* 49 of pigeonpea and 13 of little millet was carried out using SSR markers. The genome sequencing of Indian jute variety JRO 524 (Navin) was accomplished. An *in-vitro* culture technique called 'Embryo Rescue' was employed for plantlet regeneration in cotton, which otherwise may be impossible in normal conditions. For the first time, efficient *in-vitro* callus induction and regeneration from mature seed explants in *Sehima* was reported. During 2016-17, total breeder seed production in field crops was 121,988.5 q against the indent of 104,045.7 q.

A total of 33 varieties of horticultural crops comprising 10 in fruits, 3 in plantation crops, 9 in vegetables, 3 in tuber crops, 2 in spices, 5 in medicinal plants and one in mushroom, were developed during the reported period. Tomato, Kashi Adarsh, a semi-determinate variety was selected, while Kashi Shivani, a high-yielding ridge gourd variety was released for green fruits. Kufri Mohan, a potato variety, with medium maturity was found moderately resistant to late blight

and outperformed Kufri Bahar in northern plains and Kufri Jyoti in eastern plains.

Livestock improvement: Improvement of indigenous cattle breeds through Selection Project was conceptualized for the genetic improvement of Gir, Kankrej and Sahiwal cattle in their home tracts. The average age at first calving in Gir, Kankrej and Sahiwal were 1,343.5, 1,273.44 and 1,189.55 days, respectively. Frozen semen doses of Gir (68,407), Kankrej (2,995) and Sahiwal bulls (20,974), were produced at respective Germplasm units. Doses are available for Frieswal (1,937,000), Gir (121,848), Kankrej (111,690) and Sahiwal (83,802). Under Network Project on Buffalo Improvement (NPBI), Nili-Ravi, Bhadawari and Swamp breed centres are functioning as conservation and improvement units, whereas, Jaffarabadi, Pandharpuri and Surti breed centres are concentrating on field progeny testing and maintaining the elite herd for bull production and a breedable herd of 567. A novel tool, Kalrumpscale was designed for measuring 3D angular and linear orientation of buffalo external rump/pelvic surface. Under Mega Sheep Seed Project, units for Chhotanagpuri, Mandya, Mecheri, Sonadi and Malpura Sheep, worked for development and maintenance of nucleus flocks of the indigenous sheep breeds and distribution of superior breeding males and other necessary inputs. AICRP on Goat Improvement covered 13 tribal villages and contributed for a better livelihood security for tribal people as goats are major source of income to poor people in tribal areas and NEH region. Rani and Asha, faster growing pig varieties, are expected to benefit socio-economically weak communities in terms of their sustainable livelihood security but also to address the issues of pig production system under changing climatic scenario by improved production and productivity. Jharsim, a multi-colour dual purpose bird suitable for rural poultry production, showed 1.6-1.8 kg body weight at sexual maturity, and egg production 120-130 eggs/annum, which is almost double than that of local native chicken (55–60 eggs/annum). Under the conservation programme, Aseel birds were characterized phenotypically with multi-colour plumage and dark red colour pea comb. Under AICRP on Poultry Breeding, all the twelve centres are working on the development of location specific rural chicken varieties utilizing the local native chicken germplasm and elite layer and broiler chicken lines developed earlier under AICRP programme. Seasonality in breeding behaviour of guinea fowls was successfully broken for the first time by feeding them with 20% dietary protein and rearing under 18 hr photo-period. The cross of Nicobari (male line) and CARI Red (female line) was adjudged as the best cross combination for dual purpose, i.e. egg and meat production. Successful seed production technologies of Indian pompano (*Trachinotus mookalee*), pig-face bream (*Lethrinus lentjan*) and orange-spotted grouper (*Epinephelus coioides*) were developed for uninterrupted supply of quality fish seeds for coastal mariculture and open sea cage farming. The farming of Indian white shrimp, *Penaeus indicus*, is being popularized because Indian white shrimp can be farmed as an alternative to exotic white-leg shrimp (*Penaeus vannamei*). The population of hilsa (*Tenualosa ilisha*), an important food fish of Indian sub-continent, is declining rapidly. Its rearing in brackishwater earthen pond suggested the possibility of captive maturation and reproduction for seed production.

Crop management: A long-term tillage experiment in maize-wheat and rice-wheat system indicated that the wheat crop was not affected by tillage in rice or maize. To study the effect of resource conservation technology in pulse based cropping system, experiments conducted for sixth year revealed that system productivity in terms of chickpea equivalent yield was higher in zero tillage and offer residue incorporation. Enhancing crop yield per unit water use through improved agro-techniques involving sprinklers in summer greengram indicated higher stability in Samrat over IPM 205-7. Sprinkler irrigation resulted in less water use (26.3%) with higher water productivity (43.2%) and net return (28.4) over flood irrigation. The analysis of grain yield date after 43 years of experimentation under rainfed soybean-wheat system confirmed that only FYM treated plot provided an increase in the wheat equivalent grain yield than the first year. The average yield with application of 10 tonnes FYM/ha along with recommended NPK (6,730 kg/ha) recorded 106% higher wheat equivalent grain yield than recommended NPK. To minimize the requirement of cane (Sett) for planting, use of ethrel was found promising, which improved the germination and also advanced the germination by 15-20 days. A minimum 0.62% soil carbon (SOC) is required to sustain perennial guinea + cowpea-berseem based organic forage production. This level of SOC can be achieved in minimum 4 years by annual application of 65 tonnes FYM/ha. A liquid Bio NPK formulation containing nitrogen fixing, P solubilizing and K sulubilizing bacteria was developed and validated for performance. Bio NPK was validated for its yield contributing attributes for cereals, millets, pulses, vegetables, fibre and oilseed crops. Seed treatment with silver nanoparticles @ 2 ppm could contain the fungal infection (*Macrophomina phaseolina* and *Rhizoctonia bataticola*) by 33.33% in jute and 10% in chickpea seedling compared to 90 and 96.66% infection in untreated plants, respectively.

Intervention with center opening of canopy and cutting the cross branches, in 40-year-old sapota cv. Cricket Ball, trees recorded higher yield (35.50 kg/tree with 375 fruits/tree having 80.00 g fruit weight) compared with the control (18.50 kg/tree with 280 fruits/tree having 68.50 g fruit weight) at Arabhavi. Similarly, at Gandevi, rejuvenation of 36-year-old trees of sapota cv. Kalipatti by topping terminal growth of 1.0 m recorded higher yield of 178.27 kg/tree with 2,790 fruits/tree having fruit weight of 64.1 g as compared to the control (138.0 kg/tree with 2,225

fruits/tree having 62.0 g fruit weight). In *rabi* season, integrated application of NADEP compost @ 25 tonnes/ha + biofertilizer (PSB+*Azotobacter*/*Rhizobium*) increased the yield of cabbage and pea by 12.8 and 23.5 %, respectively, over the conventional inorganic system. Drip irrigation in cassava at 100% of cumulative pan evaporation (CPE) resulted in 400% increase in tuber yield of cassava (44 tonnes/ha) compared to the rainfed crop (11 tonnes/ha) in summer. It resulted in 30% increase in tuber yield and 50% saving in water consumption compared to surface irrigation. The insect-proof net covering walk-in-tunnel gave maximum seed yield of 22.7, 25.4 and 8.2 q/ha in fennel, dill and cumin, whereas plastic sheet covered walk-in-tunnel gave maximum seed yield of 28.73 q/ha in fenugreek. Vertical walls of plastic sheet were also effective to reduce the frost damage and improve seed yield of coriander and fenugreek. The green and black shaded net were more effective for production of off-season leafy coriander and fenugreek than white and red shaded nets in June and July. The DMRO 327 was the best strain of mushroom with maximum BE of 60.23%. The production technology of king oyster on saw dust based substrate supplemented with organic nitrogen materials with a biological efficiency of 30% was standardized. Nine out of 13 bee species as active pollinators of cashew are wild bee. The CIARI Bio-Consortia was tested in different field conditions for management of bacterial wilt in brinjal. An entomopathogenic fungus, *Lecanicillium psalliotae,* is so far the first report on its application in management of cardamom thrips in India. It is recommended as 3-4 times soil application during May – September, for effective control of thrips.

Livestock management: Distillers' grains (DG) are considered a good sources of protein for dairy cattle, and can replace the protein source in their diets. The supplementation of molasses based multi-nutrient supplement (MMS) (250 g/buffalo/day) improved milk yield by 16-18% and can replace 7.5% concentrate mixture without having any adverse effect on lactating Murrah buffaloes. Supplementation of 10% linseed and 5% Ca-soap in the diet of finisher lambs significantly increased ω-3 fatty acids and CLA content in adipose tissue and in *Longissimus dorsi* (LD) muscle of lambs. CLA enriched mutton possesses numerous health benefits, including anti-cancer properties. Nanocalcium carbonate and nanocalcium phosphate prepared as calcium supplement showed 15-20% better absorption than conventional calcium supplements in camels. Maize silage was prepared in polythene bags (500 kg capacity) at an altitude of 2,800 m above msl to mitigate winter feed crisis and supplement green fodder in the form of silage to yaks. Supplementation of nano-zinc at reduced levels in diet (80-7.5 mg/kg) improved feed efficiency, reduced lipid peroxidation and improved glutathione peroxidase activity and SOD in spleen and liver in broiler chicken. In the process of clean poultry production, efficacy of synbiotics, improved feed conversion ratio (FCR), immunity, and survivability of poults than those fed either prebiotics or probiotics in growing turkey poults. Comparison of milk metabolite profile from *Bos indicus* cattle raised in intensive system of management with that of maintained under extensive system revealed that grazing cattle have favourable milk composition characteristics and can be assigned special value, which can become an important tool to maintain native genetic resources characterized by low production levels. Feed supplement comprising a source of energy, protein and an antimicrobial agent, increased average milk fat from 2.59 to 3.85%, and improved conception in 76% animals that had reproductive problems. The 'Doublesynch' and 'Estra-doublesynch' estrous synchronization protocols along with fixed time artificial insemination showed more than 80% success in conception rate in problematic cows and buffaloes in field conditions. Salivary fern patterns and RNAs proved new tools for estrus determination in buffaloes. Species-specific semen extender was developed for buffalo based on its sperm structure and seminal plasma composition because average post-thaw motility and fertility of frozen-thawed buffalo spermatozoa is substantially low compared to that of cattle sperm. IGF1 proved as sperm motility enhancer for developing a species-specific semen extender for buffaloes. A single semen diluent, was developed for chicken, duck, turkey and Guinea fowl, which can help in easy transportation of elite poultry semen throughout country as well as internationally by air; hence, may prove vital in maximizing the multiplication of elite germplasm. Monthly disease forewarning information about the possible occurrence of important livestock diseases was sent to DADF and other state animal husbandry departments two months in advance to take up suitable preventive measures. As per the NADRES report, foot rot, hemorrhagic septicemia (HS), black quarter (BQ), enterotoxaemia (ET), glanders and anthrax were the predominant bacterial diseases; *peste des petits ruminants* (PPR), capripox, bluetongue (BT), rabies and classical swine fever (CSF) were major viral diseases; and fasciolosis, amphistomosis, anaplasmosis, babesiosis, coccidiosis and trypanosomosis were frequently reported parasitic diseases from the country. Fluorescent polarization assay (FPA) for sero-monitoring of brucellosis in livestock, was developed and validated. The kit was transferred to ADMaC core Lab-I to generate the epidemiological data on brucellosis in north eastern states. Estimation of economic losses due to pox infection in sheep and goats at assumed 1% annual incidence levels revealed the total estimated loss as ₹480.72 crore. A questionnaire was developed to assess the risk factors for occurrence of porcine reproductive and respiratory syndrome (PRRS). Phage lysate candidate vaccines against *Brucella abortus* and *Pasteurella multocida* were developed. Diagnostic methods were developed for detection of Japanese encephalitis infection in pigs; rotavirus group A infection in animals; Newcastle disease virus in the vaccine

formulation, with diagnostic specificity 100% and diagnostic sensitivity 95%; four extraneous agents MDV, EDSV, CIAV, and avian mycoplasma in poultry and cell lines of avian origin; classical swine fever virus (CSFV) and haemoparasitic diseases. Infrared thermal imaging technology could be used as a potential non-invasive, quick cow-side diagnostic technique for screening and early detection of subclinical and clinical mastitis in crossbred cows.

Bone and tendon biomaterials were prepared for healing the lost bone and tendon tissues through use of tissue engineering techniques. Nano structured hybrid polymer of catechin increased *in vitro* antioxidant property, enhanced bioavailability and drug releasing property denoting its potential use as a hepatoprotectant. Nano-based test was standardized as colorimetric detection test for *Mycobacterium avium* subspecies *paratuberculosis* (MAP) in milk samples with 100% specificity. Marine fish landing during 2016 was estimated as 3.63 million tonnes, asserting an increase of 6.6% compared to that of 2015. Gujarat remained the major producer followed by Tamil Nadu and Karnataka. Guidelines, Indian Marine Fisheries Code (IMFC), were developed to put in practice the FAO's Code of Conduct for Responsible Fisheries (FAOCCRF 1995), and to change the manner in which marine fisheries is managed in the country. Tilapia lake virus (TiLV), a threat to global tilapia industry, was detected from West Bengal and Kerala. This is the first report of TiLV from India. Alerts were issued to State Fisheries Departments and other stakeholders for preventing its spread.

Mechanization and energy management: A planting machine was developed to carry out bund forming, fertilizer placing, mulch laying, drip laying, pressing, punch planting and covering, in a single pass to reduce labour, time and cost as compared to traditional practices. The cost of the complete system is ₹ 5.5 lakh and cost of controlled puddling with this system is ₹ 2,300/ha. Planting of cassava is tedious and expensive, usually done manually by women labourers (20 days/ha). The estimated cost of the planter is ₹ 95,000 which covers 0.36 ha/h @ row to row spacing of 90 cm. The overall discomfort rating (ODR) was 38% lesser than traditional method due to reduced bending posture. A gender friendly double lever hand-held vegetable transplanter was developed for transplanting of vegetable plug seedlings in soil or plastic mulch bed. The traditional practice of manual weeding in paddy requires about 300 man-h/ha. Presently no mechanical weeder is available for intra-row weeding of field crops. To counter these problems a five row paddy weeder was developed, which showed zero percentage of intact weeds in inter-rows and 71% of the weeds were destroyed for intra row. The SPAD meter, a portable unit, may be used by KVKs, SAUs, ICAR Institutes and farmers for indirect estimation of chlorophyll content of crop leaves and subsequent assessment of nitrogen requirement of the crop. The vertical boom type air assisted sprayer with sensor attachment was developed to deliver the precise amount of chemicals to match the tree configurations and reduce pesticide use and environmental pollution. Use of pneumatic cotton picker saved 36% time and 58% cost as compared to conventional method. A cost effective electric motor operated two-way garlic stem and root cutter was developed for reduction of human drudgery with increased output capacity. To meet the future requirement of energy and food, an agri-voltaic system was developed in which electricity generation, crop production and rainwater harvesting can be done on a single land unit. Such system of 105 kW capacity was established at ICAR-Central Arid Zone Research Institute, Jodhpur. The cost of installation was about ₹ 52.33 lakh for 105 kW systems and annual income will be about ₹ 7.5 -8.0 lakh/ year. An existing machine was upgraded to perform stubble shaving, off-barring, root pruning and fertilizer placement (SORF) operations under trash mulched conditions with 12.6% higher B:C ratio. Water pumped by solar pumping systems was used for agriculture and for augmentation of the adjoining ponds to be used for fish production. A community-based solar lift irrigation system was developed on Kuwari Rivulet, Madhya Pradesh. The crop yield increased compared with crop grown before installation of solar irrigation system. Besides, system also generates 10,000 watts electricity through 40 solar panels (each panel of 250 watts)

Post-harvest management and value-addition: A process, standardized for the production of pectin from dried kinnow fruit waste, resulted in 10 to 11% purified pectin as compared to commercial processing (6 to 7%). The honeycomb structured packaging material, developed based on the average size of fig fruits, effectively minimized transportation losses (< 2%) in fresh fig fruits and enhanced shelf life from 3 to 5 days compared to conventional packaging practice. Application of citronella based microcapsules, having mosquito repellent properties, on cotton fabric showed 100% mosquito repellent property with finish durability up to five washes. Turmeric value chain machinery consisting of turmeric washer, turmeric cooking vessel, turmeric dryer and turmeric polisher was developed. Kalpa drinking chocolate was produced by a unique technology that makes the product soluble instantly in hot or cold milk releasing the chocolate aroma. Papaya fruit bar was prepared, which is safe and meets dehydrated fruit requirements standards of FSSAI. This technology has potential to encourage small-scale processing units in rural areas. Technologies were developed to improve the shelf life of small and large broccoli, coriander leaves, carrot and garlic cloves. Potato starch can be used for starch based films and also as replacement of polypropylene owing to its higher strength. Farmers adopted a technical intervention which enhanced gum arabic production by more than 10-times from each tree of Acacia senegal. For routine monitoring of pesticides under field application, spore enzyme sensor on paper strip was developed, which

is rapid, cost effective, reproducible, selective and sensitive to larger groups of pesticides at their regulatory limits, and was protected (Application no. 3819/ DEL/ 2015). A method was developed for measuring the intact mass of beta casein variants (A1 and A2 type) in milk. Hard grade sandesh packaged in polystyrene trays and sealed with bionanocomposite film was acceptable at the end of 10 days of storage at refrigeration temperature. A new method for enrichment of caseino-phosphopeptides (CPPs) along with mineral (iron and zinc) was developed. Quality and time-temperature indicator sensors were developed to assess the change in quality and temperature abuse conditions of chicken meat stored at different temperatures. NRC on Meat developed the protocols for organic sheep production, and recently received organic livestock certification from Organic India. A braiding process technology was developed for the use of coarse wool in preparation of furnishing items. Industrialization of poultry farming generates poultry wastes, which is posing many environmental and health threats due to lack of disposal methods. A DAC technology, developed for all-weather biogas production has the capacity to convert excreta of 5,000 layer birds into biogas and manure worth around ₹ 1.31 and 2.56 lakh/ annum, respectively. Besides, financial gains to poultry farmers, this technology affected environment by drastically reducing pollutants, bad odour and flies. Omega-3 (ω-3) polyunsaturated fatty acids (PUFAs) play significant roles in human health, hence food fishes were classified into lean fish (<2% fat), low fat fish (2-4% fat), medium fat fish (4-8% fat) and high fat fish (> 8% fat) based on their fat content. An anti-obesity nutraceutical product, Cadalmin™ Antihypercholesterolemic extract (CadalminTM ACe), which is effective in combating dyslipidemia and obesity was developed and commercialized.

Agricultural human resource development: The Agricultural Education Division continued to strive for maintaining and upgrading quality and relevance of higher agricultural education in the country. Financial support was provided for constructing 27 new student hostels, including 17 girls' hostel for gender mainstreaming, 3 auditoriums and 6 examination halls for strengthening infrastructure and student amenities, Niche Area of Excellence (15, including one new), Experiential Learning (10 new), besides refurbishing and maintenance of educational structures, student and faculty amenities, course curricula revision, strengthening libraries with ICT and modernization of teaching with multimedia learning resources, etc. HRD programmes/activities facilitated promotion and execution of ICAR sponsored schemes that include centralized admissions in UG/PG and Ph.D. to reduce inbreeding, infuse merit and promote national integration; award and distribution of fellowships to attract talent and promote merit; admission of foreign students for globalization of agricultural education; capacity building of faculty through Summer-Winter Schools and Centre of Advanced Faculty training; National Professor and National Fellow programmes for promotion of excellence; and Emeritus Scientist programmes as a structural method of utilizing skill bank of the outstanding superannuated professionals. Quality assurance of AUs was ensured through accreditation. Several new initiatives, viz. ranking of universities, declaring UG degrees in agriculture and allied subjects as professional monitoring and review of fund utilization etc., have been introduced during the current year.

Social sciences: The Government of India in its annual budget of 2016-17, for the first time, indicated a change in policy stance from excessive emphasis on food production towards improving farmers' income, and has set a target of doubling it by 2022. Six broad thematic groups, related ministries and operationalised developmental programmes were identified for mainstreaming climate change adaptation (CCA) in India is still in its preliminary stage. Incorporation of local knowledge and strategies in dealing with the climatic aberrations form a significant supplement to the decision making process both in district and state level plans since the adaptation integration process requires synergy between all the decision making levels. The Network Project on Market Intelligence provided reliable and timely price forecasts to farmers for major agricultural commodities throughout the country to facilitate informed-and intelligent-decisions by the farmers. The study on resource use efficiency and identification of the determinants of technical efficiency of paddy, wheat and cotton crops in Punjab, found that reallocation of inputs saved money; farm size and education level of head of family significantly affected efficiency; and number of fragments, and bio-abiotic stress negatively influenced the technical efficiency. Study on ICT initiatives in NARS revealed that the productivity of faculty improved by increasing availability and use of ICT initiatives. The government of India intends to reach the research intensity of one per cent of AgGDP as higher allocation of public fund and well qualified scientific manpower will strengthen India's position as a major provider of agricultural R&D services globally.

Statistics and computer applications: Union Minister for Agriculture and Farmers Welfare inaugurated the ICAR Data Centre and launched the KVK Mobile App at ICAR-Indian Agricultural Statistics Research Institute, New Delhi. ICAR Data Centre provides the ICT infrastructure for hosting the web applications developed by ICAR Institutes; and the unified messaging solution (https://mail.icar.gov.in) of all ICAR personnel under single ICAR domain for effective communication. ICAR Data Center is ISO-27001:2013 certified for Information Security and ISO 20000-1:2011 for IT Service Management System. The Management System for Post Graduate Education, was implemented for IARI, CIFE, NDRI and CAU. PMIS, a workflow

based system, was successfully implemented for posting of newly recruited scientists and online transfer process in ICAR. A mega team of ICAR scientists from ICAR-IIPR, Kanpur and ICAR-IASRI, New Delhi has successfully reported candidate genes and pathways of herbicide tolerance in chickpea for the first time in the world (http://journal.frontiersin.org/article/10.3389/fpls.2017.00958/full). These findings can be of immense use in improving productivity of chickpea germplasm with better ecological and food safety. Genetic code of fungus *Atheliarol fsii*, the causal agent for groundnut stem rot, was successfully sequenced for the first time in the world (https://www.nature.com/articles/s41598-017-05478-8). This finding will pave the way of genome based solution in stem rot disease management, leading to better productivity of groundnut crop in tropical region of the world. Sampling methodology for estimating crop area, yield and production under mixed and continuous cropping was developed, tested and validated in Indonesia, Rwanda and Jamaica. A suitable sampling methodology aligned with existing Input Survey for estimation of private food grain stock and post harvest losses at farm level, was developed. This will provide farm level reliable estimates of food grain stock including post-harvest losses at district level. An android based free mobile application Vanami Shrimpapp, provides information on better management practices of Pacific white shrimp (*Penaeus vannamei*) farming.

Empowering women in agriculture: Empowerment in Crop Production Index (ECPI) was developed, tested and verified for integrating gender perspectives in agricultural research and extension. Gender Knowledge System Portal, having data on gender friendly technologies, information and statistics, publications and schemes, may serve as sources of inputs for researchers in formulation of projects. Tools and implements repository, database on gender friendly tool packages for paddy, vegetables and maize, checklists and test protocol for hand ridger were developed under the project Ergonomic Studies for Increasing Work Efficiency and Productivity of Farm Women. Projects entitled Developing competency of rural youth in agriculture through vocational intervention and Sensitizing rural families for management of youth were carried out. A Counseling centre, established at Hatichungi Komar Gaon, AAU, Joraht, is helping youth having the socio- emotional problems and make them financially independent.

Information, communication and publicity services: The Directorate of Knowledge Management in Agriculture is committed to promote ICT driven technology and information dissemination system for quick, effective and cost-effective delivery of messages to all the stakeholders in agriculture. 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 DKMA organized a two- day National Workshop on 'Developing a Roadmap for Agricultural Knowledge Management in India" at NASC Complex, Pusa, New Delhi from 27 to 28 September 2017. The strategic policies to be developed for content development, infrastructure and manpower for Knowledge management in agriculture at ICAR-DKMA were discussed at length. ICAR-DKMA has developed an ICAR-Public Interface, *e- Krishi Manch*. The top ten countries those read ICAR literature are China, Iran, Turkey, USA, Pakistan, Egypt, Mexico, Brazil, Philippines and Indonesia. Research journals have 55,405 registered readers and total registered users on the e-publishing platform of research journals are more than 75,000. Viewership analysis revealed that on this portal—total sessions were 253,376 by 139,865 users, and they viewed 1,459,581 pages in 188 countries. Consortium for e-Resources in Agriculture (popularly known as CeRA) is the first of its kind for facilitating 24×7 online access of select journals in agricultural and allied sciences to National Agricultural Research and Education System (NARES) through IP authentication. Currently CeRA is subscribing to over 3,900 journals and 1,174 e-books to 152 member institutions of NARES. During this period over 23 lakhs of full text journals were downloaded by member institutions of CeRA and over 5 thousand Document Delivery Requests were successfully fulfilled.

Technology assessment, demonstration and capacity development: National Agricultural Research System (NARS) of the country has taken up several activities through Krishi Vigyan Kendras (KVKs) and other programmes for application of farm technology in farmer's field. Extension programmes organized were: training courses (38,941) benefiting 11.31 lakh farmers and farm women; skill-oriented training courses for 1.75 lakh rural youth; and capacity development programmes for 1.14 lakh extension personnel, out of which 28,614 (25%) were women personnel. KVKs organized 6.07 lakh extension programmes for 147.50 lakh participants. During the year, 9.67 lakh quintal seeds, 459.49 lakh quality planting materials and bio-products, namely, bio-agents (94.46 q), bio-pesticides (1,771.67 q), bio-fertilizers (2,935.23 q), vermicompost, mineral mixture etc. were produced at KVK. As many as 90,532 SMSs were sent to benefit 627.23 lakh farmers on various aspects of agriculture. ICAR-Agricultural Technology Application Research Institutes (ATARIs) upgraded the knowledge and skills of 5,362 staff of KVKs by arranging 100 capacity development programmes. The major thrust of *Sankalp-Se-Siddhi*, country level awareness programme, was to create mass awareness about government of India's commitment for doubling farmers' income by the year 2022; 4.5 lakh farmers participated in the programmes. Pulses seed hubs, have been set-up at 97 KVKs for production of quality seeds of major pulse crops. The KVKs created awareness about *Pradhan Mantri Fasal Beema Yojana* (PMFBY) in which farmers need to

pay a very low premium. ARYA project under, 930 different entreprises were established benefiting 2,467 rural youths. Under Farmer FIRST project 51 FFP (Farmer FIRST Programme) centres spread over 20 states of India were funded. KVKs organized skill development training in 30 job roles in which 3,778 rural youths participated.

Research for tribal and hill regions: The maize hybrid, Central maize VL Baby Corn 2 (resistance against turcicum leaf blight, maydis leaf blight, common rust and PFSR) and central maize VL 55 (moderate resistance against maydis leaf blight, common rust and PFSR), were released for the West Himalayan, Central India and Deccan plateau states (except Kerala). VL Dhan 158 (highly resistant to blast) was released for the rainfed upland (June sown) ecosystem of Uttarakhand and Himachal Pradesh. Diversification of rainfed upland rice system with vegetable, pulses and millets was more profitable in Eastern Plateau and Hill Region. *Cuscuta reflexa*, *Cephalo texas*, *Rhus semialata* and *Arisaema tortusum* showed potential for development of non-steroidal anti-inflammatory drugs (NSAIDs). Compound 1 (gallic acid), isolated from *Rhus semialata*, when tested for anti-cancer activity against U937 breast cancer cell line, significantly reduced the cell viability in a dose-dependent manner. Demonstration of grow-out farming of silver pompano, *Trachinotus blochii*, in marine sea cage was launched to popularise cage culture technology of marine fin fishes among the fish farmers in South Andaman. Freshwater fishes *Mugilogobius tigrinus*, *Redigobius oyensii*, *Brachydanio rerio* and marine fish *Tomiamichthys russus* were reported for the first time from Andaman Island.

Under the Tribal Sub Plan (TSP), a watershed was developed at Bernia, Rajasthan, where availability of water was improved by increasing capacity of the existing village pond or nadi, connecting the pond to farmers' field with a channel and constructing three rainwater harvesting tankas. *Kharif* crop yield increased over the traditional cropping practices of the farmer, and survival of various fruit trees varied from 60-80%. Adoption of tuber crops based farming system by the Nicobari tribal communities increased employment generation from 41 man days/year in their traditional system to 101 days/year. Its success attracted more tribal youths and they came forward to adopt the system as their livelihood options.

Organization and management: The workflow based transfer application module consisting of different phases of transfer cycle was developed. This is accessible through the on-line module ICAR Personnel Management Information System (PMES). The on-line transfer system was implemented on 23 May 2017. In alignment with UGC Regulations, the ARS Study Leave Regulations, 1991 were notified. Revision of guidelines for redeployment/ transfer/ diversion/ adjustment/up-gradation/re- designation of various positions in ICAR was made during the reported period. Further, disciplines, namely 'Agricultural Structures and Environmental Management' and 'Agricultural Process Engineering' were merged and named as 'Agricultural Structure and Process Engineering'. These disciplines have been implemented w.e.f. 17 April 2017.

Intellectual property and technology management: To protect new innovations, ICAR filed 101 applications from 31 ICAR institutions; these are at different steps of patent grant, viz. newly filed (20), published (50) and granted (31); taking the cumulative figure to 1,045 patent applications from 75 ICAR institutes. As the Protection of Plant Varieties and Farmers' Rights Authority notified new genera, a total of applications for 1,201 varieties (1,033 extant, 141 new, and 27 farmers' varieties) were submitted by ICAR at the Registry; out of these, 787 varieties were granted registration certificates. Six copyright applications were filed and their research outcomes include, data entry software for crop area and yield estimation survey; design of micro irrigation system (DOMS); mobile assisted personal interview version 1(MAPI ver. 1); statistical analysis of agricultural experiments part 1: single factor experiments Swarna Tripti; and Swarna Vasundhara (Soybean). A total of 110 filed copyrights have been thus recorded from 24 ICAR institutes. Applications filed by NRC on Meat, Hyderabad and CIFRI, Barrackporer, included: (i) Burger patty mould; (ii) Cage culture structure; and (iii) Tissue embedding machine. A total of 23 filed design applications have been thus recorded from 5 ICAR institutes.

This year 259 partnership agreements were finalized by 24 ICAR institutes with 154 organizations, and 44 individual entrepreneurs. These agreements were signed for 120 technologies of agriculture and its allied fields, viz. Animal Products and Processes (4); Biofertilizers (66); Dairy Products and Processes (10); crop varieties (47); farm machines and tools (5); fish base products and processes (25); food processing and value addition (74); plant protection (8); soil management (7) and textile (11).

Agri-business incubation (25) centres were supported/established in various institutes. These ABIs have undertaken different activities—Entrepreneurs/ Incubators admitted for incubation (173); Entrepreneurs/ Incubators graduated (56); Entrepreneur/ Startups Initiated their business (194); New products/ technologies developed under incubation (54); Entrepreneur Development Programme (EDPs) organized (60); Agri-business Development/Awareness Programmes Organized (63), Meeting Organized for Negotiations/ Technology Discussions (156). Technology Seekers/ Inventors/ Business People/ VIP/ VVIP/ Foreigners (6,066) visited these ABI Centers.

Technical coordination: During the reported period the Council provided financial support to 78 societies for the publication of Scientific Journals. In addition, Societies/association/universities were supported for

holding National Seminars/ Symposia/Conferences (85 Nos.) and International Seminars/Symposia/Conferences (31 Nos.). Annual Report (2016-2017) of DARE/ICAR was laid on the table of both the houses of parliament.

Award Ceremony, 2016: The Indian Council of Agricultural Research has been recognizing and rewarding the institutions, scientist, teachers, farmers and agricultural journalists every year. To commemorate 89 th Foundation day of ICAR, the Award ceremony was organized at NASC, New Delhi on 16 July 2017. Various ICAR Awards for 2016 were presented to the winners on the occasion. The awards were given to 19 farmers. It is heartening to note that of the 80 scientists, 13 were women. Three Institutes, two AICRPs, 12 KVKs were also awarded.

Finance: The Revised Estimates in respect of DARE/ ICAR for 2016-17 was ₹ 6,238.00 crores. An internal resource of ₹ 275.15 crore (including interest on Loans and Advances, income from Revolving Fund Schemes and interest on Short Term Deposits) was generated during 2016-17. The total allocated Budget Estimates for 2017-18 is ₹ 6,800.00 crore.

Partnership and linkages: A Declaration of Intent (DoI) was signed between the Ministry of Agriculture and Rural Development of the State of Israel and the Ministry of Agriculture and Farmers Welfare of the Republic of India for Cooperation in the field of agriculture. Delegations from Germany, UAE, Seychelles, Suriname, Republic of Namibia, Thailand, Norway met the ICAR authorities to discuss issues of mutual interest. Centres. Syllabi were developed for the M.Sc. courses of Afghan National Agricultural Sciences and Technology University (ANASTU). Similarly, revision of Course Curriculum for Post Graduate students of Yezin Agricultural University (YAU), was completed. India is now one of the voting members in the CGIAR System Council. Additional Secretary (DARE) & Secretary (ICAR) is the official member in the CGIAR System Council from India. AgrInnovate India Limited has earned net profit of ₹ 21,052,092 in 2016-17 as against net profit of ₹ 24,670,104 in Financial Year 2015-16. The Board has approved the Guidelines for commercialization of technologies developed under ICAR and institutions under National Agricultural Research System (NARS) for implementation by the Company.

Supporting basic and strategic research: The National Agricultural Science Fund (NASF) with an outlay of ₹ 164.5 crore from 2017-18 to 2019-20, has funded 145 projects, out of which 64 are on-going projects and 61 are multi-institutional. The NASF approved 32 projects and remaining proposals are in the process of being evaluated. The workshop on Transgenic Chickpea and Pigeon Pea - Way Forward, recommended that all the *Cry* 1 Ac events across centres need to be evaluated at IIPR, Kanpur. The transgenic rice plants tolerated up to 6× dosage of glyphosate without any visible harm to the transgenic plants, whereas the control plants dried and died at the recommended dose of glyphosate. 1-hydroxy-3-methyl anthraquinone (IH3MAQ) demonstrated reduction in fungal growth in comparison to the other analogs. Significant positive effects of elevated CO_2 and temperature on plant growth parameters, pod attributes and grain yield were observed in soybean-wheat cropping system. Interaction of eCO_2 and N can be exploited in modulating the EPS producing bacterial population, thereby affecting the total EPS/ soil carbohydrate, which will alleviate soil moisture deficit stress. Biochemical and endocrine parameters revealed that high serum free fatty acids and low leptin levels are concerted negative energy balance (NEB) indicators in buffaloes. On the basis of these parameters, NEB was found to be confined to 1-1.5 months of postpartum in buffaloes.

Strengthening the research system: The ASRB recommended 15 applicants on lateral entry basis, comprising eight Directors, two Project Coordinators and five Head of Divisions, during the period. Recruitment process was deferred due to the proposed revision of score card for direct recruitment. In combined examination for ARS (preliminary) 2016 and NET 2017(I), 21,740 candidates registered for the examination and 2,563 (16%) candidates qualified. A total of 42,937 candidates registered for NET (I)-2017 examination; and 6,987 candidates (22.45%) have been qualified in this.

Training and capacity building: The ICAR is pursuing the systematic approach to training and capacity building of all categories of employees. The complete training details of Scientists, Technical, Administrative staff and SSS are now available in the system. Identified and updated 136 training need areas for Scientists, 56 for Technical, 39 for Administrative and 31 for Skilled Supporting Staff during 2016-17. For the first time, training programmes on Enhancing Efficiency and Behavioural Skills, Automobile maintenance, Road Safety and Behavioral Skills were organized. During the reported period, 4,391 employees were trained, about 23.4 % of the total employees in ICAR.

I hope that the report would be useful for policy-makers, planners, development-agencies, researchers, farmers and students alike. It will go a long way in making Indian agriculture a profitable venture and attract youths in adopting agriculture as their profession.

(T Mohapatra)
Secretary
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and
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2. Soil and Water Productivity

Agro-ecological Region (AER) map updated: Agro-ecological Regions Atlas of India prepared in 1992, was updated by the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) based on length of growing period (LGP) information for over 450 locations, soil and climate, information at finer scale, geographical and biodiversity data, and ecological and land use information. The New Atlas is useful for drawing up integrated land use plans for sustained and increased ecologically sensitive, and environmentally safe agricultural production systems.

Potential crop zones delineated: Area/region-specific **e**fficient 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 the relative spread and productivity of reference crops and cropping sequences. The soil and site suitability evaluation maps were developed for paddy, rubber and spices cultivation in Kerala, and rice, sugarcane, groundnut and cotton in Tamil Nadu.

Web-based decision support system (DSS): The NBSS&LUP in collaboration with Bhaskaracharya Institute for Space Application and Geo-informatics, Department of Science and Technology, Government of Gujarat, Gandhinagar, developed an android-based mobile application on GIS platform to facilitate web-based decision support system (DSS) for land use planning and dissemination of soil health cards information at village and farm level for Gujarat. The main menu of the App contains five options, viz. soil parameter, suitable crops, fertility map of survey number of interest and technologies of ICAR/SAU. Depending on requirement of information, one can select district, taluka and within the taluka desired village, followed by survey number of interest. App will display details of soil map unit information and suggested land use plan for that survey number.

LRI based land use planning: The NBSS&LUP is preparing Land Resource Inventory (LRI) of different blocks in the country on 1:10000 scale to work out block level agricultural land use plan. So far, LRI of 99 blocks have been completed.

Basudevpur Block, Bhadrak District, Odisha: The Zn deficiency status in soils of AESR 1.2,6.4, 14.1, 14.2 and 16.2 was recorded lesser than 10%, while soils of AESR 7.3, 12.3, 14.2, 14.4, 15.1, 15.3, 16.3, 17.1, 18.3 and 19.1 falls in 10-20% deficiency range. The soils of these regions are mostly acidic in nature containing high organic carbon content and sloppy land. The Zn deficiency is highest (> 50%) in soils of central (AESR 4.4, 10.1, 10.2 and 10.4), western (AESR 2.1 and 2.2) and southern (AESR 8.1, 8.2, 8.3 and 18.1) parts of India. In general, other AESR region falling in western India (AESR 2.3, 5.1, 5.2, 6.1, 6.2 and 6.3) are showing acute Zn deficiency as compared to north east, east and extreme northern part of India. The soils of AESR 4.1, 4.2, 7.1, 9.1, 11, 12.1, 12.2,

Soil characterization and management

Geoportal 'BHOOMI'

The NBSS&LUP developed NBSS BHOOMI Geo-portal to access various thematic information on major physiographic regions of India, sub-physiographic regions of India, agro-ecological regions (1992), agro-ecological regions (2015) and agro-ecological sub-regions of the country. The point database for benchmark soil information of India for 300 sites, state-wise soil series of India for 18 states (3,795 sites), soil series database for 22 districts (495 sites), grid point data on soil physical and chemical properties of 752 NATP (National Agricultural Technology Projects) sites and soil fertility data (20,7269 sites) were processed and uploaded on Geoportal.

14.5, 18.4 and 19.2, are showing 20-30% Zn deficiency.

The B deficiency occurs predominantly in eastern (AESR 12.1,12.2,12.3 and 15.1), north east (15.2 and 16.3) and extreme north (14.1 and 14.3) and south western (6.1, 8.2 and 8.4) parts of the country where soils are acidic in nature. Boron deficiency is lesser than 10% in central (AESR 4.4, 10.1,10.2,10.3 and 10.4), western (AESR 2.1 and 2.2) and south eastern (AESR 7.3, 18.2 and 18.3) parts of India. The soils of AESR 1.2, 7.2, 9.2, 11,13.1,19.2 and 19.3 are exhibiting B deficiency in the range of 20-30%. These digitized maps of micronutrients status would be helpful in providing site-specific variable rate application of micronutrients prescription for sustainable agricultural productivity.

***Leucaena* Biochar:** Biochar, a product of slow pyrolysis of biomass, can enhance natural rates of carbon sequestration in soil, reduce farm waste, and improve soil quality. The amendment effect of *Leucaena* biochar was investigated in an incubation study in acid soil (pH 4.5) of northwest India. The mean increase in soil pH was 0.695, 1.35 and 2.0 unit at 2, 4 and 6% of biochar incorporation, respectively. Application of biochar significantly reduced ammonium content of soil, whereas nitrate N content increased by 3 and 5 times by application of 2 and 4% of biochar respectively. Exchangeable soil potassium and Ca+Mg concentrations increased with the application of biochar. Application of biochar above 2%, reduced exchangeable aluminum concentration to non-detectable limit. Thus, *Leucaena* biochar may serve as an amendment for N transformation in highly acidic soils.

Cost-effective check dam with plastic sheet head wall: Check dams were constructed using two thickness of sheets (10 mm and 15 mm) and 3.0 m × 1.5 m size for 1.2 m high head wall with MS angle frame, while other components of check dam were of cement brick masonary. A saving of 30-47% on cost was indicated without any effect on life and performance of the check dam. These plastic structures successfully withstood the monsoonal runoff and overflows without any notable damage. Such constructions will be very useful for instalation of quick and low cost check dam structures in remote areas.

Drainage solutions for waterlogged saline Vertisols: The subsurface drainage SSD system was installed in waterlogged saline soils (EC_e 3.4-41.0 dSm) at 2 locations of Bharuch district of Gujarat. The SSD was installed with two different lateral spacings (35 m and 40 m) at 1.2 m depth. These sites have gravity outlet condition and natural drainage channel was present along the boundary of one site. Local communities are being sensitized for the active participation for successful operation of these projects.

Cost -effective drainage solutions for waterlogged saline Vertisols

***In situ* decomposition technology for crop residues:** The crop yield was better in *in-situ* decomposition treated plot than removal/burning of crop residues. Such experiments were conducted at farmers' fields (20) in Haryana and Madhya Pradesh (20). Moreover, *in-situ* decomposition technique was tested at farmers' fields (20) in Maharashtra for sugarcane trash, wherein it took 45 days for *in-situ* trash decomposition.

Critical limits for heavy metals: Growth reduction of spinach crop due to high doses of lead was more in alluvial soil compared to black soil and absent in red and laterite soil. Chromium showed phytotoxicity only in alluvial soil. Soil Pb contents causing 20% reduction in above ground biomass yield of spinach were computed as 393 mg/kg for black soil and 168 mg/kg for alluvial soil. Similarly, soil Cr content causing 20% reduction in above ground biomass yield of spinach was computed as 265 mg/kg for alluvial soil.

Transfer coefficient of lead in alluvial soil was higher as compared to black, red and laterite soils indicating more uptake of Pb by spinach in the former soil. Transfer coefficient of chromium was lower in red and laterite soil as compared to black and alluvial soil. Heavy metals extracted by dilute (0.01M) $CaCl_2$ are considered available for plant uptake. Dilute (0.01M) $CaCl_2$ extractable Pb and Cr were strongly correlated to their concentrations in above ground biomass of spinach. A method of determination of critical limits of heavy metals in soil has been developed earlier. Determination of lead and cadmium concentration limits in agricultural soil and municipal solid waste compost through an approach of zero tolerance to food contamination was developed.

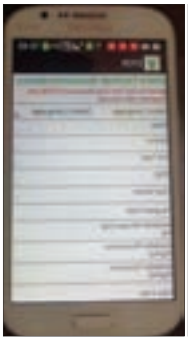
Maximum safe concentration limits (based on food contamination approach) of total and available (0.01M $CaCl_2$ extractable) Pb and Cr in different types of experimental soils

	Critical limits of total heavy metals		Critical limits of 0.01M $CaCl_2$ extractable heavy metals	
	Pb	Cr	Pb	Cr
Black soil	143	52	0.007	0.018
Red and laterite soil	78	332	0.002	0.071
Alluvial soil	84	87	0.006	0.034

STCR mobile App: Bilingual (Marathi and English) STCR mobile App for fertilizer recommendations of Maharashtra was developed in collaboration with

National Informatics Centre (NIC), Pune. Based on resource endowment capacity of farmers, the App helps realize the targeted yield of crops. Farmers can get the precise fertilizer recommendations based on soil test value and for a specific yield target. The STCR prescription equations for sugarcane, wheat, upland paddy, transplanted paddy, pearl millet, *kharif* sorghum, dryland *rabi* sorghum, finger millet, fodder maize, Bt cotton, groundnut, soybean, sunflower, pigeon pea, green gram, chickpea, okra, brinjal, cabbage, cauliflower, potato, tomato, turmeric, chill, onion, garlic, marigold, bitter gourd, banana, and maize are included in the STck mobile App.

ASTCR Mobile APP



Soil and water productivity

Groundwater storage: Using National Aeronautics and Space Administration's (NASA) Gravity Recovery and Climate Experiment (GRACE) data, groundwater storage changes in India were assessed, and the results were validated for the first time using *in-situ* observation. There was substantial groundwater depletion of about 1.25 and 2.1 cm of water equivalent height per year in the Ganges Basin and Punjab, respectively, known as the India's grain bowls. However, high volume of subsurface water storage loss is in the drought years, because of unsustainable pumping of groundwater to meet moisture stress. There was approximately 41, 44, and 42 km^3 losses in drought years of 2004, 2009, and 2012, respectively.

Sustainability of farming systems vis-a-vis inter annual rainfall variations: The AICRP on Integrated Farming Systems (IFS) is being operated in 24 states and 1 union territory covering all the 15 Agroclimatic regions of country. Through on station research, 38 region specific IFS models in 14 Agroclimatic regions along with business model (Bankable projects) were developed. These models indicated 2-3 times higher income than existing farming systems. Besides meeting the households demand of food, fodder and fuel completely fibre and fertilizer up to 65-80% could be met with. To know the effect of climate variability on sustainability and profitability of IFS model, five IFS models of different agro-ecosystems namely at Jorhat (Asom), Kalyani (West Bengal), Pantnagar (Uttrakhand), SK Nagar (Gujarat) and Thanjavour (Tamil Nadu) were studied.

The model having field crops, horticultural crops,

Farming system

livestock, fishery, and other components like vermicompost, biogas unit and composting unit developed in lower Gangetic plains agroclimatic region in Kalyani, West Bengal, recorded higher sustainability yield index (SYI) of 0.78, followed by a model having cropping systems, dairy, horticulture, vermicompost and water harvest developed under Gujarat plains and Hill Agroclimatic region in SK Nagar, Gujarat with 0.66 SYI.

The IFS model from area having more rainfall with less coefficient of variation (CV) showed higher sustainability yield index like IFS model of Kalyani, West Bengal with 1,396.0 mm annual rainfall with 15% CV was found to be the most robust model with 0.78 SYI. The higher CV (82.7%) for Jorhat which also falls under similar agro-ecosystems (humid) with SYI of 0.43 clearly indicated that inter-annual variation in rainfall has severe impact on sustainability of yield. A very strong but negative correlation between SYI and CV of annual rainfall, clearly showed that inter-annual rainfall variation has visible impact on sustainability of integrated farming systems.

Varieties for organic farming: Under Network Project on Organic Farming (NPOF), operating in 16 states for promotion, following best performing varieties of crops for organic farming were identified.

District Database of Agricultural Statistics: A database Management System was developed including district level data on land use classification (9 fold),

District Agriculture Contingency Plans

Best varieties of identified crops in different states

State	Season	Crop	Variety
Chhattisgarh	*Kharif*	Rice	Jayagundi CR Sugandh Dhan- 907
	Rabi	Chickpea	Vijay Daftari-21
Himachal Pradesh	*Kharif*	Okra	Chameli 015 Indranil
	Rabi	Pea	Ten plus Nirali
		Cauliflower	US-178 Chandra mukhi
	Summer	Tomato	Red Gold Hybrid 7730
Jharkhand	*Kharif*	Rice	MTU-10 Lalat
	Rabi	Wheat	K-0307 Raj-4229
Karnataka	*Rabi*	Chickpea	BGD 103 JAKI 9218
		Wheat	UAS 347 (bread wheat) NIAW 1415 (bread wheat)
Kerala	*Kharif*	Turmeric	Sudarsana Suvarna
		Black pepper	Sreekara Panniyur 1
Madhya Pradesh	*Kharif*	Soybean	RVS-2002-4 JS-20-41
		Maize	Kanchan-101 Proagro-4412
	Rabi	Wheat	GW-366 HI-8498
		Chickpea	JG-130 RVG-203
Maharashtra	*Kharif*	Rice	Sahyadri-5 Sahyadri-3
		Groundnut	Konkan Gaurav TG-26
Meghalaya	Pre-*Kharif*	Maize	DA-61-A RCM-75
	Kharif	French bean	Naga local RCM FB 18
	Summer	Tomato	MT 2
Punjab	*Kharif*	Basmati rice	Pusa Basmati 1509 Pusa Basmati 1121
	Rabi	Wheat	PBW 621 PBW 644
Tamil Nadu	*Rabi*	Rice	CB 05022 Mappillai Samba
Uttar Pradesh	*Kharif*	Maize	PMH -4 Seed Tech-2324
	Rabi	Mustard	RGN – 229 RH - 0406
Uttarakhand	*Kharif*	Rice	NDR-359 Pant Basmati 1
	Rabi	Wheat	HD-2967 UP-2565

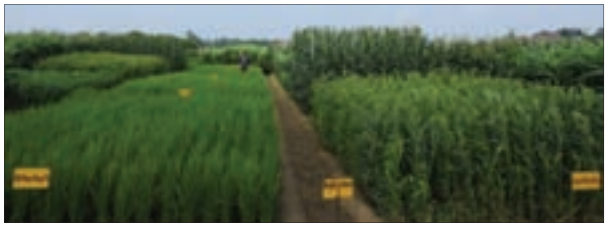
source-wise net irrigated area, indicators of extent of irrigated area, fertilizer consumption (N, P and K), monthly rainfall and crop-wise area sown, production and yield, and area sown with irrigation (for 20 crops) etc. Data included in database were validated. The database is useful for monitoring the progress made by districts with introduction of developmental programmes/ schemes operated by state and federal governments. It enables the researchers in selecting rainfed regions/ low productivity regions for sample/ case studies. A screen shot of trend (using line diagram) in area sown, area sown with irrigation and productivity in cotton in Warangal district of Telangana generated from web enabled Database Management System, was prepared.

Decision support system to bridge yield gaps in major rainfed crops: The Decision Support System (DSS) was developed for accommodating 15 rainfed crops, viz. rice, sorghum, pearlmillet, maize, fingermillet, chickpea, pigeonpea, blackgram, greengram, groundnut, soybean, sunflower, sesame, castor and cotton. User has to select a crop and a

district cultivating the crop. The DSS provides climate and available water-holding capacity (AWHC) of soil of district and share of irrigated area and of a particular season (in rice, sorghum, maize, blackgram and greengram) in area under the crop and yield of the district. The DSS gives unreaped yield potential and its percentage to potential yield and nutrient use in terms of N, P, and K and extent of adoption of HYVs in target district. Nutrient use in terms of N, P, and K and extent of adoption of HYVs were furnished for model districts also to explore scope for bridging the yield gap in those lines.

Decision support system for white fly in cotton: A weather-based decision support system for white fly in cotton was developed by AICRPAM, Ludhiana centre, PAU for Punjab. Favourable weather conditions identified for the pest are: heavy rainfall > 50 mm, T max (32-39 ºC), T min (22-28 ºC), Morning relative humidity (73-90%) and evening relative humidity (38-63%).

Diversification of rice-wheat system: A salt tolerant variety (CS58) of Indian mustard was developed for cultivation under moderate to high soil salinity and alkalinity conditions in Haryana, Uttar Pradesh, Punjab, Delhi and Rajasthan (North Western Plain Zone) with high seed yield and oil content. It produces seed yield of 2.0-2.2 tonnes/ha under saline and 2.6-2.8 tonnes/ha under normal conditions, about 25% higher than high-yielding control variety.



Diversification of rice-wheat system through climate resilient cropping in Eastern India

New varieties: Two varieties of *Cenchrus ciliaris*, CAZRI 358 and CAZRI 2178 and one variety of *Lasiurus sindicus* (CAZRI Sewan-1) were recommended for release. CAZRI Sewan-1 has an average green fodder yield of 156.8 q/ha which recorded 2.7 per cent higher than the overall mean (152.7 q/ha). Frequency in a group of top three genotypes was high (8/11) than the overall mean (5/11) for green forage yield. At Jodhpur (2014-2016), this selection produced 61.9 q green forage yield which was 29.0 per cent more than the general mean (48.0 q/ha). Likewise, genotypes recorded 29.1 per cent more dry matter yield than general mean (19.9 q/ha).

Rice establishment methods: Three rice establishment methods, viz. zero-till direct-seeded rice (ZT-DSR), ZT transplanting (ZT-TP) and conventional (puddle) transplanting (CT-TP) were evaluated during *kharif* 2016. The ZT DSR recorded maximum rice yield (5.14 tonnes/ha), followed by CT (5.05 t/ha) and ZT (3.89 tonnes/ha), respectively. In similar set during *rabi*, two pulses (chickpea and lentil) and three oilseeds (mustard, linseed, and safflower) were superimposed on *kharif* treatments with crop resides management, i.e. retaining 30% residue and without residues. Among establishment methods, maximum yield was recorded with ZTDSR compared to ZTTP and CTTP.

The ZT-DSR recorded significantly higher seed yield (1348.8 kg/ha), rice equivalent yield (3656.3 kg/ha) and system rice equivalent yield (6226.3 kg/ha). In residues management, significantly higher seed yield (1049.1 kg/ha) was recorded with residues retention of 30%. The highest rice equivalent yield (3271.2 kg/ha) and system rice equivalent yield (5799.3 kg/ha) were recorded with chickpea as compared to rest of the crops.

Wealth from waste

Lac mud is the waste product of lac processing industries which is about 2.5–4.5% on dry and wet weight basis, respectively, of the raw material (sticklac) processed. In absence of a proper disposal method of lac mud, it causes pollution. Enriched lac mud application ensures quality vegetable production, saving of inorganic fertilizers, improvement in soil fertility status and moreover it may give another diversified dimension to lac industry, which may be helpful to sustain the lac production system. Application of decomposed enriched lac mud in vegetables produced 22.0, 22.5 and 18.3% higher yield of brinjal, tomato and spinach, respectively, over 100% N through inorganic source (farmers' practice). This technology saves 48% of N and P fertilizers, and 65% of K fertilizer in brinjal and tomato. In spinach, similar saving in N and P fertilizers along with 36.6% saving of K fertilizers was recorded. Application of fortified lac mud in floriculture produced 31.7 and 38.5% higher flower yield of rose and chrysanthemum, respectively, over conventional method of manuring, ensuring saving of 5 kg and 700 g of manure/ plant in rose and chrysanthemum, respectively.

Crop management

Long-term effect of weed management: In wheat, major weed flora was *Medicago denticulate* (64.2%), *Vicia sativa* (10.9%), *Euphorbia geniculate* (7.0%), *Physalis minima* (4.4%), *Cichorium intybus* (3.9%) and *Phalaris minor* (3.1%) apart from these weeds like *Paspalidium* sp. (2.2%), *Sonchus arvensis* (2.2%), *Convolvulus arvensis* (1.7%) and *Chenopodium album* (0.4%) were also present in meager numbers. Among weed management practices, pendimethalin (750 g/

ha), followed by (*fb)* mesosulfuron + iodosulfuron (12+2.4 g/ha) registered 97.4% of weed control efficiency closely followed by mesosulfuron + iodosulfuron (12 + 2.4 g/ha) at 25 DAS *fb* 1 HW at 40 DAS. The highest grain yield (5.61 tonnes/ha) of wheat was recorded with two hand weeding (20 and 40 DAS) which was statistically comparable to mesosulfuron + iodosulfuron (12 + 2.4) *fb* 1 HW (5.48 tonnes/ha) and lowest with control (1.95 tonnes/ha).

In soybean, *Echinochloa colona* (26.0%), *Dinebraret roflexa* (10.6%), *Cyper usiria* (15.9%), *Euphorbia geniculate* (17.4%), *Convolvulus arvensis* (2.6%), *Commelina benghalensis* (16.2%), *Physalis minima* (1.9%) and *Phyllanthus niruri* (9.4%) were major weed flora. Among weed control measures, maximum weed control efficiency (93.7%) was recorded with two hand weeding (20 and 40 DAS), followed by imazethapyr (100 g/ha) *fb* one hand weeding (87.6%). The better weed control leads to harvest the highest seed yield (1.05 tonnes/ha) of soybean with two hand weeding followed by imazethapyr (100 g/ha) *fb* one hand weeding (0.86 tonnes/ha) and lowest with control (0.28 tonnes/ha).

Terrestrial weed based phyto-remediation system: The phyto-remediation system consisted of pretreatment overhead settling zone and treatment zone having three pairs of sequential tanks (3m × 2m × 0.75 m). The fast growing terrestrial weeds, *Typh alatifolia* and *Vetiveria,* were planted in two rows of tanks separately filled with porous media. The polluted water from waste water carrying drain was flown into overhead tanks subsequently to sequential treatment tanks. Thus, *Typha* treated, *Vetiveria* treated, tube well water and untreated waste water were used for irrigation.

Higher heavy metals were reduced by *Typha* than *Phragmite skarka*. Higher concentration of DTPA extractable cadmium was recorded in soil irrigated with untreated drain water as compared to *Typha* treated water. The effect of irrigation water on heavy metal uptake by Fenugreek indicated that among irrigation water treatments, higher concentration of DTPA extractable heavy metals were observed in plots irrigated with untreated drain water as compared to tube well water. Fenugreek in plots irrigated with untreated drain water absorbed higher concentration of manganese than tube well water irrigation. The EDTA significantly enhanced the manganese in leaf part of fenugreek.

Genetic diversity analysis: A total 107 entries were examined containing 92 entries of weedy rice germplasm with 12 cultivated and 3 wild rice accessions collected from different geographical regions. Genomic DNAs were extracted using DNA extraction kit with high purity. The polymerase chain reaction was carried out using 18 highly polymorphic SSR markers. The entries were grouped into three main clusters. Weedy rice accessions showed high degree of admixing among populations which indicates the gene flow due to their out-crossing nature while wild rice did not show any admixing or allele sharing.

Freshly harvested grains of different weedy rice biotypes, rice cultivars and wild rice biotypes were tested for germination on monthly basis in controlled conditions in environmental chambers providing favourable conditions for germination. Dormancy percentage was calculated taken into account number of ungerminated grains. Huge difference was observed in terms of dormancy percentage among different entries tested. After six months of harvesting, out of 45 entries, only 4 entries showed 0% dormancy. Fifteen entries exhibited 0-25%, 7 entries 26-50%, 10 entries 51-75% while 9 entries showed 76-100% dormancy.

Similarly, significant difference was observed in bulk density (BD) of treated soil. As compared to 1.34 g/cm^3 value of control, bulk density decreased by 7.5, 8.0 and 8.7% for 0.1, 0.2 and 0.3% hydrogel treated soil, respectively. Porosity of the soil, based on these BD values, was about 49% for control, whereas for treated soils it was above 53% for all three treatments showing *guar* gum based hydrogel as a potential soil conditioning material.

Performance of rice and wheat crops under different microirrigation systems: Future crop production will depend on improvements in water use efficiency for growing field crops as the groundwater table is depleting year after year. Therefore, a study was taken up by adopting microirrigation systems to minimize the quantity of water applied rice and wheat crops without effecting their yields. Irrigation treatments, viz. conventional irrigation; drip irrigation; rain hose; portable sprinkler and drip irrigation plus plastic mulching, were evaluated. In conventional irrigated crop all the conventional practices were followed but in other treatments crop intensification practices were adopted till transplanting/sowing.

Pusa-1121 variety of rice and Purna variety of wheat were evaluated during *kharif* and *rabi* respectively. In rice crop maximum number of effective tillers (274/m^2) were under drip irrigation plus plastic mulching.

Novel hydrogel

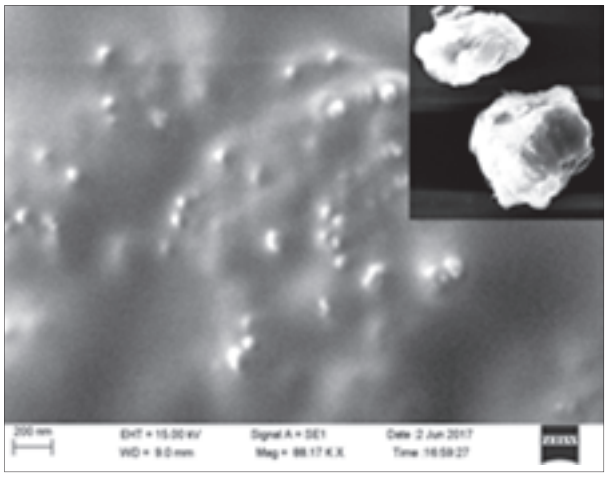
Water deficiency affects agricultural productivity, especially in arid and semi-arid regions, and to address this concern, natural gum based superabsorbent hydrogels were synthesized, characterized and evaluated as soil conditioners. Novel hydrogels were synthesized from *guar* gum (*Cyamopsis tetragonolobus*) and characterized by FT-IR, SEM and thermal studies. Characterization revealed highly porous, sponge like structure of hydrogels, which was thermally stable up to about 200°C. Hydrogels showed complete biodegradation within six months. Half-life period of synthesized hydrogel was about 77 days. Swelling studies of powdered hydrogel showed tremendous water absorption capacity, up to 600 ml distilled water/g hydrogel. Evaluation of synthesized hydrogels for their efficiency as soil conditioners revealed that treated soils showed geometric increase in water retention for 0.1, 0.2 and 0.3% hydrogel addition, as compared to the control. Water holding capacity of soil was noted highest with 0.3% dose, which increased up to 1.5 times as compared to the control.

Panicle length (29.3 cm), panicle weight (3.4g), number of grains/panicle (160), and grain yield (4.6 t/ha) were also maximum under the same treatment followed by drip irrigation. Water productivity was also maximum under drip irrigation plus plastic mulching (1.46 kg/m^3), followed by drip irrigation (0.79 kg/m^3), rain hose (0.74 kg/m^3), portable sprinkler (0.67 kg/m^3) and conventional irrigation (0.47 kg/m^3).

In wheat crop, maximum plant height (97.7 cm) was observed under the drip irrigation with plastic mulch followed by rain hose. Similar trends were observed for average number of effective tillers/ m^2 (580), ear head length (13.2 cm), ear head weight (3.9 g), number of grains/earhead (82). Grain yield (6.9 tonnes/ha) was also maximum under drip irrigation plus plastic mulching followed by rain hose (or perforated pipe) treatment (6.2 tonnes/ha). In conventional practice, grain yield was 4.9 tonnes/ha.

Fish

Green synthesis of sodium-bentonite nanoparticles: The seepage of water from ponds constructed on poor soil quality is a common problem in aquaculture. The high rate of seepage not only increases the cost of fish production but also make it difficult in retention of nutrient in water which is an important component of natural pond productivity. In order to reduce the seepage from such ponds, soil sealant can play very important role in using poor quality soil for aquaculture. The ICAR-CIFA, Bhubneswar has 'Synthesised Nanoclay' using matured coconut water (*Cocos nucifera* Linn.) as reducing agent and capping material. The characterization of nanoparticles showed bathochromic and hyperchormic shift and addition of weak vibration bands of aromatic compound indicating capping of nanoclay. SEM image showed intercalation of aromatic compound between the layers of nanoclay and thus these particles can help in sealing the leaky soils to a greater extent.



Green synthesis of sodium-bentonite nanoparticles using coconut water

Mapping brackishwater aquaculture resources

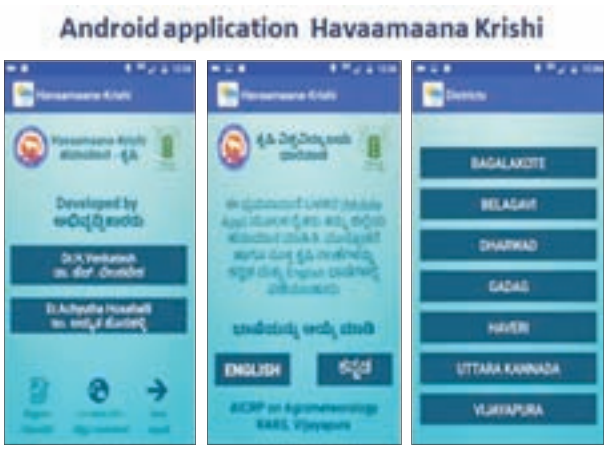
Mapping brackishwater aquaculture resources: One of the problems associated with brackishwater aquaculture is selection of the suitable sites for aquaculture and its leasing by the respective state governments. To generate precise data on potential brackishwater resources, the mapping of district Ramnadhapuram, Tamil Nadu was undertaken using GIS based multiple criteria decision support system (MCDSS) in a phased manner. Agricultural land, fallow land, settlement, water bodies and mudflat were the four major land use of the study area. The district has aquaculture in 921 ha, abandoned aquaculture in 62 ha, abandoned salt pan 325 ha, salt affected land 944 ha in addition to the salt affected waste lands, which can be used for aquaculture with buffer provision of 100 m. Spatial analysis indicated that 14,418 ha is available for aquaculture development in district Ramanathapuram.

Environmental flow requirements for Mahanadi mahseer: Environmental flows (e-flows) describe the quantity, timing and quality of water flows required to sustain freshwater and estuarine ecosystems. The e-flow requirement of *Tor mahanadicus,* an endangered fish species and the State fish of Odisha, in river Mahanadi was estimated by hydrologic-wetted perimeter method. The study revealed a minimum of 24.284 million cubic meters (MCM) of water requirement during lean period and 331.953 MCM during monsoon. ❑

3. Climate Change and Resilient Agriculture

Thumb rules of weather for aphids in mustard: Weather conditions, viz. wind speed (>2 km h^{-1}), BSS (>7 hr), mean temperature of 19° to 25.5°C, diurnal temperature range of 14°-19°C, mean RH (53-70%) and THI (2-3) were identified as most conducive for the spread of aphids in mustard at Anand. Sowing window between 10 and 20 October was identified as ideal for avoiding high aphid infestation in mustard.

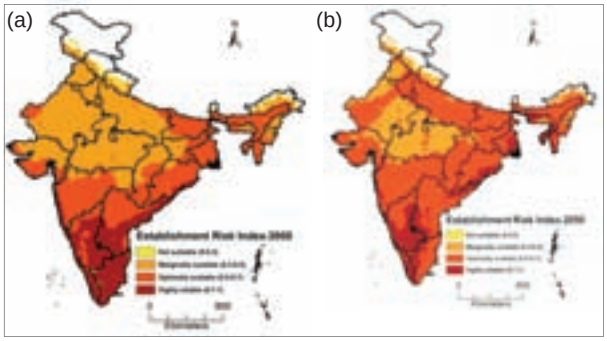
Dissemination of agro-met advisory services: An android application 'Havamaana-Krishi' in Kannada language was developed by Bijapur center to disseminate the advisories to farmers in northern Karnataka.



Decision support system for white fly in cotton

Insect population dynamics: Real time pest dynamics (RTPD) data were recorded for development of forewarning model of mango pests under climate change scenario through a better understanding of host-pest interaction and dynamics in mango. Weekly population of fruit-flies in para-pheromone traps in mango orchards was interpreted with soil moisture data and respective average temperature. Soil moisture of 6-8% and soil temperature of 25-30°C were found to be the most favourable for fruit flies population build-up. High level of fruit fly catches coincided with marble stage of mango fruits.

Activity of *Bactrocera zonata:* A process-based climatic phenology model (ILCYM) was used for predicting future distribution and abundance (damage potential) of *Bactrocera zonata* under changing climate scenario. Establishment, generation and activity generated risk indices were implemented in a geographic information system (Arc-GIS) environment to map and quantify changes for climate change scenarios of 2050 A.D. based on downscaled climate-change data of the A1B emission scenario from the WorldClim database.



Change in establishment and future distribution of *B. zonata* in India based on establishment risk index

The optimum temperature for development of eggs, larvae and pupae were 25.0°C, 25.8°C and 26.3°C, respectively, through a linear model with corresponding lower development thresholds being 9.1, 11.2, and 13.8°C. Females could lay no eggs at the extreme low (15°C) and high (35°C) tested temperatures, demonstrating the importance of optimum temperature in determining the suitability of climate for mating and reproduction in *B. zonata*. The changing climates will be more favorable for *B. zonata* and its damage potential will progressively increase in all mango-producing regions of India where the pest already prevails.

Mango fruit fly: The spatial and temporal changes in voltinism of three major mango fruit fly species, viz. *Bactrocera dorsalis*, *Bactrocera correcta* and *Bactrocera zonata* were estimated using growing degree days models with temperature data in major mango regions of India. The daily temperature projections were generated from each combination of eight GCMs under four RCP-based scenarios and three time periods (2020s, 2050s and 2080s). It is predicted that 1-3 more generations would occur during the three future climate periods with significant variation among scenarios, models and locations. Increased number of generations across 10 mango-growing locations of India suggested that incidence of fruit flies may increase due to projected increase in temperatures in future climate change periods.

Soil organic carbon change and crop productivity: Under balanced fertilization in soybean and wheat, change in soil organic C in soil depth of 0-15 cm and 15-30 cm was non-significant in all RCPs and time slices. This result agreed well with the change in grain yield of soybean and wheat. In 2050, soybean yield will increase by 12, 17, 15 and 22% in RCPs 2.6, 4.5, 6.0 and 8.5, respectively. Similar trend in soybean grain yield was also observed for year 2080 in RCPs under investigation.

The yield of soybean increased by 14, 19, 25 and

37% over base in RCPs 2.6, 4.5, 6.0 and 8.5, respectively. The result showed that soybean yield increase will be more in year 2080 than 2050. The increased temperature effects in all RCPs and time slices are masked by increase CO_2 concentration, positive effects of which are reflected in increase in soybean yield and minor change in wheat yield. However, increase in wheat yield would be 2-4% over in year 2050 whereas 1- 6% in year 2080.

Climate change impact on livestock: Studies carried out at NIANP with supplementation of silkworm pupae oil at 2-4% level of basal diet decreased methane (CH_4) production by 30% *in vitro* without any reduction in dry matter digestibility in sheep. Similarly, in cattle, supplementation of tamarind seed husk alone or in combination with soapnut significantly reduced *in vivo* methane emission (22 to 24%) and decreased the population of rumen protozoa and methanogens.

Studies carried out at NIANP established that irrespective of the geographical locations (Uttar Pradesh and Karnataka). *Methanobrevibacter smithii* and *Methanobrevibacter thaueri* were the most abundant methanogens in buffalo and *Methanobrevibacter millarae* in cattle.

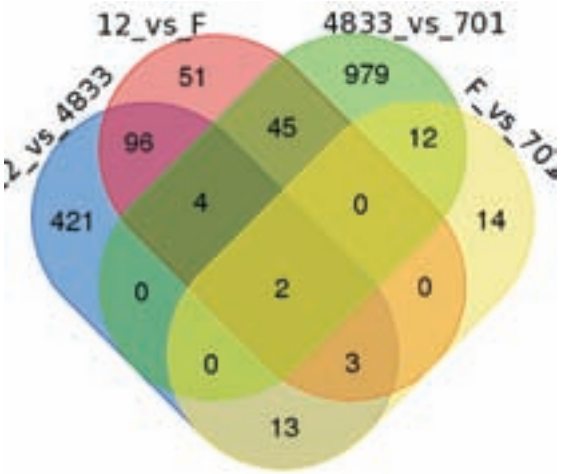
Feed additives for reducing methane emission and improving feed utilization: A composite feed additive (RESMI) was developed for reducing methane emission and improvement in fibre utilization by ruminants. Methane emission was reduced by 75% (0.50 vs 2.07 ppm) by reducing number of methanogenic archaea ($10^{5.31}$ vs 10^{7}) in rumen and promoting growth of alternate hydrogen utilizers like sulphate reducing bacteria (Desulfuromonadales and Desulfobacteriales). The feed additive did not influence number of useful microbes in rumen (bacteria and fungi) and stimulated rumen ecosystem by increasing microbial fibrolytic activity which increased fibre digestion, reduced rate of ammonia production in rumen and thus brought about improvement in feed utilization by 15% in buffaloes. As a result, growth rate enhanced by 9.7%.

Stressol –G, herbal powder based bolus to reduce the climatic stress in goats

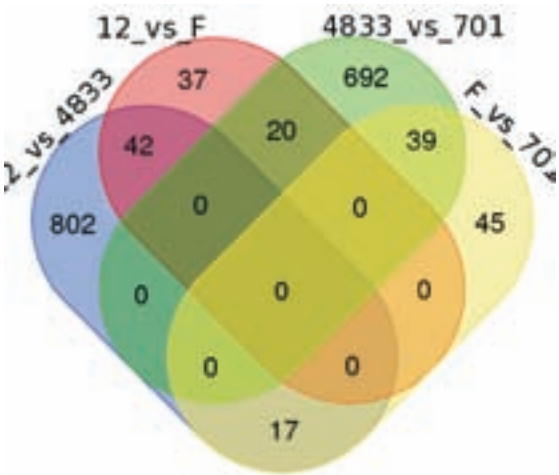
Tree leaves in pellet feed reduce methane emission: Feeding of tree leaves (*Leucenea leucocephala* and *Ficus*) based complete feed resulted in 9.8-18.93% reduction in enteric methane emission (g/day) in goats in comparison to traditional complete feed.

Herbal crude powder based bolus: A herbal crude powder based bolus, consisting of three plant materials, reduced climatic stress in goats. One bolus (5 g), given daily (orally) to the goats during heat and cold stress period (15-30 days), regulated the stress. The product is in the process of patenting and commercialization. This combination can also be given to the goats as extract based herbal formulation @ 10mg/kg body wt or as a feed mix @ 5% in concentrate mixture.

Assessment of heat stress in pigs: The whole transcriptome changes in indigenous (Mali) and exotic (Hampshire) pigs during summer and winter were examined. Considering the size of pig genome, whole transcriptome sequencing was done. The RNA sequencing generated an average 110.54 million of 100bp paired reads per sample. About 88.35% of reads were mapped to the reference *Sus scrofa* genome. The



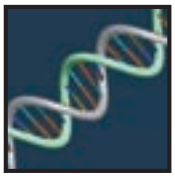
Venn diagram showing significantly up-regulated genes in indigenous (Mali) and Exotic (Hampshire) during two different seasons (Summer Vs Winter)



Venn diagram showing significantly down-regulated genes in indigenous (Mali) and Exotic (Hampshire) during two different seasons (Summer Vs Winter)

analysis revealed 421 upregulated and 802 down regulated genes and several gene isoforms differentially expressed due to change in ambient temperature in Hampshire breed. Indigenous Mali pigs recorded only 14 upregulated and 45 down regulated genes in response to change in ambient temperature indicating better adaptation.

❑



4. Genetic Resources

Crops

Germplasm augmentation, conservation and use: Total 21 explorations were undertaken and 1,532 accessions were collected comprising 1,095 cultivated and 437 wild accessions. The explorations were undertaken mainly two each in Andhra Pradesh, Assam, Chhattisgarh, Maharashtra, Tamil Nadu, Uttar Pradesh, West Bengal and one each in Andaman and Nicobar, Arunachal Pradesh, Karnataka, Nagaland, Odisha, Tripura and Uttarakhand. The population of *Momordica cochinchinensis* collected from the middle Andaman Island was described as a new subspecies, i.e. *Momordica cochinchinensis* subsp. *andamanica*, which was subsequently validated through DNA barcoding of *matK* and *rbcL* chloroplast loci. During the period, 411 herbarium specimens were added to the National Herbarium of Cultivated Plants. Germplasm added to the National Genebank for long-term storage comprised 2,821 accessions of orthodox seed species and 15,399 accessions of regenerated material. Ten accessions were added to the *in-vitro* Genebank and 581 accessions of seeds (291), pollen (4) and genomic resources (286) of different crop species were successfully cryostored.

A total of 28,516 accessions were imported from 39 countries. Additionally, 8,239 entries (26,352 samples) of CGIAR trials/nurseries were also imported. Some of the promising introductions were: wheat with excellent grain quality and resistance to Lr, Yr, Snb genes, imported for heat stress tolerance studies (EC 919308) from USA, wheat with increased amylose and resistant starch (EC 915108) from USA; paddy with superior drought and cold tolerance (EC 900415-904276) from the Philippines, CMS and restorer lines (EC 904493-904518) from the Philippines, bacterial leaf blight tolerant, blast tolerant and drought tolerant lines (EC 907578-912489) from China, insect tolerant, early maturing, lodging and drought tolerant lines (EC 906093-906130); finger millet with high iron, calcium and zinc content (EC 915296-915344) from Kenya; semi-determinate tomato lines with multiple disease resistance against gray leaf spot, fusarium wilt (race 2), tomato mosaic virus and tomato yellow leaf curl virus (EC 904110-904117) from AVRDC Taiwan; Macadamia nuts with good flavor, soft texture, early and heavy bearing trait (EC 896468-896475) from USA and rubber resistant to South American leaf blight disease (SALB) (EC 898375-898377) from Ghana.

A total of 18,776 germplasm accessions were characterized and evaluated at NBPGR, New Delhi and its regional stations. Screening against biotic and abiotic stresses in different crops was done in 2,911 and 787 accessions, respectively. Biochemical evaluation of 1,693 accessions was undertaken in different crops for oil content, fatty acid profile, protein, sugar, minerals, amino acids, antioxidants and active principles. Multi trait near-infrared spectroscopy prediction model was developed for oil, protein, fatty acids, lysine and methionine in amaranth and buckwheat to enable rapid screening of germplasm. Germplasm field days were organized on wheat, barley, oilseeds and maize at New Delhi; okra at Thrissur and *kharif* pulses at Shimla. A total of 7,343 accessions were supplied for research use and crop improvement within the country.

Plant quarantine: A total of 47,432 samples of imported germplasm including transgenic and trial materials were processed for quarantine clearance. Out of the total 914 pest infected samples, 804 were salvaged using appropriate treatments. Important interceptions include: fungi, viz. *Tilletia barclayana* on *Oryza sativa* from China, *Dendryphion penicillatum* on *Papaver somniferum* from UK, *Puccinia carthami* on *Carthamus* spp. from the USA, *Fusarium solani* on *Lycopersicon esculentum* from Germany, *Xanthomonas campestris* pv. *campestris* on Brassica from Germany, *Verticillium albo-atrum* on *Calendula officinalis*, *Peronospora manshurica* on *Glycine max* from Costa Rica, *Phoma sorghina* on *Momordica charantia* from Thailand; nematodes, viz. *Aphelenchoides besseyi* on *Oryza sativa* from China, Japan, Philippines and USA; insects, viz. *Carpophilus truncates* on *Zea mays* from USA, *Rhizopertha dominica* and *Tribolium castaneum* on wheat from Lebanon, *Rhizopertha dominica*, *Sitophilus oryzae* and *Tribolium castaneum* on *Hordeum vulgare* from Morocco, *Acanthoscelides obtectus* on *Phaseolus vulgaris* from South Africa, *Bruchus atomarius* on *Lens culinaris* from Lebanon, *Rhizopertha dominica* and *Sitophilus oryzae* on *O. sativa* and *Zea mays* from Philippines, *Sitotroga cerealella* on *O. sativa* from USA, *Plodia interpunctella* on *Zea mays* from Thailand and *Callosobruchus chinensis* on *Vigna radiata* and *V. mungo* from Bangladesh. Ten phytosanitory certificates were issued for export of germplasm.

Germplasm registration: During the period under report 27 genetic stocks comprising cereals and pseudocereals (20), grain legumes (1), oilseeds (2) and fibre and forages (4) were registered.

Promising wheat genetic resources for different diseases/attributes: Wheat genotypes, viz. WBM 3713 (FLW 16+*Yr*5/VL 876), WBM 3717(FLW 16+*Yr*5/ EC 582298), WBM 3721(VL 906/FLW 13+*Yr*15) and WBM 3733 (WBM 2112/ FLW 13+*Yr*15) developed through bulk-pedigree method of breeding, were found resistant

Plant germplasm registered by PGRC

Crop	National ID	INGR No.	Novel unique features
Wheat (*Triticum aestivum*)	IC 0620914	17001	Blue grain (aleurone) color.
Wheat	IC 0620915	17002	Purple grain (pericarp) color.
Wheat	IC 0620916	17003	Black grain colour (Purple pericarp + Blue aleurone).
Wheat	IC 0621693	17005	Highly tolerant to heat stress.
Wheat	IC 0621833	17006	Resistant to yellow rust carrying Yr10 + in WH 542 background.
Wheat	IC 0621834	17007	Resistant to yellow rust carrying Yr5 + in UP 2338 background.
Wheat	IC 0621836	17008	Resistant to yellow and brown rusts carrying Yr15+Lr24 in background of UP 2338.
Wheat	IC 0621837	17009	Resistant to brown rust (Lr28) and yellow rusts (YrChina84) in the background of WH 542.
Wheat	IC 0621838	17010	Resistant to brown carrying Lr19+Lr24 in the background of PBW 343.
Wheat	IC 621839	17011	LWH, local bread wheat is susceptible to all the pathotypes of *Puccinia triticina* (brown rust of wheat) in India.
Wheat *(Triticum durum)*	IC 0621692	17004	High yellow pigment content (High beta-carotene).
Barley (*Hordeum vulgare*)	IC 0620682	17012	DWRB 137 is highly resistant to stripe rust (*Puccinia striiformis* f. sp. Hordei) at seedling and adult plant stages coupled with short plant height.
Maize (*Zea mays*)	IC 621103	17013	Moderately resistant to maydis leaf blight (MLB). Moderately resistant to turcicum leaf blight (TLB). Tryptophan content 0.69% in protein
Maize	IC 621104	17014	Moderately resistant to maydis leaf blight (MLB). Moderately resistant to turcicum leaf blight (TLB). Tryptophan content 0.71% in protein.
Maize	IC 0612721	17022	Source of resistance to charcoal rot. Mean anthesis silking interval of 2.0 days.
Maize	IC 0612704	17023	Source of resistance to charcoal rot in QPM background. Mean tryptophan (0.90%) and lysine (3.73%.).
Maize	IC 0593934	17024	Resistant to multiple disease post flowering stalk rots, turcicum leaf blight and maydis leaf blight. Stiff and stay green character of stalk. High oil content > 5.0 (5.53%).
Lentil (*Lens culinaris*)	IC 0621470	17015	Drought tolerant
Sorghum (*Sorghum bicolor*)	IC 0621690	17016	Six stamens and two gynoecia against the normal sorghum genotype bearing three stamens and one gynoecium. It produces twin seeds but the spikelet bears six stamens and two gynoecia.
Castor (*Ricinus communis*)	IC 0621469	17017	Pistillate line, Good combiner.
Toria (*Brassica rapa* var. *toria*)	IC 0621691	17018	Earliness in maturity and flowering.
Rice (*Oryza sativa*)	IC 0513420	17019	Rice breeding line tolerant to both vegetative as well as reproductive stage drought stress.
Rice	IC 0612955, IC 0612956	17020	CMS line/maintaine line with higher rate of medium slender grain type.
Rice	IC 0612957, IC 0612958	17021	CMS line/maintainer line with higher rate of stigma exertion. Long slender grain type. High out crossing rate.
Jute (*Corchorus olitorius*)	IC 0503186	17025	Super fibre wedge length and diameter.
Jute	IC 0503703	17026	Superior bark cross section length.
Jute	IC 0503297	17027	High number of fibre cells/fibre bundle

to new virulent stripe rust pathotypes, 110S119, 238S119, 110S247 and PST mix under greenhouse conditions. Eighty six advanced bulks of wheat were evaluated for seedling resistance to 121R63-1 pathotype of leaf rust, out of which 19 were resistant. Preliminary Disease Screening Nursery consisted of 584 wheat breeding lines were evaluated for adult plant resistance to stripe rust under natural condition at rust hot spot Dhaulakuan. One hundred and fifty one were recorded with infection type (0), 98 (TR-10MR), 72 (5MS-10MS), 178 (10S-20S), 81 (30S- ≥40S), 04 (NR=Not recorded). To identify Karnal bunt resistant genotypes, a set of 35 genotypes were inoculated artificially. Of these, 11 genotypes showed less than 5% infection hence considered promising.

Evaluation of rice germplasm for yield and other components related to yield stability: A set of 210 tropical *japonica* rice (TPJ) germplasm lines were assessed with gene based/linked markers for fertility restorer genes, *Rf3* and *Rf4* for identification of potential restorers and maintainers. The identified genotypes were further crossed with *indica* rice genotypes for improvement of parental lines in hybrid rice breeding. A set of 550 rice genotypes, including mega varieties, short grain aromatic rice, NPTs and lines collected from different parts of country were evaluated for yield and components such as number of tillers/plant, plant height, panicle length, days to 50% flowering,

Micronutrient analysis to identify high Zn and/or Fe donors in wheat: A set of 500 landraces were screened for their grain iron and zinc concentration. The lowest amount of grain Zn (34.7 mg/kg) was found in landrace IC 5324457 and the highest was found in the landrace, IC 59587 (85.2 mg/kg). The lowest grain iron was observed in the land race, IC 118744 (30.4 mg/kg), while the highest Fe in grains was observed in IC 82250 (69.9 mg/kg).

days to maturity, number of grains/panicle, spikelet fertility and 1000 grain weight during *kharif* 2016. Further, these lines were also inoculated for screening by different isolates of *Xanthomonas oryzae* pv. *oryzae* (*Xoo*), causal organism of bacterial blight (BB) and resistant lines were utilized in crossing programme.

Field evaluation of rice germplasm lines

Powdery mildew resistant tomato genotype identified: In order to find out resistant genotypes for the most devastating disease of greenhouse tomato, i.e. powdery mildew (*Oidium neolycopersici*), existing set of tomato germplasm were screened using whole plant resistance method (spore suspension of *O. neolycopersici* 2×10^4 conidia/ml); VTG 13 and one advance line VTG 1327-2 showed 0 powdery mildew incidence on 0-3 scale.

Microbial genetic resources: The NAIMCC (National Agriculturally Important Microbial Culture Collection) is a repository of more than 6,000 accessioned microbial strains representing actinomycetes, bacteria, fungi and cyanobacteria groups of agricultural importance. During this period around 100 microbial cultures have been accessioned including some cyanobacterial strains received from DBT-Institute of Bioresources and Sustainable Development, Imphal, Manipur. Two bacterial species namely *Delftiat suruhtensis* and *Klebsiella varicola* have been introduced for first time into the collection. NAIMCC has supplied more than 70 cultures of bacteria and fungi to different private and government institutions for research purposes. Recently, NAIMCC has started receiving cultures for accessioning under safe deposition to fulfil the requirements of registration of biopesticides through CIB (Central Insecticide Board) and RC (Registration Committee) and from other researchers for some other specific purposes.

Horticulture

Fruit crops: A total of 55 accessions in banana, 20 in citrus, 13 in grape, 23 in guava, 29 in jackfruit, 12 in litchi and 44 in mango were added to the existing germplasm collections at different centres. In banana, Belgium, an exotic introduction from the Philippines, was found promising under Indian condition.

In grape, germplasm was strengthened by importing four trait-specific accessions from USDA, USA. These accessions are self-thinning and early-ripening. IC number was allotted to 118 accessions, thus increasing the number of accessions with IC number to 416. Further, 100 grape accessions were characterized for 35 traits. Maximum variation was observed for 100-seed weight, bunch compactness and juice content. Several accessions with bold berries, loose bunch and high fruitfulness were identified. Among 100 accessions, 11 were found to have loose bunch and five accessions had naturally bold berries.

In apple, 13 genotypes were assessed to identify and determine the alternate bearing index (ABI), based on quantitative evaluation of alternation. Medium alternanace was shown by Gala Mast, Vance Delicious, Firdous, American Apirouge, Mollies Delicious and Oregon Spur with ABI values of 0.28, 0.33, 0.36, 0.40, 0.41 and 0.44, respectively. Cultivars Starkrimson, Cooper-IV, Golden Delicious, Silver Spur and Red Chief are susceptible to alternanace with ABI values of 0.52, 0.54, 0.61, 0.62 and 0.68, respectively. High degree of

VTG 805 (Highly susceptible genotype) (left), VTG 13 (Resistant) and VTG 14 (susceptible) (middle) and VTG 1327-2 (Resistant) (right)

alternanace was shown by Red Delicious and Red Fuji with ABI values of 0.71 and 0.83, respectively.

In pears, among 20 European pear cultivars evaluated, maximum fruit weight (200.1 g) and fruit diameter (75.3 mm) were recorded in cultivar King Pear, whereas maximum fruit length (102.0 mm) was recorded in cultivar Santya Braskaya. Among Asian pear cultivars, Chinese sand pear produced fruits with maximum weight (175.6 g), length (58.9 mm) and diameter (70.2 mm).

In pomegranate, hardwood cuttings (HWC) of two varieties Kabul Kandhari and Kandhari Seedless from YSPUHF, Solan, whereas HWC of three-way cross hybrid (Ganesh × Nana) × Daru were collected. Currently, 375 pomegranate collections have been maintained. Important breeding material consisting of hybrids, mutant population (M_1 generation) of Ganesh and Bhagwa, selected advanced lines with desirable characteristics were also conserved in the field genebank.

Vegetables: A total of 66 breeding materials and parental lines of hybrids consisting of 23 in okra, 2 in tomato, one in pointed gourd, 9 in radish, 16 in carrot, 4 in *bathua*, 10 in French bean and one in ridge gourd were assigned IC numbers. Seventeen varieties/hybrids of vegetables, viz. Kashi Ageti in pea; Kashi Vardaan in okra; Kashi Surkh, Kashi Anmol, Kashi Gaurav in chilli; Kashi Sinduri in paprika; Kashi Harit in pumpkin; Kashi Madhu in muskmelon; Kashi Vishesh, Kashi Amrit, Kashi Anupam, Kashi Hemant and Kashi Sharad in tomato; Kashi Sandesh and Kashi Taru in brinjal and Kashi Bahar and Kashi Ganga in bottle gourd were registered.

Plantation crops: In cashew, for efficient conservation and utilization of germplasm, core collection representing the spectrum of diversity present in base collection was identified using a relatively new and efficient technique 'Advanced M strategy with Heuristic Approach' to retain maximum diversity with minimum number of accessions. The base collection of 478 accessions with 68 characters was subjected to analysis resulting in core collection of 49 accessions. Heuristic approach could efficiently represent and retain the diversity compared to core collection obtained by clustering. For better utilization of cashew germplasm resources, a Decision Support System (DSS) has been developed to host data on 478 accessions with 68 characters.

The genotypes (1 each) of date palm and grapefruit (1 each), acid lime (11), mandarin (8), sweet oranges (11), different species of *Citrus* rootstocks (17) and guava (5) were added to field genebank. Diversity rich areas of Gujarat and Rajasthan were surveyed and genotypes of guava (25), lime (27) and custard apple (22) were identified on the basis of desirable horticultural traits. Genotypes of these different fruit crops were evaluated for morphological, yield and yield-attributing characteristics. Besides bud wood of 10 elite ber accessions were collected from Haryana followed by budding for evaluation.

Mushrooms: A total of 27 mushroom specimens were collected from forests of Himachal Pradesh and Tripura, and 21 were identified up to genus level. Pure tissue cultures of 21 mushroom specimens were obtained and deposited in the genebank including *Lepista* sp., *Leucocoprinus* sp., *Gymnopilus* sp., *Laccaria* sp., *Macrolepiota* sp. and *Austroboletus* sp.

Orchids: A total of 32 germplasms were registerd and IC number were allotted. A total of 20 rare orchid species were collected from the Himalayan Ecosystem, of these, six species were identified as *Chiloschista parishii*, *Cymbidium cochleare*, *Dendrobium praecinctum*, *Dendrobium nanum*, *Dendrobium ruckeri* and *Taeniophyllum retrospiculatum*. Native orchid species (10) of genus *Paphiopedilum* were characterized using ISSR markers.

Livestock

Registration of new breeds of livestock and poultry: Nine new populations of livestock and poultry have been registered as breeds, which include one breed of cattle, two breeds each of goat and sheep, three breeds of pig, and one breed of chicken. With these new additions, the total number of registered indigenous breeds now in the country is 160, which includes 40 for cattle, 13 for buffalo, 26 for goat, 42 for sheep, 6 for horses and ponies, 9 for camel, 6 for pig, 1 for donkey and 17 for chicken.

Phenotypic characterization

Cattle of Sikkim, Meghalaya and Nagaland states: The indigenous cattle of the NE region were characterized to record phenotypic variability available in indigenous cattle of the region. Animals of different coat colour, i.e. brown, grey and black were seen in different states but majority of them were of brown colour except Siri in Sikkim. Birth weight ranges from 10-20 kg, whereas adult body weight ranges from 150 to 250 kg in cows and 200 to 350 kg in bull/bullocks. Daily milk yield ranges from 1.0 to 5.0 kg, while Siri cattle produces milk up to 10 kg/day. The age at first calving, lactation length, service period, dry period and calving interval ranges from 28 to 42 months, 150 to 210 days, 90 to 120 days, 120 to 180 days and 15-20 months, respectively. Indigenous cattle of Nagaland and Sikkim are slightly bigger than the indigenous cattle of Meghalaya. The height at wither is the most differentiating trait in these cattle populations of North East states.

Konkan cattle: Konkan cattle are distributed in Thane, Palghar, Raigad, Ratnagiri and Sindhudurg districts of Konkan region of Maharashtra and Goa. The coat is generally brownish red or black, animals

Cattle of Sikkim, Meghalaya and Nagaland states

New breeds registered

Species	Breed	Home Tract	Accession number
Cattle	Badri	Uttarakhand	INDIA_CATTLE_2400_BADRI_03040
Goat	Teressa	Andaman & Nicobar	INDIA_GOAT_3300_ TERESSA _06025
	Kodi Adu	Tamil Nadu	INDIA_GOAT_1800_ KODIADU _06026
Sheep	Chevaadu	Tamil Nadu	INDIA_SHEEP_1800_ CHEVAADU _ 14041
	Kendrapada	Odisha	INDIA_SHEEP_1500_ KENDRAPADA _ 14042
Pig	Tenyi Vo	Nagaland	INDIA_PIG_1400_ TENYIVO _09004
	Nicobari	Andaman & Nicobar	INDIA_PIG_3300_ NICOBARI _09005
	Doom	Assam	INDIA_PIG_0200_ DOOM _09006
Chicken	Kaunayen	Manipur	INDIA_CHICKEN_1200_ KAUNAYEN _12017

Konkan cattle

of brown, white or mixed coat are also available. The muzzle and tail are generally black but in some animals carroty/mixed muzzle or creamy tail switch are also seen. The forehead is small and straight, sometimes slightly concave. The horns are straight in majority of cattle with orientation outward, upward and backward. Udder is small in size; teats are small, cylindrical with pointed/rounded tips. The hump and dewlap are small to medium in size in cows and medium to large in bulls. The animals are small in size with compact body. The animals are hardy and survive well in hot and humid conditions of the coastal area. The average daily milk production is 2.23 kg; few elite animals with milk production of 5-6 litres were also reported. The age at first calving, calving interval and lactation period are 49.27±0.56 months, 17.21±0.35 months, and 226.53±6.22 days, respectively.

Burgur buffalo: Burgur buffaloes are reared by Burgur Lingayat, an indigenous Kanada speaking community, in the Burgur villages of Anthiyoor taluk, Erode, western Tamil Nadu. Burgur buffaloes are medium in size with coat colour varying from black to light brown and brownish black. The animals are maintained under zero input system of management and are left to graze in the forest area. The animals are reared mainly for milk, meat and manure. The milk yield of the animals ranges from 1.5 to 2.0 litres/day and is mainly consumed as curd and butter milk.

Burgur buffalo

Mouli sheep of Karnataka: Mouli sheep are tall with deep body and long legs. Average estimated body weights at birth, 3-month, 6-month and 12-month of age are 4.0, 23.8, 34.1 and 48.6 kg, respectively, in males, and 3.5, 21.6, 31.0 and 44.3 kg, respectively, in females. Average body weight, length, height at wither and chest girth are 41.4 kg, 77.0±0.8 cm, 79.3±0.5 cm, and 81.3± 0.7 cm in ewes; and 58.6 kg, 85.4±0.9 cm, 88.4±0.6 cm and 89.7±0.9 cm in rams. Coat is white with or without brown spots/patches. A brown ring is present around the eyes. The nose line is roman. About 0.8% ewes and 25% rams are recorded as horned. The age at first lambing is about 13-18 months with lambing rate of 70 to 80%.

Mouli sheep

Yalaga sheep: Yalaga animals are medium to large in size. Average estimated body weights at birth, 3-month, 6-month and 12-month of age are 4.0, 23.8, 34.1 and 48.6 kg, respectively, in males and 3.5, 21.6, 31.0 and 44.3 kg, respectively, in female lambs. Average body weight, length, height at withers and chest girth

Network Project on Animal Genetic Resources of India (Core Lab)

Measures of diversity which forms the basis for planning their utilization and/or conservation were calculated for 10 populations of seven different species, viz. Dharwadi buffalo; Hazara birds; Poonch, Tibetan sheep; Bhakarwal goat; Rajasthani donkey; Arunachali yak; Kosali cattle; and Jalori and Mewari camel.

All the populations except Tibetan sheep exhibited fair genetic variation, which is evident from average number of alleles and observed heterozygosity. Despite higher genetic diversity, significant heterozygote deficiency was also observed within eight populations except Poonch sheep and Bhakarwal goat. The diversity indices pointed towards diminished genetic diversity and declining populaton in the Tibetan, a valuable Himalayan sheep breed. In view of the declining population of Tibetan sheep (less than 250) in the breeding tract, need of the hour is immediate scientific management of the population so as to increase the population hand in hand with retaining the founder alleles to the maximum possible extent.

Yalaga sheep

are 33.9 kg, 69.2±0.5 cm, 74.0± 0.3 cm and 77.3±0.3 cm in ewes, and 55.0 kg, 77.8±0.6 cm, 83.2±0.5 cm and 89.9±0.5 cm in rams. Coat is white and consists of thick hair. Face is white or white with black or brown patches of varying size or black. Horns are present in 90% rams, whereas ewes are generally polled. Horns are thick, corrugated and curved in rams. Tail is small and thin. Udder is well developed. In Yalaga, age at first lambing is 18-24 months and lambing percentage ranges from 70 to 95%.

Nagaland goats: Nagaland long hair goats have different colour variants, viz. white with black patches, black, brown with grey hair. Only adult males have long hair. Animals are of medium size having proportionate body, straight nose line, erect but horizontally placed ears. The horns in females are shorter, pointed, directed upward and backward while in males thicker, longer, orienting upward and backward. The wattles and beard are present in majority of goats. Muzzle is black/brown/pinkish. The belly and legs below knee joint are black. The udder and teats are

Nagaland goat

moderately developed. Udder is bowl shaped and teats are small and cone type. The under belly is black/white. The average body weight for adult male and female is 31.48 kg and 25.79 kg, respectively. The milk yield is 0.3 to 0.5 litre/day. The litter size varies from 1 to 4. Hair obtained from the Nagaland goats have commercial utility for the tribal people and is used for beautification of garments, ornaments and weaponry.

Genetic characterization

Taurine and Indicine breeds: Individuals belonging to taurine and indicine breeds were clearly distinguished using SNP markers and applying Principal Component Analysis (PCA). The hybrid cattle were clearly placed in-between the two breeds. The first and second principal components explained 15.75 and 4.25% of the variation among breeds, respectively.

Screening for genetic diseases in Frieswal and indigenous breeds: A faster and economic genotyping protocol was developed for congenital vascular malformation (CVM) and the same was registered for an Indian Patent. A displacement PCR based tetra-amplification-refractory mutation system (T-ARMS DPCR) genotyping assay was also developed for bovine leukocyte adhesion deficiency (BLAD) and CVM.

Differential expression and SNP identification of genes related to establishment of pregnancy in Frieswal and Sahiwal cattle: Specific amplification of 2'-5'- oligoadenylate synthase 1 (OAS1) gene in DNA samples of 250 animals (82 Sahiwal and 168 Frieswal) revealed 28 SNPs and one dinucleotide repeats, among them 14 were mis-sense variants. The SNPs in the promoter region of OAS1 gene were associated with production and reproduction traits as well as in the incidence of normal calving. The genotypes of various exonic regions, viz. exon 2, 5 and fragment 1 of exon 6 of OAS1 gene had significant association with various reproductive traits. The mRNA transcript level of OAS1 gene increased from day 12 post AI, which reached a peak on day 18 post AI, with a slight decline noticed on days 21 and 25 in pregnant nulliparous animals; however, the difference

was not prominent among multiparous animals.

Modulating thermo regulatory response in cattle: A putative Internal Ribosomal Entry Site (IRES) was screened at 5' Un-translated region (UTR) of bovine heat shock protein 90 AA1 (HSP90AA1) gene using a set of primers. The amplification and cloning of the product and isolation of plasmid followed by restriction enzyme based digestion released 120 base pair PCR fragment. Final confirmation of the positive clones was done by sequencing, which revealed 100% homology of 5' UTR region of bovine HSP90AA1 genes. The IRES product was sub cloned in a mammalian expression vector and confirmed by sequencing.

Cataloguing of miRNA transcripts: The bovine *Hsp70* specific RT-LAMP assay revealed significant correlation between absorbance level and the fold change of *Hsp70* transcripts at different kinetic intervals of heat stress recovery in bovine PBMC cell culture models. This suggested that RT LAMP based absorbance assay could be used as an indicator to measure the degree of bovine *HSP70* transcripts produced during thermal stress and be used as an alternative to the traditional real time PCR assay.

Genetic polymorphism of heat shock protein genes: The study was conducted to investigate the expression profile of two important nucleotide binding and oligomerization domain receptors (NLRs) (NOD1 and NOD2) and their central signalling molecule RIP2 gene during *in vitro* thermal-stressed bovine peripheral blood mononuclear cells (PBMCs) of native (Sahiwal) and crossbred (Sahiwal × HF) cattle. The findings revealed that the expression patterns during thermal stress were comparatively superior among indigenous compared to crossbred cattle, which may add references regarding the better immune adaptability of zebu cattle.

Burgur buffalo: The Burgur buffaloes were genetically characterized using 24 loci of neutral microsatellite markers. All the loci studied in the population are polymorphic. Overall average number of alleles was 8±0.55 and average effective number of alleles 3.85±0.25. The average observed (H_o) and unbiased expected (uHe) heterozygosity were 0.66±0.04 and 0.71±0.032 for Burgur buffaloes. The observed heterozygosity in the studied population was lower than the expected heterozygosity. F_{IS} value was 0.056±0.037. Microsatellite diversity analysis revealed no recent bottle neck in the Burgur buffalo and gives L-shaped curve.

Murrah: The FCGRT gene in Murrah buffaloes was found to be polymorphic for intron-1 with MseI, exon-3 with BbvI , exon-7 with HpaII RE using PCR-RFLP analysis. The coding region SNPs were nonsynonymous and led to amino acid change. The association of exon3 polymorphs of dams was significant between the high and the low colostral IgG groups.

Mouli and Yalaga sheep: Genetic diversity study, using FAO recommended microsatellite markers, was carried out in the Mouli and Yalaga sheep populations of Karnataka. The values for effective number of alleles, mean observed heterozygosity and gene diversity were 5.23, 0.637 and 0.783 in Mouli and 4.865, 0.596 and 0.757 in Yalaga sheep, respectively. A normal L-shaped curve under Mode shift test suggested absence of a recent reduction in the effective population size or a genetic bottleneck.

Nagaland goats: Microsatellite based genetic diversity of Nagaland goats was carried out using 25 markers recommended by FAO. The observed heterozygosity ranged from 0.043 to 0.786 with an overall mean of 0.347±0.040, whereas, effective hetrozygosity ranged from 0.045 to 0.815 with an overall mean of 0.499±0.051. The difference between the observed and expected heterozygosity revealed possibility of inbreeding. This is reflected by the positive F_{IS} (0.258 ± 0.063). The overall polymorphic information content value is 0.494 ±0.052, which revealed its usefulness in determining the genetic diversity.

On comparing with goats of Sikkim state and other goat breeds from plain region, Nagaland goats form a separate cluster indicating their genetic distinctness.

Donkeys: The brown type donkeys of Andhra Pradesh were evaluated using heterologous microsatellite markers (20 loci of the horse origin). Only 12 loci gave scorable results in the studied population. The observed number of alleles varied from 4 to 10 with a mean of 6.92 ±1.83. The effective number of alleles ranged from 1.62 to 7.91 with a mean of 4.21 ± 2.06. The observed heterozygosity ranged from 0.32 to 0.92 with a mean of 0.57 ± 0.20. The expected heterozygosity ranged between 0.39 to 0.89 with a mean of 0.72 ± 0.14. The mean genetic diversity estimate (F_{IS}) was 0.21 indicating a moderately high level of inbreeding. The cumulative exclusion probability (PE) of these loci is 0.99 indicating their suitability for parentage testing in these donkeys. The sign test, standardized differences test, the Wilcoxon test indicated absence of any recent genetic bottleneck in Brown type donkeys of Andhra Pradesh.

Pigs: The Laminin Subunit Beta 1 (LAMB1) was significantly down-regulated (-3.448) in indigenous piglets and consequently the copy number variation revealed that viral load of CSF virulent virus was significantly higher in macrophages of crossbred pigs than that in indigenous pigs.

Genomic profiles of chicken lines: Chicken Activin receptor type 2B (*ACVR2B*) gene was silenced through RNAi under *in vitro* conditions where the shRNA constructs were transfected into chicken fibroblast cells. The per cent knock down of ACVR2B mRNA expression varied between 47 and 87%. Expression profiling of bone morphogenetic protein 3 (*BMP3*), bone morphogenetic protein 4 (*BMP4*), fatty acid synthase (*FASN*) and acetyl-coA carboxylase (adipose tissue) (*ACACA*) genes during embryonic and juvenile phases, was established in layer and broiler chickens. Certain haplogroups showed significant effect on body weight. The expression profile of growth hormone

receptor gene in 5 tissues (breast muscle, bursa, heart, spleen and gizzard) in Aseel and Ghagus breeds of chicken during early post hatch period indicated breed and tissue differences at expression levels. Further, the expression of ovalbumin gene (Delta ct) in oviductal cells cultured from different parts of oviduct varied from 35.8 to 43.2. Evaluation of immune competence traits in different breeds of chicken (Ghagus, Dahlem Red and Nicobari) showed significant differences among the breeds and between sexes. Ghagus showed better expression profile of genes linked to innate immunity. Highest number of SNPs in coding regions of PRR (pattern recognition receptor) genes was found in Nicobari breed followed by Ghagus and layer chicken.

Conservation (Ex situ)

Germplasm repository at NBAGR is being strengthened by preserving diversified form of germplasm (semen, embryos, DNA, epididymal sperms and somatic cells). The germplasm procured during the reported period is as follows:

Germplasm	Species	Breed	Number of doses
Semen	Cattle	Bargur	3,022
Semen	Cattle	Khillar	4,000
Semen	Cattle	Dangi	1,000
Semen	Cattle	Rathi	1,500
Epididymal sperms	Goat	Gaddi	317
Epididymal sperms	Goat	Marwari	500
Epididymal sperms	Sheep	Gaddi	123
Somatic cells	Camel	Double hump	404
Total			10,866

Fish

Discovery of new fish species: ICAR-NBFGR, Lucknow, during survey of water bodies of Peninsular and North-east India, discovered two new fish species. These species were identified on the basis of morphological features, osteology and molecular characterization. The fish species discovered were: *Pangasius silasi*, from Nagarjuna Sagar Dam of Krishna River System, Andhra Pradesh, and *Osteobrama serrata* sp. nov., from Jiri River in Manipur.

Discovery of new fish species-*Pangasius silasi* (top); *Osteobrama serrata* (bottom)

Genome sequencing of food fishes: *Clarias magur* commonly known as magur and *Tenualosa ilisha*, commonly known as hilsa are the two economically important food fishes of Indian sub-continent with promising aquaculture potential due to food preference, good nutritional profile and high market price. Whole genome sequencing of *Clarias magur* and *Tenualosa ilisha,* was carried out for generation of comprehensive genomic information of these fishes.

Whole genome sequencing of *Clarias magur* revealed maximum contig length and N50 value of 3.9 Mb and 237 kb, respectively. Transcriptome assembly resulted in 54,061 and 109,204 transcripts with maximum transcript length of 15,442 bp and 15,456 bp in ovary and testis, respectively. The gonadal transcriptome study is an attempt to decipher the differential gonadal transcripts and miRNAs, along with miRNA-mRNA interaction in *C. batrachus*. It will help in determining the molecular mechanisms of sex determination and sex specific genes in *C. magur.* Similarly the draft assembly of *T. ilisha* comprised primary assembly of 2,867 contigs (763.19Mb) and alternate assembly of 3448 contigs (15.56Mb). Genome showed largest contig of 17.431 Mb and N50 2.624 Mb. The mitogenome has contig length of 16,745 bases and 13 protein coding genes, 2 ribosomal RNA, 22 tRNA's and a D-loop region.

The consolidated knowledge of sequenced genome of both the species will facilitate understanding of genetic mechanisms influencing production traits through mining of genes, which in turn can provide protocols for fast selection of economically important adaptive traits and improvement of organisms.

Mitogenome sequencing in edible oyster: The edible oyster, *Crossostrea madrasensis* inhabits intertidal zone in estuaries, backwaters, ports and harbors and constitute an important molluscan fisheries of Indian Ocean. Oyster meat is highly esteemed seafood and aquaculture is widely practised particularly in Kerala in India. Mitochondrial genome sequencing of *C. madrasensis* comprises 22,410 bp in size and codes for 14 functional proteins, viz. Cox [1-3], Cob, NAD[1, 2-0,2-1,3,4,5,5-1,6,4L] and ATPase6, 27 tRNAs and 2 ribosomal RNAs. The genome also possess several unique features such as absence of ATPase 8, duplication of rRNA S, and presence of additional tRNA K and tRNA. The study will help in identification of stocks for future production programmes.

Genome sequencing of *Aphanomyces invadens:* Infection with oomycetes fungus, *Aphanomyces invadens* causes large-scale mortalities of cultured and wild fish. The fish infected with *A. invadens* precipitated further and develop ulcers over the fish body in associations with other organism leading to death of fish. Since, this is a syndrome and causes mass-scale mortalities particularly during winters, the study on genome sequencing of *A. invadens* was carried out at ICAR-NBFGR, Lucknow. The study revealed that genome has 914 contigs (primary 396 contigs and

alternate 518 contigs). Genome completeness showed 423 genes conserved among eukaryotes with 98.6% completeness. Protein-coding genes (18,622) were predicted from genome assembly. Functional annotation of predicted genes assigned Gene Ontology (GO) terms to 14,819 protein-coding genes. Total 24,226 genes were assigned with GO terms in biological process (BP), 18,135 genes in molecular function (MF) and 14,081 genes in cellular component (CC). Additionally, 5,700 genes belonging to metabolic pathways were annotated. These genes were functionally categorized into 4 major processes- cellular processes (1,611 genes), environmental information processing (1,114 genes), genetic information processing (2,025 genes) and metabolism (1,604 genes). Maximum number of genes were involved in signal transduction followed by those involved in cell growth and transport. The study will help in understanding the pathway of *A. invadens* infection in fish.

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5. Crop Improvement

Crop improvement

Crop improvement is the mandate of Crop Science Division, which is the largest division of ICAR. It has one deemed to be university, 19 national institutes, 3 bureaux, 3 project directorates, 2 national research centres, 32 all-India coordinated research projects and all-India network projects, four Consortia Research Platforms and other projects like Technology Missions on Cotton and Jute, Incentivizing Research in Agriculture, Application of Micro-organisms in Agriculture and Allied Sectors (AMAAS), Microbial Genomic Resources Repository Network and Seed Production in Agricultural Crops and Fisheries. There are eight major schemes, viz. Genetic Resource Management (7 sub-schemes), Basic and Strategic Research and Education (8 sub-schemes), Rice, Wheat and Barley Improvement (7 sub-schemes), Maize, Millet and Forage Crop Improvement and Hill Agriculture (9 sub-schemes), Pulse Improvement and Seed Research (8 sub-schemes), Oilseed Crop Improvement (10 sub-schemes), Commercial Crop Improvement (11 sub-schemes) and Plant Protection and Pollinator Research (10 sub-schemes) which have 70 sub-schemes. Major emphasis in most of the institutes has been the development of new varieties/hybrids tolerant to various biotic and abiotic stresses with enhanced quality. During 2017, total 209 varieties were developed which have been mentioned in this chapter.

Cereals

One hundred and seventeen high-yielding varieties/hybrids of cereals comprising 65 of rice, 14 of wheat, 24 of maize, 5 of finger millet, 3 of pearl millet, 1 each of sorghum, barley, foxtail millet, kodo millet, little millet and proso millet were released for cultivation in different agro-ecologies of the country during 2017.

Improved varieties/hybrids of cereals released

Variety	Area of adoption	Salient features
Rice		
HRI-183 (Arize Swift Gold) (IET 24082)	Haryana, Uttarakhand, Uttar Pradesh and Gujarat	Early duration irrigated, bacterial leaf blight (BLB) resistant hybrid developed by deploying Marker Assisted Selection (MAS), medium slender grain, yield 6,100 kg/ha
HRI-180 (Arize Tej Gold) (IET 24120)	Punjab, Haryana and Uttarakhand	Early maturing hybrid, irrigated, resistant to bacterial leaf blight (BLB) and tolerant to blast, brown spot (BS) and false smut, yield 6,100 kg/ha
PAC 129 (Arize 6129)	Madhya Pradesh	Short duration hybrid (115-120 days), less water requirement, fits well in rice - vegetable/potato/mentha - wheat crop rotations, suitable for Direct Seeded Rice (DSR) system
BS 129G (Arize 6129 Gold)	Chhattisgarh	Early duration hybrid (115-120 days), BLB resistant, less water requirement and fits well in vegetable / potato/mentha and wheat crop rotations
28P09 (IET 24156)	Odisha, West Bengal, UP, Assam, Chhattisgarh, Maharashtra, Gujarat, TN and AP	Rice hybrid, irrigated, medium slender grain, moderately resistant to BLB, tolerant to neck blast (NB), BS, LF, yield 5,834 kg/ha
CO 51	Haryana, Uttarakhand, Odisha, Bihar, WB, UP, MP, Maharashtra, Gujarat, AP, Kerala, Karnataka and TN	Early maturing variety, moderately resistant to green leaf hopper (GLH), brown plant hopper (BPH), yield 6,620 kg/ha
27P36 (IET 24103) Hybrid	Bihar, Madhya Pradesh, Jharkhand, Chhattisgarh and Odisha	Tolerant to BLB, grain - long slender, maturity 128-132 days, average yield in rainfed/upland environment 7,200 -7,500 kg/ha
VL Dhan 158 (8657) (IET 22982)	Himachal Pradesh and Uttarakhand	Developed for hill ecology, resistant to leaf and NB under field and controlled condition, yield 2,750 kg/ha
Jalkunwari (TTB 202-4)	Assam	Irrigated lowland (IRL), moderately resistant to blast, yield 4,000 kg/ha

Variety	Area of adoption	Salient features
Jalashree (TTB 202-3)	Assam	Irrigated lowland (IRL), moderately resistant to blast and stem borer, yield 4,300 kg/ha
Kanaklata (TTB 103-3-1)	Assam	Non-lodging, non-shattering, responsive to fertilizer, suitable for irrigated transplanted in boro ecology, yield 6,000 kg/ha
Gitesh (TTB 283-1-26)	Assam	Irrigated lowland (IRL), resistant to sheath rot, moderately resistant to blast, brown spot and stem borer, yield 5,300 kg/ha
Malviya Sugandha Dhan HUR-917 (IET 21838)	Uttar Pradesh	Scented rice, tolerant to NB, moderately tolerant to bacterial leaf blight and stem borer, yield 3,355 kg/ha
Sabour Surbhit (RAU 3036) (IET 19806)	Bihar	Irrigated medium maturity for upland, grain type slender, moderately resistant to major pests and diseases, yield 4,000- 4,500 kg/ha
SHIATS Dhan-2 (AAIR 203) (IET 22576)	Uttar Pradesh	Ecosystem irrigated mid-early (IRME), long slender grains, suitable for rice-wheat cropping system, moderately resistant to sheath blight, brown spot (BS), yield 5,065 kg/ha
SHIATS Dhan-3 (AAIR 205) (IET 22522)	Uttar Pradesh	Ecology irrigated mid (IRM), long slender grains, suited for late sown wheat cropping system, moderately resistant to BS, sheath blight, yield 4,834 kg/ha
Dhruba (BNKR-2) (IET 20761)	West Bengal	Irrigated lowland, short bold grain, moderately resistant to leaf and NB, BS, leaf folder (LF), yield 5,000-5,500 kg/ha
JKRH-3333 Hybrid	MP, WB, Bihar, Gujarat, Chhattisgarh and AP	Hybrid, suitable for DSR and machine sowing, medium slender grain, medium duration with 135-140 days maturity
CR Dhan 508 (CR3835-1-7-2-1-1) (IET 23601)	Assam, West Bengal and Odisha	Ecology - deep water, grain long bold, moderately resistant to NB, brown spot and sheath rot, yield 4,048 kg/ha
27P22 (IET 24122)	Punjab and Haryana	Hybrid, irrigated mid-early maturity, medium-slender grain, moderately resistant to BLB, yield 6,477 kg/ha
NPH 8899 (IET 23494)	Uttar Pradesh, Bihar and Assam	Hybrid, suitable for boro ecology, short bold, moderately resistant to leaf blast, NB, BPH, yield 5,667 kg/ha
GK 5022 (IET 23445)	Bihar and Chhattisgarh	Hybrid suitable for aerobic ecology, long- slender grain, moderately resistant to leaf blast, NB, BPH, yield 4,232 kg/ha
PAN-2423 (IET 21395)	West Bengal	Hybrid, yield 5,500 kg/ha
Gujarat Anand Rice-3 (GAR-3) (NWGR-4005)	Gujarat	Irrigated, resistant to BLB, NB and LB, moderately resistant to stem borer (SB), LF, long bold grain
Pant Dhan-23 (UPR 2962-6-2-1)	Uttarakhand	Moderately resistant to leaf blight, sheath blight and stem borer, yield 4,453 kg/ha
Pant Dhan-26 (UPR 3425-14-3-1)	Uttarakhand	Moderately tolerant to stem borer, BLB, sheath blight, Rice Tungro Disease (RTD), NB and sheath rot, yield 4,530 kg/ha
Chhattisgarh Sugandhit Bhog	Chhattisgarh	Resistant to gall midge biotype 1 and 5, moderately resistant to LB, sheath rot (SR), BS and RTD
Tarangini (MTU 1156) (IET 23300)	Andhra Pradesh	Irrigated ecology, resistant to leaf blast (LB), BPH, long slender grains, yield 7,500 kg/ha
Bheema (Dheera) (MTU 1140) (IET 23933)	Andhra Pradesh	Tolerates flash floods for 10 days at vegetative stage, stagnant flooding and submergence during germination for 2 weeks, resistant to BPH, moderately resistant to BS, yield 6,000 kg/ha
Rajdeep CN 1039-9 (IET 17713) (CNR 4)	West Bengal	Tolerant to sheath blight and sheath rot

Variety	Area of adoption	Salient features
Sabour Deep (RAU 3055) (IET 21098)	Bihar	Irrigated medium upland ecology, tolerant to BLB, SB, LB, BS, yellow stem borer, green leaf hoppers (GLH) and gundhi bug, grain-elongated slender, yield 3,500-4,000 kg/ha
Sabour Ardhjal (BRR 0007) (IET 24036)	Bihar	Irrigated, medium upland and aerobic, moderately resistant to BLB, grain long slender, yield 4,500-5,500 kg/ha
CARI Dhan 1 (IET 25029)	Andaman and Nicobar	Selection from Quinglivan 1, rainfed shallow lowland, grain medium slender, yield 4,800 kg/ha
CARI Dhan 5 (IET 16885) (BTS 24)	Andaman and Nicobar	Somoclonal selection from Pokkali, suitable for rainfed lowland and coastal saline conditions, short-bold, yield 4,500-5,500 kg/ha
Hybrid Indam 200-022 (IET 20710)	Madhya Pradesh	Suitable for upland cultivation, early duration (110 days from seeding), grain-long bold, paddy-vegetable crop rotation, moderately resistant to LB, NB, BS and white backed plant hopper (WBPH)
Dehangi (AAUDR 9313-14-3) IET 18243	Assam	Rainfed, upland rice, maturity 120 days, average yield 2,800 kg/ha
Inglongkiri (AAUDR 9301-14-1) IET 17452	Assam	Rainfed, upland rice, maturity 120 days, average yield 2,800 kg/ha
Rongkhang (AAUDR 9312-13-1) IET 18242	Assam	Rainfed, upland rice, maturity 120 days, average yield 2,800 kg/ha
Bauna Kalanamak 102 CR Dhan 506 (IET 23053)	Uttar Pradesh Assam, AP and Karnataka under semi deep water	Aromatic rice High yeilding variety for the rainfed ecology, tolerant to waterlogging
CR Sugandh Dhan 908 (IET 23189)	Odisha, West Bengal and Uttar Pradesh	Scented rice, shallow low line area, non-lodging, semi-dwarf plant type
Pusa Basmati 1718 (IET 24565 – Pusa 1718-14-2-150)	Punjab, Haryana and Delhi	Marker assisted selection (MAS) derived near isogenic line of Pusa Basmati 1121, maturity 136-138 days, resistant to BLB, long slender grains with strong aroma
Gangavati Ageti (IET 19251)	Karnataka	Suitable for normal, early and late conditions, resistant to shattering, good for idli and dosa preparation, medium slender grain type, yield 6,500-7,000 kg/ha
Rajendra Nilam (RAU-1484-Aer-04) (IET 24010)	Bihar	Resistant to lodging and non-shattering, tolerant to LF, SB and gundhi bug, adapted to aerobic condition
Purna (IET-18654)	Gujarat	Rainfed area of south Gujarat
PAN 802 (IET-23498) (Hybrid)	West Bengal	Resistant to grain discoloration (GD) and sheath rot, tolerant to SB and LF, resistant to lodging and shattering
Karjat 8	Maharashtra	Rainfed and irrigated areas in transplanted conditions during *kharif* season, non-lodging, non-shattering
Karjat 9	Maharashtra	Non-lodging, non-shattering, moderately resistant to NB, BLB and resistant to leaf blast, BPH, WBPH and moderately resistant to SB
RCM-30, IET-24200 (RC Maniphou-13)	Manipur	Resistant to gall midge (GM), tolerant to NB, duration 125 to 135 days
CN 1272-55-105 (IET 19886)	WB, Bihar, Odisha, AP, Maharashtra and Karnataka	Late duration, grain - short bold, resistant to NB, BS and sheath rot (SR)
CR Dhan 408 (IET 20265) Chakaakhi	Odisha	Suitable for shallow lowland, grain - long bold, medium tolerance to LB, NB, BLB, SR, SB, LF and WBPH along with moderate submergence tolerance for one week, yield of 4,800 kg/ha
Surabhi (IET 24760)	Maharashtra and Gujarat,	Suitable for irrigated *kharif* and *rabi*, medium slender super fine grain, moderately resistant to BLB, SBL, BS, maturity (*kharif*) 125-135 days

Variety	Area of adoption	Salient features
KPH-459 (IET 24888)	Gujarat and Maharashtra	Mid duration hybrid, grain type medium slender, moderately resistant to BLB, suitable for late sown condition
TKM 13 (IET 22565)	Gujarat and Maharashtra	Irrigated mid-early, moderately resistant to Bl, RTD, BS, SR, SB, LF, GLH, yield 5,940 kg/ha
KPH 473 (IET 24825)	Chhattishgarh, Madya Pradesh and Maharashtra	Hybrid with mid early duration, long bold grains, moderately resistant to LB
BIO 799 (IET 22919) Hybrid	Odisha, Bihar, West Bengal, Uttar Pradesh, Jharkhand	Hybrid, long bold grain with multiple disease resistance to BLB, LBL, RTD and field tolerance to BPH
MRP 5408 (MEPH 114) IET 24143	Andhra Pradesh, Karnataka and Puducherry	Hybrid, long slender grains with moderately resistance to LB, NB, BS, RTD, and false smut
CR Dhan 909 (IET 23193)	Assam, Bihar, Uttar Pradesh and Maharashtra	Irrigated, aromatic, short grain, tolerant to LB, NB, SR, RTD, SB
Nandyala Sona (NDLR 7) (IET 23715)	Andhra Pradesh	Suitable for late sown conditions, replacement to BPT 5204 (Kurnool Sona), recommended for scarce rainfall zone, tolerant to water stress, , maturity 135-140 days, non-lodging, fertilizer responsive, non-shattering, short slender grain, highly tolerant to BPH, LF and moderately tolerant to blast, yield: 6,500 - 7,000 kg/ha
SRIMATI CR Dhan 207 (IET 23448)	Odisha	Early maturing (110-115 days), non-lodging, intermediate grain shattering, moderately resistant to LBl, NBl, BS, SR, SB, LF, GLH, GM 1 and 4, fertlizer responsive, av. yield of 3,700 kg/ha
PRIYA (CR Dhan 209)	Odisha	Early maturing (110-115 days), non-lodging, intermediate grain shattering, fertilizer responsive, grain long slender. Moderately tolerant to LB, NB, BS, RTD, SB, LF, WBPH, GLH, average yield 3,570 kg/ha
CR Dhan 507 (IET 22986)	Odisha	One week submergence tolerance, tall plant type, intermediate grain shattering, fertlizer responsive, late maturity (160 days), moderately resistant to NB, BS, SB, SR, SB, LF, average yield 4,750 kg/ha.
CR Dhan 409 (IET 23110)	Odisha	One week, submergence tolerance, moderately resistant to NBl, LB, SR, SR, SB, LF
CR Dhan 800 (IET 20672)	Odisha	Tolerant to BLB
CR Sugandh Dhan 910 (IET 22649)	Odisha	Moderately resistant to blast, BL, NB, SR, RTD, SB, LF, WBPH
Wheat		
WB-02	Punjab, Haryana, Delhi, Rajasthan, Uttar Pradesh, Jammu and Kashmir, Himachal Pradesh, Uttarakhand	Bread wheat, high zinc (42 PPM) variety, timely sown, irrigated condition, good level of yellow (stripe) rust resistance
Pusa Tejas (HI 8759)	Madhya Pradesh, Chhattisgarh, Gujarat, Rajasthan and Uttar Pradesh	Suitable for timely sown irrigated conditions, Durum wheat, rust resistance, dual purpose variety suitable for making *chapati*, pasta and other traditional food products. high protein content (12%), and essential micronutrients like iron (42.1 ppm) and zinc (42.8 ppm), average yield 5,700 kg/ha
Pusa Ujala (HI 1605)	Maharashtra, Karnataka and Tamil Nadu	Suitable for timely sown, restricted irrigation conditions, high levels of resistance to black and brown rust diseases, excellent *chapati* making quality, high protein (around 13%) and rich in micronutrients like iron (43 ppm) and zinc (35 ppm), average yield 3,000 kg/ha
HD 3171	Uttar Pradesh, Bihar, West Bengal and Assam	Rainfed, timely sown condition, resistance to leaf rust (LR) and leaf blight (LB)

Variety	Area of adoption	Salient features
Unnat PBW 343 (PBW 723) (Bread Wheat)	Punjab, Haryana, Delhi, Rajasthan, UP, J and K, HP and Uttarakhand	Suitable for timely sown, irrigated condition. Bread wheat, developed through MAS, carrying five rust resistance genes, possesses resistance to yellow rust (YR) and brown rust (BR) diseases, maturity 155 days, average yield 5,480 kg/ha
PBW 1Zn (HPBW 01)	Punjab, Haryana, Delhi, Rajasthan, Uttar Pradesh, Jammu and Kashmir, HP and Uttarakhand	Suitable for timely sown, irrigated condition, high zinc, resistant to BR and moderately resistant to YR, maturity 151 days, average yield 5,600 kg/ha
MACS 3949	Maharashtra and Karnataka	Suitable for timely sown, irrigated condition. Durum wheat, resistance to stem rust and LR and having good pasta quality (7.25/9), maturity 110-115 days, average yield 4,398 kg/ha.
Chhattisgarh Genhu 4 (CG 1015)	Chhattisgarh	Suitable for late sown, irrigated condition, heat tolerant,
Sabour Samriddhi	Bihar	Suitable for timely sown, irrigated condition, semi dwarf, erect type, strong waxiness on leaf sheath, maturity 120-125 days, yield 4,000-5,000 kg/ha.
Sabour Shreshtha (BRW 934)	Bihar	Suitable for late sown, irrigated condition, resistant to important diseases and insect pests, good *chapati* making quality, high protein and zinc content, highly responsive to nitrogen up to 120 kg N/ha, lodging resistant, having easy threshability and non-shattering in nature, average grain yield 4,300 kg/ha.
Sabour Nirjal (BRW 3723)	Bihar	Rainfed, lodging and drought tolerant, timely sown, strong waxiness on leaf sheath and ear, semi erect plant, maturity of 125- 130 days, yield 2,500-3,000 kg/ha.
Gujarat Junagadh Wheat 463 (GJW 463)	Gujarat	Suitable for timely sown irrigated conditions and early sown irrigated conditions, protein content 12.7% and micronutrients Fe, Zn, Mn and Cu content of 31.9, 23.8, 22.4 and 5.9 ppm, respectively, good *chapati* making quality, grain yield 5,575 kg/ha (Saurashtra) and 5,091 kg/ha (Gujarat)
CoW 3 (Bread Wheat)	Tamil Nadu	Suitable for limited irrigation, timely sown, short winter conditions, maturity 95-100 days, resistant to LR, SR, yield 4,076 kg/ha
K-1317	Eastern UP, Bihar, Jharkhand, Odisha, WB (excluding hills), Assam and plains of NE States	Recommended for rainfed, timely sown conditions, resistant to BR and leaf blight, good *chapati* quality (Score:8.05)
Barley		
Central Barley DWRB 123	Punjab, Haryana, UP, Delhi and Rajasthan	Suitable for timely sown, irrigated condition, malt barley, resistance for YR, BR under natural field conditions
Maize		
Vivek Hybrid 27 (Central	J and K, Uttarakhand, HP, Delhi,	Suitable for *kharif*, early duration high yielding
Maize VL Baby Cron	Punjab, Haryana, UP, Karnataka, TN, AP, Telangana, Maharashtra, Rajasthan, Gujarat, MP and Chhattisgarh	Babycorn hybrid, maturity (babycorn) in 52-54 days in hills and in 48-52 days in plains, moderately resistant to *H. turcicum* and *H. maydis* leaf blight, common rust and post-flowering stalk rot.
P3401 (X35D601) (Hybrid)	Andhra Pradesh, Telangana, Maharashtra, Karnataka and Tamil Nadu	Hybrid suitable for *kharif* season, moderately tolerance to turcicum leaf blight (TLB), Rajasthan downy mildew (RDM), brown stripe downy mildew (BSDM) and post flowering stalk rot (PFSR), *Chilo partellus* and *Sesamia inferens*
P3533 Hybrid	AP, Telangana, TN Maharashtra, Karnataka	Suitable for *rabi* season, resistance to TLB and *C. rot*
P3544 Hybrid	Punjab, Haryana, Delhi, UP, Bihar, Jharkhand, Odisha, WB, AP, Telangana, Maharashtra, Karnataka and TN	Suitable for *kharif* season, orange yellow, semi flint grain

Variety	Area of adoption	Salient features
Central Maize VL 55 (FH3605) Hybrid	J and K, Uttarakhand, HP and Karnataka, TN, AP, Telangana and Maharashtra	Suitable for *kharif* season, moderately resistant against *H. turcicum* and *H. maydis,* common rust and PFSR
VMH 4106 Sweet Corn Hybrid	Bihar, UP, Jharkhand, West Bengal and Odisha	Tolerant to MLB, TLB, banded leaf and sheath blight (BLSB), SDM, DM and rusts, tolerance to *Chilo paretellus*
HTMH 5402	AP, Telangana, Maharashtra, Karnataka and Tamil Nadu	Suitable for *kharif* season, resistant to RDM, sorghum downy mildew (SDM), bacterial stalk rot (BSR), Curvularia leaf spot (CLS), tolerance to *Chilo paretellus*, tolerant to mild moisture stress
GK 3150	Punjab, Haryana, Delhi and Uttar Pradesh	Suitable for *rabi* season, resistant to TLB, SDM, PFSR and moderately resistant to *C. rot* resistant to *Sesamia inferens* and *Chilo partellus,* tolerant to drought, heat and cold.
DRONA (KMH-2589)	Punjab, Haryana, Delhi, Uttar Pradesh, Andhra Pradesh, Telangana, Maharashtra, Karnataka and Tamil Nadu	Suitable for *rabi* season, resistant to common rust, PFSR and *C.rot*, tolerant to drought
Hy-brix 53 (ADVSW-2) Hybrid	J and K, HP, Uttarakhand, North East Hills, Punjab, Haryana, Delhi, UP, Bihar, Odisha, Jharkhand, WB, TN, AP, Telangana, Maharashtra and Karnataka	Suitable for *kharif*, resistant to *Fusarium* stalk rot (FSR), RDM and moderately resistant to TLB and maydis leaf blight (MLB)
Hi-brix-39 (ADVSW-1) (Sweet Corn)	J and K, HP, Uttarakhand, Punjab, Haryana, Delhi, UP, Bihar, Odisha, Jharkhand, WB, TN, AP, Telangana, Maharashtra, Karnataka, Assam, Manipur, Meghalaya, Mizoram, Arunachal Pradesh, Tripura and Nagaland	Suitable for *kharif*, resistant to common rust, BSR, *Fusarium* stalk rot, RDM and moderately resistance to TLB and MLB
Shalimar Pop Corn-1 (KDPC-2)	J&K, HP, Uttarakhand, Punjab, Haryana, Delhi, UP, Bihar, Odisha, Jharkhand, WB, Rajasthan, Gujarat, MP, Chhattisgarh, Assam, Manipur, Meghalaya, Mizoram, Arunachal Pradesh, Tripura and Nagaland	Suitable for *kharif*, moderately resistant to banded leaf and sheath blight and FSR, resistant to stem borer
Pant Sankar Makka 4 (PSM4) (DEH-153) (DH-188)	Uttarakhand	Suitable for *kharif*, resistant to TLB, BLSB, BSDM and ESR
Bisco Champion 61 (Bisco 2238)	J and K, HP, Hills of Uttarakhand, and NE region and Maharashtra, Andhra Pradesh, Karnataka and TN	Suitable for *kharif* season, moderately resistant to prevailing diseases (TLB, MLB, DM, BSDM, PFSR, *C*. Rust and tolerant to pests)
Bisco X 5129	Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu (Zone 4)	Suitable for *rabi*, moderately resistant to prevailing diseases (TLB, MLB, DM, BSDM, PFSR, *C. rust* and tolerant to pests)
Karimnagar Makka (KNMH - 4010141)	Telangana, Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu	Suitable for *kharif*, rainfed situation, grows in both high and low fertility conditions
Pusa HM-8 Improved (AQH-8)	Maharashtra, Karnataka, Telangana, Andhra Pradesh and Tamil Nadu	QPM hybrid developed through MAS, nutria-rich with enhanced tryptophan (80 %), lysine (76%) and high protein (4.18 %)
Pusa HM-9 Improved (AQH-9)	Bihar, Jharkhand, Odisha, Uttar Pradesh and West Bengal	QPM hybrid developed through MAS, nutria-rich with enhanced tryptophan, lysine and high protein
Pusa HM-4 Improved (AQH-4)	Punjab, Haryana, Delhi, Uttarakhand and Uttar Pradesh	QPM hybrid developed through MAS, nutri-rich with enhanced tryptophan, lysine, high pro-vitamin A, high protein

Variety	Area of adoption	Salient features
Pusa Vivek QPM-9 Improved (APQH-9)	J and K, HP, Uttarakhand, Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur, Arunachal Pradesh, Maharashtra, TN, AP and Telangana	QPM hybrid developed through MAS, nutria-rich with enhanced tryptophan (74%), lysine (60%) and high protein (3.62 %)
JKMH-4848 (IMR 498)	Maharastra, Karnataka, Andhra Pradesh, Telangana and Tamilnadu	Resistant to *Chilo partellus*, FSR, charcoal rot and common rust, moderately resistant to MLB, TLB, charcoal rot, RDM and CLS
DMRH-1301 Hybrid	Bihar Jharkhand, Odisha, West Bangal and Uttar Pradesh (Eastern Region), Rajasthan, Madhya Pradesh, Chhattishgarh and Gujarat	Tolerant to *Sesamia inferens*, *Chilo partellus* and moderately resistant to TLB
DMRH-1402 Hybrid	Punjab, Haryana, Delhi, Uttarakhand (Plain), UP (Western Region), Rajasthan, Gujarat, MP and Chhattishgarh	Popcorn hybrid, moderately tolerant to *Chilo partellus* (Zone II) and (Zone V), and moderately resistant to FSR (Zone V)
DMRH-1308 Hybrid	Rajasthan, Madhya Pradesh, Chhattishgarh and Gujarat	Tolerant to *Sesamia inferens* and *Chilo partellus*
Sorghum		
PDKV Kalyani (AKSV–181) (SPV 2029)	Maharashtra	Clean foliage (no leaf diseases) and non-lodging nature
Pearl millet		
PBH - 306	Maharashtra, Karnataka, Telangana, AP and TN	Resistant to downy mildew and smut
Mahabeej 1005 (MH-1852) Hybrid	Maharashtra	Suitable for rainfed condition in Maharashtra, non-lodging
NBH 4903 (Balwan)	Maharashtra, Karnataka, AP, Telangana and TN	Late maturing, medium plant height, tolerant to major diseases (downy mildew, ergot and blast), tolerant to drought
Little millet		
Chhattisgarh Kutki 1 (BL-6)	All India	Suitable for upland cultivation, rich in zinc and calcium
Proso millet		
TNAU 202	AP, MP,Chhattisgarh, Karnataka, Gujarat, TN and Bihar	Profuse tillering and bold grains
Kodo millet		
TNAU 86	AP, MP, Chhattisgarh, Karnataka, Gujarat and TN	Early duration, non-lodging, high milling recovery (52-53%)
Finger millet		
Dapoli - 2 (SCN - 6)	Maharashtra	High yielding, rich in iron and calcium, moderately resistant to blast, tolerant to aphids and *Spodoptera litura*
CO 15	Tamil Nadu	Highly responsive to nitrogenous fertilizer, non-lodging, resistant to leaf, neck and finger blasts and nutritionally rich grain and fodder
KMR 340	Karnataka	Irrigated and rainfed parts of Karnataka
GNN 7	Gujarat	High mineral matter (%), crude fibre, calcium, phosphorous and good amount of protein, fat, carbohydrates and magnesium
VL Mandua 376 (VL 376)	All ragi growing areas of country	Responsive to fertilizer and moderately resistant to blast
Foxtail millet		
Rajendra Kauni - 1 (RAU-2)	Bihar	Resistant to leaf blast, rust, smut, brown spot, downy mildew and leaf blight. High iron (15.45 mg/100g) and zinc (5.02 mg/100g) content

Oilseeds

Twenty eight high-yielding oilseeds varieties comprising 8 of rapeseed-mustard, 5 of soybean, 4 each of groundnut and linseed, 3 of sunflower, 2 each of castor and niger were released for different agro-ecological regions.

Improved varieties/hybrids of oilseeds released

Variety	Area of adoption	Salient features
Indian mustard		
CS-58 (CS 1100 – 1-2-2-3)	Haryana, Punjab and Uttar Pradesh	Salinity tolerant
Pant Rai 21 (PRB 2008-5)	Uttarakhand	*Alternaria* blight tolerant
Yellow sarson		
Pant Sweta (PYS – 2007-10)	Uttarakhand	For irrigated condition
Toria		
Pant Hill Toria-1 (PT-2006-4);	Uttarakhand	Spring type toria
Pant Toria-508 (PTE-2008-2);	Uttarakhand	Moderately resistant to white rust and resistant to stag head formation
Raj Vijay Toria 1	Madhya Pradesh	Tolerant to drought, suitable for rainfed and irrigated condition, tolerant to shattering, sowing time - first to second week of September
Taramira		
Jobner Tara (RTM-1351)	Rajasthan, Haryana, Punjab, UP, Gujarat, Delhi, Uttarakhand and Maharashtra	Suitable for rainfed situation
Jwala Tara (RTM 1355)	Rajasthan, Haryana, Punjab, UP, Madhya Pradesh, Gujarat and Delhi	Suitable for rainfed situation
Soybean		
Raj Soya 24 (RVS 2002-4)	Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh	Tolerant to major leaf, pod and root rot diseases, girdle beetle and semi looper attacks
Pant Soybean 24 (PS 1477)	Uttar Pradesh and Uttarakhand	Multiple disease resistant, free from lodging and shattering, tolerant to drought to some extent
Pant Soybean 21 (PS 1480)	Uttarakhand	Resistant to yellow mosaic virus (YMV) and bacterial pustule, tolerant to RAB, rainfed/irrigated cultivation in plains and lower hills of Uttarakhand
Pant Soybean 23 (PS 1523)	Uttarakhand	Resistant to lodging and shattering, rainfed/irrigated cultivation in plains and lower hills of Uttarakhand
Raj Soya 18 (Pragya)	Madhya Pradesh	Resistant to YMV and charcoal rot, erect plant type suitable for intercropping
Groundnut		
Central Groundnut ALG06-320 (ALG-06-320)	Tamil Nadu and Andhra Pradesh	Suitable for irrigated situation, tolerant to rust, LLS and peanut bud necrosis disease (PBND), *S. litura*, leaf miner and thrips
Kadiri Amaravathi (K1535)	Andhra Pradesh	Suitable for rainfed situation, field tolerance to PBND
VRI 8 (VG 09220)	Tamil Nadu	Suitable for rainfed and irrigated condition, moderately resistant to sucking pest (jassids and thrips), LLS and rust
GJG 32 (ICGV 03043) Gujarat Junagadh GNut	Tamil Nadu, Andhra Pradesh, Telangana, Karnataka, Kerala and Southern Maharashtra	Tolerant to stem rot, collar rot and rust
Linseed		
Indu (LCK 1108)	Uttar Pradesh	Suitable for irrigated areas, resistant to rust, powdery mildew and bud fly
Uma (LCK 1101)	Uttar Pradesh	Suitable for rainfed condition, tolerant to wilt, *Alternaria* blight and rust
Priyam (BAU-2012-1)	Punjab, Haryana, Himachal Pradesh and Uttar Pradesh	Suitable for rainfed and moderate fertility condition during *rabi* season, high yield and oil content (41.3%), highly resistant to bud fly and rust
JLS-66 (SLS 66)	Madhya Pradesh	Short in height, maturity 107-114 days, moderately resistant to powdery mildew, alternaria blight, rust and major insect pests, oil content 40.5% and yield potential 2,200 kg/ha

Variety	Area of adoption	Salient features
Niger		
Jawahar Niger Selection 28 (JNS 28)	All India niger growing areas	Tolerent to *Cercospora* and *Alternaria* leaf spot
GNNIG 3 (NRS 1304)	Gujarat	Resistant to *Alterneria* and *Cercospora* leaf spot disease
Sunflower		
Kaveri Champ	Punjab, Haryana, Bihar, West Bengal and Odisha	Tolerant to downy mildew and leaf hopper
Prabhat (Hybrid NDSH 1012)	Andhra Pradesh	Tolerant to downy mildew
PDKVSH-952 (Hybrid)	Maharashtra	Rainfed and irrigated area in *kharif* and *rabi*; moderately resistant to powdery mildew
Castor		
GNCH 1	Gujarat	Possesses high level of resistance in sick plot and through root dip method
YRCH-2 (YRCH 1116)	Tamil Nadu	Resistant to wilt, tolerant to spodoptera, semilooper, leafhopper and capsule borer

Pulses

Thirty two high-yielding varieties of pulses comprising 10 of chickpea, 6 of lentil, 4 of cowpea, 3 of greengram, 2 each of pigeonpea, horsegram and field pea, 1 each of urdbean, rajmash and fababean were released for different agro-ecological regions.

Improved varieties/hybrids of pulses released

Variety	Area of adoption	Salient features
Greengram		
Pusa 1371	Tripura, Manipur, J and K and Himachal Pradesh	Multiple disease resistance (MYMV, root rot, web blight and *Anthracnose*)
Pant Mung 8 (PM 09-6)	Uttarakhand	Resistant to MYMV, *Cercospora* leaf spot and powdery mildew diseases
DGG 1	Karnataka	Resistant to powdery mildew, flaking variety
Blackgram		
Tirupati Minumu-1 (TBG 104)	Andhra Pradesh	Suitable for *rabi* cultivation, tolerance to YVMV
Chickpea		
Gujarat Gram 5 (GJG 0809)	J and K, HP, Uttarakhand and NEH Regions	Tolerant to wilt, stunt and collar rot
Meera (GNG- 2171)	Punjab, Haryana, UP, J and K, Delhi, Rajasthan, HP and Uttarakhand	Tolerant to wilt, stunt and root rot
Indira Chana-1	Chhattisgarh	Resistant to wilt and moderately resistant to dry root rot.
Nandyal Gram 49 (NBeG 49)	Andhra Pradesh	Tolerant to wilt and dry root rot
Pant Gram 4 (PG 065)	Uttarakhand	Tolerant to wilt and BGM
Pant Gram 3 (PG 043)	Uttarakhand	Tolerant to wilt and BGM
Pant Kabuli Gram-2 (PG071)	Uttarakhand	Tolerant to wilt and BGM
Dheera (NBeG 47)	Andhra Pradesh	Tall and erect plant, suitable for mechanical harvesting
Pant Gram 5 (PG 0109)	Rajasthan, Haryana, Punjab, UP, Uttarakhand, and Jammu & Kashmir	Late sown rainfed/ irrigated conditions, tolerant to pod borer
Phule Vikram (Phule G-08108)	Maharashtra	Suitable for rainfed, timely sown irrigated and late sown condition, resistant to *Fusarium* wilt
Lentil		
RVL 11-6	MP, Maharashtra, Gujarat, UP and Rajasthan	Tolerant to wilt, semi erect, medium height and branches with broad leaves which is very much suitable for intercropping
L 4717 (Pusa Ageti Masoor)	MP, UP, Rajasthan and Chhattisgarh	Semi erect, early, resistant to powdery mildew, wilt and *Ascochyta* blight

Variety	Area of adoption	Salient features
Pant Lentil – 9 (PL 098)	Uttarakhand	Resistant to rust, wilt and *Ascochyta* blight diseases
Kota Masoor 1 (RKL 607-1)	Rajasthan	Tolerance to wilt
Shekhar 4 (KLB 345)	Uttar Pradesh	Tolerance to wilt and rust, bold seed
Shekhar 5 (KLS 122)	Uttar Pradesh	Tolerance to wilt and rust, small seed
Pigeonopea/ red gram		
Amaravathi (LRG-52)	Andhra Pradesh	Moderately resistant to wilt
BDN 716 (BDN 2008-7)	Maharashtra	Resistant to wilt and sterility mosaic, red and large seeded
Cowpea		
Phule Rakhumai (PCP 0306-1)	South Zone	Moderately resistant to *Cercospora* leaf spot
Tirupati Cowpea 1 (TPTC 29)	Andhra Pradesh, Karnataka, TN and Odisha	Moderately resistant to dry root rot and YMV
DC-15	Karnataka, AP, Tamil Nadu and Kerala	Moderately resistant to dry root rot and YMV
Pant Lobia 5 (PGCP 12) (Pant Grain Cowpea 12)	UP, Uttarakhand, Rajasthan, Gujarat, Karnataka and Kerala	Resistant to YMV
Field pea		
Central Field pea (IPFD 12-2)	Madhya Pradesh, Chhattisgarh, Gujarat and Rajasthan	Resistant to powdery mildew, pod borer and moderately resistant to aphids and leaf miner
Pant Pea 155 (Pant P–155)	Uttarakhand	Resistant to rust and powdery mildew and tolerant to pod borer
Horse gram		
Chhattisgarh Kulthi 3 (BHG 03)	Chhattisgarh	Resistant to collor rot, powdery mildew and leaf spot
Chhattisgarh Kulthi 2 (BWH 1)	Chhattisgarh and neighboring states	Suitable for rainfed condition, resistance to powdery mildew, significantly low YVMV incidence
Rajmash/French bean		
Shalimash (SKUAR R-132) Rajmash 2	Jammu and Kashmir	Moderately resistant to bean common mosaic virus (BCMV) and aphids
Faba bean		
HFB 1 (HB 82)	Haryana, Punjab, Delhi, Uttar Pradesh, Bihar, Jharkhand and Chhattisgarh	Rich in protein (25.3 %), fibre, plant nutrients and a good source of vitamins and minerals. It contains levo-dopa, a precursor of neuro-chemicals in brain such as dopamine, epinephrine, resistant to major diseases and insect-pests and tolerant to lodging, pod shattering and climatic stresses. Seed yield 2,287 kg/ha

Commercial crops

Twenty four high-yielding varieties of commercial crops including 13 of cotton, 8 of sugarcane and 3 of jute were released for different agro-ecological regions.

Varieties/hybrids of commercial crops released

Variety	Area of adoption	Salient features
Cotton		
DHB 915	AP, Tamil Nadu, Gujarat, Maharashtra and MP	Extra-long staple, interspecific (*hirsutum* × *barbadense*) hybrid
CSH – 3129	Punjab, Haryana and Rajasthan	Moderately resistant to cotton leaf curl disease (CLCuD), tolerant to fungal foliar diseases and major insect pests
MRC -7377 (Hybrid)	AP, Telangana, Karnataka and Tamil Nadu	Tolerant to bacterial leaf light (BLB), *Alternaria* leaf spot (ALS)
Central Cotton (CSH 3075)	Punjab, Haryana and Rajasthan	Suitable for high density planting system (HDPS)
LD 949 (Desi)	Punjab, Haryana and Rajasthan	Absorbent cotton, moderately resistant to *Fusarium* wilt, resistant to jassids and white fly
MR 68 (American Cotton)	Punjab, Haryana, Rajasthan and Uttar Pradesh	High yielding variety, denim purpose, yield 20 – 25 q/ha
Central Cotton NHH 250	Maharashtra, Madhya Pradesh and Gujarat	High yielding hybrid suitable for rainfed condition, tolerant to BLB and ALS and sucking pests

Variety	Area of adoption	Salient features
Phule Asmita (RHH-0917) Hybrid	Maharashtra, Madhya Pradesh and Gujarat	Resistant to BLB, ALS, MLB and gray mildew; moderately resistant to sucking pests and bollworms
Phule Prabha (RHB 0812) Hybrid	Maharashtra, MP, Gujarat, Karnataka, AP, Telangana and TN	Resistance to ALS and disease free reaction to BLB and gray mildew; tolerant to sucking pests and bollworms
DHB 1071	Karnataka	Extra-long staple interspecific (*hirsutum barbadense*) hybrid
GN.Cot.Hy 14 (GSHH 2729)	Gujarat	Resistant to jassids, thrips, whitefly and aphids; tolerant to BLB and ALS
GJ Cot 111 (GAM 162)	Gujrat, Madhya Pradesh, Maharashtra and Odisha	Tolerant to jassids, white fly, and major diseases, average yield 1,514 kg/ha, maturity 160-170 days
K 12	Tamil Nadu	Moderately resistant to BLB and ALS, resistant to leaf hopper, aphids, thrips and stem weevil, average yield 1,193 kg/ha, maturity 135 -140 days
Jute		
NCJ-28-10 AAUCJ-2 (Khyati)	Assam and West Bengal	Suitable for cultivation in waterlogged area and rainfed condition
Kisan Pat (BCCO-6)	Entire tossa jute growing states	Coppery red stem colour variety with better fibre quality in terms of both fibre tenacity (21.18 g/tex) and fineness (2.81 tex), average yield 2,835 kg/ha
DAWB-ZARSKgr-Jute-KRO4	West Bengal, Bihar, Odisha, Assam and Maharashtra	Tolerant to stem rot disease and less incidence of semi-looper, apion, Bihar hairy caterpillar (BHC) and yellow mite
Sugarcane		
Revathi (2000 A 225 (CoA 05323)	Coastal Areas of Andhra Pradesh and Tamil Nadu	Moderately resistant to red rot, smut and tolerant to moisture stress
Buddhi 2003 A 255 (CoA 08323)	Andhra Pradesh, Odisha and Tamil Nadu	Moderately resistant to red rot, tolerant to water-logging
Co 09004 (Amritha)	TN, Kerala, AP, Telangana, Karnataka, Gujarat, Maharashtra, MP and Chhattisgarh	Moderately resistant to red rot and resistant to smut; early maturing, high yielding, non-lodging, smut resistant, tolerant to drought and salinity
Co 9022 (Karan 12)	Haryana, Punjab, Rajasthan, Uttarakhand and Uttar Pradesh	Moderately resistant to red rot, smut and resistant to wilt; high sugar recovery, non-lodging
GNS 9 (2004 N 817) (CoN 09072)	Gujarat	Moderately resistant to red rot, smut; and resistant to wilt, red rot and whip smut, high sugar content, good ratooning ability
SNK-632 (CoSnK 03632)	Karnataka	Tolerant to moisture stress; yield 185 tonnes/ha, suitable for 'adasali' planting
CoVSI 03102	Sugarcane growing areas of high rainfall zone of Maharashtra	Tolerant to drought, non-lodging, resistant to smut, brown eye spot disease, cane yield 156.37 tonnes/ ha and sugar yield 22.79 tonnes/ha
CoC 25	East Coast Zone	High yielding, fast growing; good ratooner; moderately resistant to red rot; suitable for early and special season, cane yield 145.0 tonnes/ha, CCS 12.77%

Forage crops

Eight high-yielding varieties/hybrids of forage crops comprising 3 of oats, 1 each of bajra napier hybrid, forage sorghum, grain amaranthus, forage cowpea and marvel grass were released for cultivation in different agro-ecologies.

Varieties/hybrids of forage crops released

Variety	Area of adoption	Salient features
Pearl millet		
Phule Gunwant (RBN 2011-12)	Maharashtra	Perennial grass, multi cut

Variety	Area of adoption	Salient features
Forage sorghum		
CSV 33 MF (SPV 2242	Haryana, Punjab, Uttarakhand, Uttar Pradesh, Gujarat, Rajasthan, Tamil Nadu, Karnataka and Maharashtra	Multi cut forage sorghum, tall 180-204 cm, resistant to all major diseases and pest infestation, tolerant to lodging
Forage cowpea		
TNFC 0926	Tamil Nadu	Resistant to cowpea yellow mosaic virus and moderately resistant to root rot disease
Oat		
Phule Surabhi (RO 11-1)	Punjab, Haryana, Uttarakhand, Rajasthan, UP, Jharkhand, WB, Odisha, Assam, Manipur, Bihar, Gujarat, MP, Maharashtra, Chhattisgarh, Karnataka, TN, Kerala and Telangana	Moderately resistant to leaf blight, root rot; less susceptible to aphids
OL 1804 (Single cut)	West Bengal, Odisha, Jharkhand, Bihar, Eastern Uttar Pradesh, Manipur, Assam	Better nutritional quality, moderately resistant to leaf blight
OL 1802 (Multi cut)	Maharashtra, Gujarat, Madhya Pradesh, Chhattisgarh, Central Uttar Pradesh	Better nutritional quality, resistant to leaf blight, *Sclerotium* root rot and leaf defoliators
Marvel grass		
Phule Govardhan (Marvel 2008-1)	Maharashtra	Perennial multi cut grass, apomictic
Grain amaranth		
KBGA 1	Karnataka	Contains high seed protein (15.32%), average yield 1,050 kg/ha, pink color plant with white seed

Quality enhancement

Biofortified varieties: Biofortified varieties of crops which could be integrated into the food chain to enable better health of human have been developed. These varieties are: wheat [WB 2 (High zinc: 42 ppm and iron: 40 ppm), HPBW 01 (High zinc: 40.6 ppm and Fe: 40 ppm)], maize [Pusa Vivek QPM 9 Improved (high pro-vitamin-A: 8.15 ppm, high tryptophan: 0.74% and lysine: 2.67%), Pusa HM 4 Improved (high tryptophan: 0.91% and lysine: 3.62%), Pusa HM 8 Improved (tryptophan: 1.06% and lysine: 4.18%), Pusa HM 9 Improved (high tryptophan: 0.68% and lysine: 2.97%)], pearl millet [HHB-299 (high iron: 73 ppm and zinc: 41 ppm), AHB 1200 (high iron: 73 ppm)], Indian mustard [Pusa Double Zero Mustard 31 (<2% erucic acid in oil and < 30 ppm glucosinolates in seed meal)] and lentil [Pusa Ageti Masoor (L 4717) (Iron rich: 65 ppm)].

Lipoxygenase-2 free soybean: Lipoxygenase-2 free soybean NRC 109 with reduced off-flavour was developed and commercialized. Non-exclusive license for 5 years has been given to M/S Sonic Biochem Pvt Ltd, Indore and M/s Nature Biocare, Tamil Nadu.

Biotechnology and genetic engineering

Identification and mapping of novel leaf rust resistance gene in wheat: A leaf rust resistant stock Selection G 12 was developed from the cross between bread wheat line CM 108-31 × *T. Timopheevii* (2n= 28, A^tA^tGG). Characterization of leaf rust resistance in Selection G 12 by multi-pathotype testing displaying high degree of broad spectrum resistance to prevalent important Indian pathotypes of leaf rust pathogen (*Puccinia triticina*). Genetic analysis of this leaf rust resistance using most virulent and prevalent pathotype 77-5 revealed that resistance in Selection G 12 is governed by a single recessive gene. Molecular mapping and linkage analysis has mapped this leaf rust resistance gene on long arm of 3B chromosome flanked by markers *Xgwm547* and *Xgwm114* at 6 cM and 28.3 cM, respectively. As no other leaf rust resistance gene has been designated on chromosome 3BL so far, the novel leaf rust resistance in Selection G 12 is tentatively named as *LrSel.G12*. This leaf rust resistance gene is expected to be of immense value in diversifying the genetic base of leaf rust resistance in wheat varieties.

Development of co-dominant marker associated with *Glu-D1* double null in Nap Hal in wheat: To identify co-dominant marker, large number of microsatellite markers representing long arm of chromosome 1 were synthesized and used in analysing segregating generations and RILs developed from a cross between Nap Hal and UP 2425. Two of the microsatellite markers co-segregated with *Glu-D*1 and exhibited weak gluten as determined by sedimentation value in this set of RILs. The co-dominant marker linked with *Glu-D1* double null was validated and used in backcross breeding for transferring *Glu-D1* double null into high yielding backgrounds.

Androgenic method for generation of double haploids (DHs) from F1s of Chakhao IR 20 of rice: The anthers containing the mid-uninucleate microspores of F_1 [(Chakhao; (Manipuri black rice) × IR 20; medium duration, semi-dwarf, high yielding, acceptable grain quality)] showed 28% callus response after four weeks of culture followed by 80% green

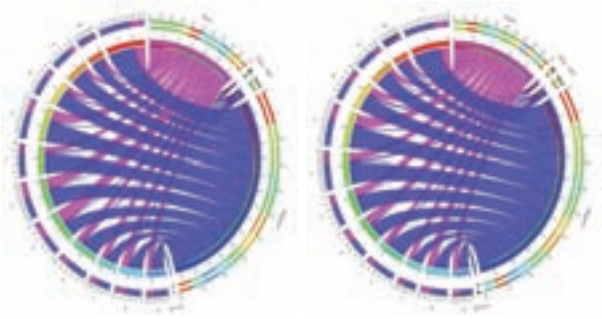
shoot regeneration after two weeks of culture during *kharif* 2016.

Mapping of genomic region responsible for salinity tolerance at germination stage using DHs of Savitri × Pokkali of rice: Identified four candidate genes [LOC_Os01g09550 (no apical meristem protein), LOC_Os01g09560 (mitochondrial-processing peptidase subunit alpha), LOC_Os12g06560 (putative protein) and LOC_Os12g06570 (cyclic nucleotide-gated ion channel)] using 117 DH lines derived from Savitri × Pokkali for salinity tolerance at germination stage.

Haplotype of recessive *opaque2* in QPM inbreds: A set of 46 QPM inbreds of exotic and indigenous origin were genotyped using *opaque2* (*o2*) gen-based two SSRs, viz. *umc1066* and *phi057*, present on exon-1 and exon-6 of the gene, respectively. Among the haplotypes, *o2*-AE had the highest frequency (76.09%), followed by *o2*-AD (15.22%) and *o2*-BD (4.35%). *o2*-BC and *o2*-AC haplotypes were observed in 2.17% each of the inbreds. Haplotype, *o2*-BE was not found in the inbred panel. Inbreds from IARI, New Delhi had *o2*-AE and *o2*-AD haplotypes. So far, breeders perceived that only one recessive *o2* allele exist in the population, the present study reports here the occurrence of at least five versions of recessive *o2* allele.

Discovery of salinity responsive long non-coding RNAs of rice at reproductive stages

Long non-coding RNAs (lncRNAs) have recently emerged as important regulatory molecules of eukaryotic gene expression in every domain of life. Computational pipeline was developed to identify lncRNAs in rice plants from RNAseq data and functionally classify the potential lncRNAs. Transcriptome data was generated from the flag leaf and roots of Horkuch, a salt tolerant genotype at reproductive stage and IR-29, a salt sensitive genotype at reproductive stage, under control and salinity stress. By applying several stringent criteria, 1626 and 2208 putative lncRNAs in root and leaf tissue, respectively, were identified and functionally annotated. Expression pattern of randomly selected lncRNAs was verified by qPCR analysis. Based upon their genomic origin, 1079, 45 and 473 lncRNAs in root tissue were categorised as lincRNAs, NAT and sense, respectively; while 1452, 67 and 6 leaf tissue lncRNAs were categorised as lincRNAs, NAT and intronic, respectively. Both root and leaf tissue lincRNAs were more evenly distributed across chromosomes. The few lncRNAs were predicted as a precursor for miRNA and siRNA molecule, while some as target mimics of known miRNAs involved in various regulatory functions. The modulated expression of lncRNAs in salinity indicated their putative role in stress response in rice.



(A) (B)

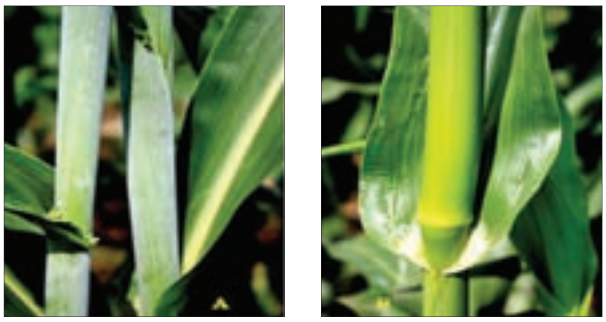
Distribution of lncRNAs on the 12 chromosomes of rice.
A: Leaf lncRNAs; B: Root lncRNAs.

Marker-assisted breeding in sorghum

Three brown midrib genes (*bmr2*, *bmr6* and *bmr12*) useful for lignocellulosic biofuel production pyramided into two sorghum cultivars, CSV 20 and CSV 27.A new genic SSR marker Sb-bmr12 was developed for effective marker-assisted gene pyramiding.

New epicuticular wax locus mapped in sorghum

A new epicuticular wax (bloom) locus has been identified and fine mapped to the 207.89 kb genomic region on chromosome 1. A putative candidate gene, Sobic.001G269200, annotated as GDSL-like lipase/acylhydrolase, is identified as the candidate gene involved in bloom synthesis/deposition.



Phenotypic expression in parents (a) BT× 623 (bloom) and (b) RS 647 (bloomless)

Cloning of RGA and sequence analysis for finger millet blast

Degenerate primers specific to P-Loop and GLPL motif of nucleotide binding site (NBS) domain were custom synthesized and resistance gene analogues were amplified, cloned and sequenced from the finger millet line IE 2911. The 511 bp long sequence contained a continuous open reading frame encoding 170 amino acids. The deduced amino acid sequence showed internal motifs characteristic of NBS domain namely P-loop, Kinase 2, Kinase 3a and GLPL. The sequence showed maximum identity (77%) to RPS2-type RGA from *Oryza sativa* in BLASTP analysis. RPS2 belongs to the non-TIR subclass of NBS LRR proteins which is characterized by the absence of Toll/interlekin-1 receptor (TIR) in the amino terminus, but instead has a coiled structure. In *Arabidopsis*, RPS2 is involved in defense against *Pseudomonas syringae*.

Development of a high-density intraspecific SNP linkage map of pigeonpea

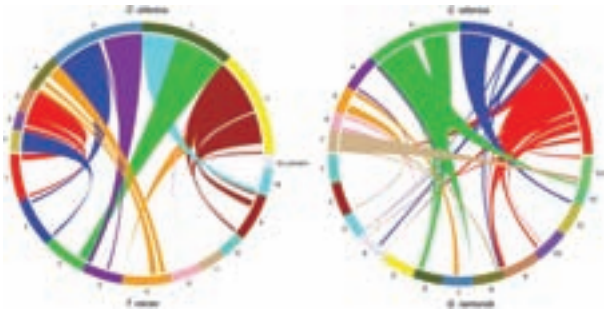
Pigeonpea is the second most important pulse crop of India. Due to high carbon sequestration and drought tolerance, pigeonpea is considered to be an important

crop for the development of climate resilient agriculture and nutritional security. However, pigeonpea productivity has remained low for decades because of limited genetic and genomic resources, and sparse utilization of landraces and wild pigeonpea germplasm. Hence, a high-density intraspecific consensus linkage map of eleven pigeonpea chromosomes comprising 932 markers that span a total map length of 1,411.83 cM was developed. The consensus map is based on three different linkage maps that incorporate a large number of single nucleotide polymorphism (SNP) markers derived from the next generation sequencing data, using Illumina Golden Gate bead arrays, and genotyping by restriction site associated DNA (RAD) sequencing. The integrated map has 547 bead-array SNP, 319 RAD-SNP, and 65 simple sequence repeat (SSR) marker loci. The availability of a high-density linkage map will help improve the anchoring of the pigeonpea genome to its chromosomes and mapping of genes and quantitative trait loci for useful agronomic traits.

DNA fingerprinting: Profiling of 23 varieties of *Brassica rapa*, 49 of pigeonpea (*Cajanus cajan*) and 13 of little millet was carried out using SSR markers. Five hundred and ninety wheat accessions were characterized for heat shock factor and for Lr34/Yr18 using STMS markers. Two hundred twenty three core accessions and 20 varieties of foxtail millet were validated using 31 SSR markers. Genotyping was conducted in 20 wheat accessions for salt tolerance and 20 finger millet accessions for blast resistance using gene based SSR markers. A total of 65,536 biallelic type SNPs were generated by resequencing of 15 brinjal landraces and *Solanum incanum*. Thottumuriyan (TCR 419), a black pepper landrace was sequenced. Putative abiotic stress responsive transcription factors have been identified in chickpea, soybean, cotton (*G. raimondii*), greengram, sesame, foxtail millet, tomato, potato, sorghum and maize. Real time LAMP assays for marker genes (*pat*, *pm*, *Sad1* and *barstar*) were developed.

Decoding of the dark jute genome

Corchorus olitorius ($2n = 2 \times = 14$), commonly known as dark jute is an important ligno-cellulosic bast fibre crop with >80% acreage of jute growing areas of the world. The genome sequencing of Indian jute variety JRO 524 (Navin) was accomplished. The draft genome of JRO-524 (Navin) has a size of 377.3 Mbp harbouring 57,087 protein-coding genes, out of which 1,765 genes codes for disease resistance-like and defence responses. The annotated genes showed the highest sequence similarity with that of *Theobroma cacao* followed by *Gossypium raimondii*. Seven chromosome-scale genetically anchored pseudomolecules were constructed with a total size of 8.53 Mbp and used for synteny analyses with the cocoa and cotton genomes.



Genomic syntenic relationships of *C.olitorius* (2n=2x= 14) with *T. cacao* (2n=2x= 20) and *G. rainondii* (2n=2x= 26).

Morphological and PCR studies of Melissococcus plutonius infecting Aphis cerana

European foul brood caused by *Melissococcus plutonius* is the major disease infecting *Apis mellifera* colonies. However, *A. cerana* colonies maintained at apiaries of the Dr Y S Parmar University of Hortculture and Forestry, Nauni, Solan exhibited symptoms of European foul brood disease. Morphological studies of bacterial isolates from the infected colonies indicated that brood was infected by two pathogens with different morphological and culture characteristics. While, molecular analysis to confirm the identity of pathogens through PCR studies with universal primer (BCF_1/BCR_2) indicated the presence of only *Enterococcus faecalis*, which was further confirmed by sequencing. *E. faecalis*, previously thought to cause European foul brood disease is secondary bacteria which rapidly accelerate the death of the infected larvae and is responsible for sour smell encountered with European foul brood.

Whole mitochondrial genomes of entomopathogenic nematodes

The whole mitochondrial genomes of two entomopathogenic nematodes, *Heterorhabditis indica* and *H. bacteriophora*, have been sequenced on Illumina NextSeq 500 for the first time. The whole genome of *H. indica* was determined to be 14,556 bp with an AT ratio of 65.2%, whereas, it was 14,679 bp and 65.4% for *H. bacteriophora*. Altogether, 36 genes, including 12 protein-coding genes (encoding ATP6, CYTB, COX1, 2 and 3, ND1-6 and ND4L), two rRNA genes and 22 tRNA genes were identified. The generated data can be used for understanding the distribution, genetic diversity and phylogenetic relationships of these two species across taxons.

DNA barcoding data generated for major spider mite pest species: Molecular systematics revealed 8 to 10 invasive spider mite species in the country, *Tetranychus truncatus*, *T. okinawanus*, *T. turkestani*, *T. udaipurensis*, *T. lombardinii*, *T. hirsutus* (new species), *Oligonychus tylus*, *Schizotetranychus baltazari* and *S. krungthepensis* infesting field crops (sugarcane, pulses), vegetable crops (okra, cucurbits, *Amaranthus*, curry leaf), flower crops (*Jasminum*), ornamental crops (*Adenium*), fruit crops (banana, grapes, citrus), date palm and medicinal plants (*Gymnema*, *Ichnocarpus*).

In-vitro regeneration of *Sehima nervosum*

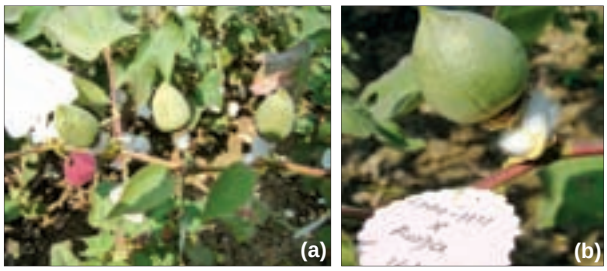
Sehima nervosum is a natural range grass found inherently rich in precursors for several industrially important biomolecules. Production of nutraceuticals (prebiotics xylo-oligosaccharides) from this grass is promising. However, *Sehima* has narrow genetic variability. Therefore, it requires the aid of biotechnology and its new tools to produce new varieties with novel traits. *Sehima nervosum* (Var. Bundelsaen 1) seeds were used as explant materials in this study. The seeds were inoculated on to a MS medium, containing different concentration of 2,4-D for callus induction. For shoot regeneration callus were transferred into various concentration of BAP and kinetin and for rooting various concentrations of NAA. The best callus induction frequency was at 3.5 mg/l 2, 4-D, where it gave 95% of callus induction. Shoot induction frequency were highest recorded (98%) at concentration of 2.5 mg/l kinetin. The maximum root inducing frequency (47%) was observed at 4.5 mg/l NAA concentration. To the best of our knowledge there are no report on *in-vitro* callus induction and regeneration in *Sehima*. Herein first time we report efficient *in-vitro* callus induction and regeneration from mature seed explant in *Sehima*. The standardized protocol would be useful for genetic transformation of *Sehima* with genes of agronomic importance.

DNA sequencing

Completed molecular analysis for DNA sequencing of *Haplidia longipennis*, *H. sikkimensis*, *H. consanguinea* and *H. serrata*. Primers for amplifying *Cox 1* and *28 Sr RNA* genes were custom synthesized and used for amplification of respective genes of predominant species. Amplified PCR products were cloned in pGEM®-TEASY vector. The BLAST N results showed that *H. longipennis* (sequence A_1) had 99% indentity to *Cox 1* from *H. consanguinea* (A_3). Similarly *H. sikkimensis* (sequence A_2) showed 80% identity to *Cox 1* from *Jekelius brullei*. *H. longipennis* (sequence A_3) showed 99% identity to *Cox 1* from *H. serrata*. *H. serrata* (sequence A_4) showed 98% identity to *Cox 1* from *H. nagpurensis*. On the other hand, sequence B_1 (*H. longipennis*) and B_4 (*H. serrata*) showed similarity to *28S rRNA* from *Hoplochelus piliger* with identity of 98 and 99%, respectively, whereas both sequences B_2 (*H. sikkimensis*) and B_3 (*H. consanguinea*) showed 99% identity to *28S rRNA* for *H. transversa*.

Tissue culture technique in wide hybridization

Embryo rescue in interspecific hybridization in cotton: During inter-specific traits introgression, species incompatibility arisen due to post fertilization barriers restricting the normal growth and development of zygote or embryo to become viable plantlets represents the most challenging task in crop breeding programs. An *in vitro* culture technique called 'Embryo Rescue' being employed for plantlet regeneration which otherwise may be impossible in normal conditions. In cotton, application of embryo rescue has been reported with



(a) Interspecific cross between *G. hirsutum* and *G. arboreum*; (b) crossed bolls.

Established interspecific F1 hybrid seedlings through embryo rescue technique.

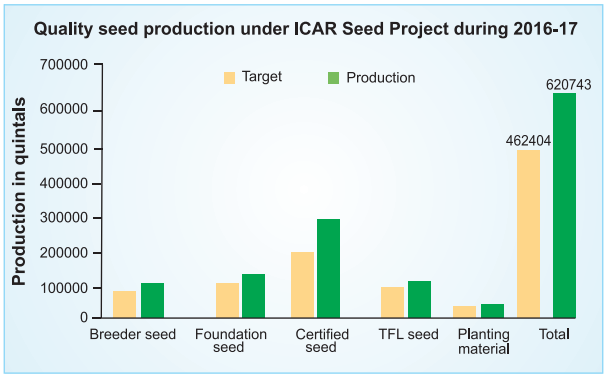
varying success, while in India, this technique has not been extensively explored. In order to maximize the retention of fertilized ovary/bolls on the female plant for at least up to 10-15 DPA, pedicels of crossed female flowers were treated with 100 ppm gibberellic acid (GA_3) hormone. For embryo rescue, interspecific crossed bolls with immature developing ovules were brought to the lab, surface sterilized with 70% alcohol for 3-5 min followed by thorough washing in distilled water 3 times with 2-3 min each. Bolls were treated with 0.1% $HgCl_2$ for 5-10 min followed by thorough washing in distilled water 3 times with 2-3 min each. Ovules were carefully detached from the ovaries and placed on to the modified solid culture medium succeeded in establishing more than 100 healthy seedlings from interspecific crosses.

Seed technology

During 2016-17, total breeder seed production in field crops was 121,988.5 q against the indent of

104,045.7 q (production comprises 83,105.0 q against GOI indent of 67,463.3 q; 25,476.9 q against state indent of 24,378.1 q and additional production of 13,406.5 q against ICAR Seed Project targets of 12,204.3 q). The major share in total breeder seed production belongs to cereal crops 70,092.8 q against indent of 51,440.7 q. Under pulse crops, a total of 20,578.1 q breeder seed was produced against the indent of 18,018.9 q. In oilseeds, total breeder seed production was 30,288.3 q against the indent of 33,692.9 q. Breeder seed produced in case of fiber crops was 130.8 q against the indent of 83.2 q and in forage crops, 898.48 q was produced against the indent of 810.0 q.

In order to promote Seed Replacement Rate (SRR) and Varietal Replacement Rate (VRR), to equip seed production centers of NARES with world-class infrastructure and to make quality seed available to the farmers by means of model deployment, ICAR Seed Project entitled, Seed Production in Agricultural Crops is being implemented under the aegis of ICAR. During the year 2016-17, total production of quality seed including all classes was 620,743 q against the target of 462,404 q. Production comprises 124,576 q of foundation seed, 273,681 q of certified seeds, 981,99 q of truthfully labelled seed and 30,422 q of planting material of field crops. In addition, 239 lakh planting material and 1.9 lakh tissue culture plantlets were produced against the targets of 288 and 2.6 lakh, respectively.



Progress under ICAR Seed Project–Seed Production in Agricultural Crops during 2016-17

Paddy seed production at CIARI, Port Blair

Groundnut (Trombay Konkan Tapora) seed production at Dapoli

Horticulture

Guava CISH-G-14

Fruit crops: In guava, CISH-G-14, a half-sib of cv. Allahabad Safeda was found promising. The variety has 12.5 ^{o}BrixTSS. It is soft-seeded (breaking force 12 kg) with attractive appearance. In aonla, Aonla - CISH A-33, a seedling selection having large-sized fruits (32-35 g), promising in terms of yield (55.45 kg/tree), rich in neutraceuticals (ascorbic acid 490.13 mg/100 g; polyphenols 1.718 TAE g/100 g and FRAP value 235.76 mg/g $FeSO_4$) was identified. In banana, cv. Udhayam is one such recalcitrant type where bacterial contamination is a major problem hindering multiplication through tissue culture. Hence, tissue culture protocol has been developed using various explants (shoot tip, cormlet and male flower bud along with suckers of cv. Udhayam). Regular package of practices were adopted and observations on vegetative parameters were recorded 3, 5, and 7 months after planting.

The plants derived from different explants showed highly significant differences in plant height, girth, number of leaves, leaf length, width and petiolar length. Crop duration was lowest in male flower buds (373 days), followed by suckers (391 days), shoot tip (406 days) and cormlet (433 days). Similarly, yield was also highest in male flower buds (26.0 kg), followed by sucker (20.30 kg), shoot tip (19.0 kg) and cormlet (18.0 kg).

Aonla CISH A-33

Evaluation of 32 progenies of banana obtained from open-pollinated seeds of natural tetraploid, Bhat Manohar, resulted in identification of promising progeny (progeny No. 667) that performed better in yield and quantitative traits. This recorded a bunch weight of 19.5 kg, which is 90% higher than original Bhat Manohar (10.5 kg). Fruit length (14.5 cm) was 50%

more than the normal (9.5cm). This could either be used directly in commercial cultivation or be used in the development of superior triploids.

Preliminary evaluation trial in banana conducted with 16 hybrids of Saba × Pisang Lilin cross-combination, revealed that three progenies namely progeny No 684, 685 and 690 recorded an average bunch weight of 22, 42 and 32 kg, respectively over a period of three years. Bunch and fruit characteristics of Progeny No.684 were like Saba (dark green fruits, blunt tip), while progeny No. 685 had green and pointed tip as in Kothia (ABB). Fruit hands of progeny No.690 are loosely packed, matured fruits are green and slightly wax coated. The preliminary sensory analyses suggested that these hybrids are more suitable for culinary purpose.

Three exotic varieties of citrus, viz. US Pummelo-145, Cutter Valencia and Flame grapefruit have been introduced and two varieties have been developed through indigenous material, viz. NRCC Pummelo-5 and NRCC Grapefruit-6. These varieties will fulfil long standing demand of citrus growers of central India for diversification and citrus varieties for processing.

In litchi, three new varieties were released. Litchi, Gandaki Sampada, is late-maturing, ripens during mid-June with larger fruit (36.85 g), high pulp recovery (>80%) and yield of 120-140 kg/tree. Gandaki Yogita is late-maturing with dwarf plants. It is tolerant to fruit-borer and fruit cracking and, suitable for high-density planting with an yield potential of 70-80 kg/tree. Gandaki Lalima is high-yielding (130-140 kg/tree) with fruit weight of 28-32 g. Fruits ripen during second week of June.

Pomegrante hybrid Solapur Lal

In pomegranate, Solapur Lal, a promising hybrid was developed for table purpose. This has early maturity (160-165 days) with high yield of 23-27 tonnes/ha, better TSS (17.5-17.7°B), vitamin C (19.4-19.8 mg/100g) and anthocyanin content of 385-395 mg/100g). Besides, it has higher content of zinc (0.64-0.69 mg/100g of fresh arils) as compared to Bhagwa (0.5-0.54mg/100g of fresh arils). The iron content is also significantly higher in Solapur Lal compared to Bhagwa.

Solapur Anardana, a promising pomegranate hybrid suitable for processing, has been developed. The hybrid has higher yield of 22-24 tonnes/ha with titrable acidity of 4.7-4.9% and anthocyanin content of 457-467 mg/100g as compared to Amlidana.

In coconut, Kalpa Shatabdi, a new variety has been developed. This variety, with large fruits, gives high copra outturn of 28.65 kg/palm/year, which is 61.4% higher than copra yield of local control, WCT (17.8 kg/ palm/year). It has tender nut water in large quantity (612 ml) with TSS of 6.12º Brix. Considering high copra outturn and tender nut quality, Kalpa Shatabdi has been recommended for cultivation in coconut-growing tracts of Kerala, Karnataka and Tamil Nadu.

Coconut Kalpa Shatabdi

A high-yielding arecanut selection, Shatamangala, was developed with dry kernel yield of 3.91 kg/palm/year and tender nut yield of 3.26 kg/palm/year. It is regular-bearing with good kernel quality and suitable for tender nut processing. It exhibited better yield over Mangala (34.24%), Sumangala (20.73%), Sreemangala (24.53%), and South Kanara Local (47.76%) with high recovery of first quality processed tender nuts (68.4%). This variety is semi-tall and characterized by medium thick stem, shorter internodes, partially drooping crown, regular-bearing with medium maturity. It starts bearing from fourth year with synchronized maturity of nuts, high yield, well placed bunches, round, orange colour fruits, higher content of polysaccharides and polyphenols with high recovery (26.80%) of dry kernel from fresh nut. The variety is suitable for production of dry kernels and processed tender nuts, and is recommended for cultivation in Karnataka, West Bengal and Gujarat.

A cocoa hybrid, VTLCH-5 (IC 622884), was released as Nethra Centura. This is precocious, stable and a heavy bearer with medium canopy (16-18 m^2) under arecanut and coconut gardens (as both seedlings and clones). This performs well under normal (2.7 m × 5.4 m under arecanut) and high-density planting (2.7 m × 2.7 m under arecanut and 2.5 m × 2.5 m under coconut). With an average of 66 pods/tree/year, 43 beans/pod, single bean dry weight of 1.11 g. It recorded highest dry bean yield of 3.2 kg/tree/year and yield 1,800 kg/ha (600 trees) with 11% shelling percentage, nib recovery of 88 and 52% fat content. Yield of VTLCH-5 was much higher than VTLCH-1 (1.4 kg/tree in hybrid trial) and VTLCC-1 (1-1.3 kg/tree in clonal trial). It is recommended for cultivation in Western Ghats, hills and plains of Kerala and Karnataka, and irrigated arecanut and coconut gardens of Tamil Nadu and Andhra Pradesh.This variety is highly suitable for chocolate industry.

Cocoa hybrid Nethra Centura

A novel method of insect assisted controlled pollination

A novel technique was developed for insect facilitated controlled pollination in oil palm. It involves covering the female inflorescence with a pollination bag, securing it at the bottom that no insects or pollen enter from outside the pollination bag, cleaning the pollinating insects and storing in a container, and transferring insects along with pollen of oil palm to reach the bagged inflorescence through a tube. This technique not only reduces the drudgery essentially required to effect the crossing programme, but will also make the pollination activity easier and more efficient. The weevils along with pollen could reach a height of 22 feet in 6 minutes under controlled conditions. Fruit setting is normal. The fruit ratio, seed germination and seedling establishment are on par with manual pollination. This method is novel, risk-free and labour-effective. It opens a new way forward for controlled insect assisted pollination to produce hybrids in plants which can be utilized even in improvement programmes.

Vegetable crops: Bacterial wilt on brinjal caused by *Ralstonia solanacearum* is a serious disease, which limits production from 20 to 50 % in Andaman and Nicobar Islands. A high-yielding brinjal variety, CARI Brinjal 2, is resistant to bacterial wilt giving an yield of 20-25 tonnes/ha has been identified. Its plants are medium tall, semi-spreading type with profuse branching having greenish medium leaves. Fruits are oblong, purple and medium compact. It is suitable for growing in island during October-May.

Tomato Kashi Adarsh

Tomato, Kashi Adarsh, is semi-determinate with 80-115 g fruit weight and 60 tonnes/ha yield. It is resistant to both monopartite and bipartite viruses. It is suitable for cultivation in Madhya Pradesh and Maharashtra.

Ridge gourd Kashi Shivani

Kashi Shivani is a high-yielding (180-200 q/ha) ridge gourd variety with green fruits and 150-200 g fruit weight. Fruits are ready for harvesting at 50-60 days after sowing. This is moderately resistant to downy mildew under field condition. It was released for cultivation in Punjab, Uttar Pradesh, Bihar and Jharkhand. Arka Prasan is an open-pollinated variety, early flowering with first fruit picking in 42-45 days, and yields of 26 tonnes/ha in 120-135 days. Arka Vikram is early-flowering hybrid with first fruit picking in 46 days, yields 34 tonnes/ha in 120-135 days.

Two red onion varieties, Bhima Super (for *kharif*) and Bhima Shakti (for *rabi*) were recommended. The bulbs of Bhima Super are attractive, red, maturity 100-105 days after transplanting, and yield, 22-26 tonnes/ha. It is suitable for cultivation in Chhattisgarh, Delhi, Gujarat, Haryana, Jammu, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan and Tamil Nadu.

The bulbs of Bhima Shakti are attractive red, maturity 125-135 days after transplanting, yield 32-36 tonnes/ha. It is recommended for cultivation in *rabi* in Andhra Pradesh, Chhattisgarh, Karnataka, Madhya Pradesh, Maharashtra and Odisha. It is also suitable for cultivation in late *kharif* in Maharashtra.

Arka Nikita is an early-flowering okra hybrid with first picking of fruits in 39 days. It yields 20-23 tonnes/ha in 115-120 days.

Potato: Kufri Mohan is medium maturity (75-90 days) with 40 tonnes/ha yield potential, moderately resistant to late blight and outperforms Kufri Bahar in northern plains and Kufri Jyoti in eastern plains.

Tuber crops: Bhu Sona, a β carotene rich (12.5 - 14.0 mg/100g) sweet potato variety, has 27-29 % dry matter, 18.8-19.7 % starch content and 20-25 tonnes/ha tuber yield, and is tolerant to salinity (up to 6-8 dS/m), suitable for cultivation in Odisha, Uttar Pradesh, Bihar, West Bengal, Andaman and Nicobar Islands and Karnataka. Bhu Krishna is an anthocyanin rich (85-90 mg/100g) variety having high dry matter (27-32%) and extractable starch (20-22%) content with 22-25 tonnes/ha tuber yield. It can tolerate salinity (electrical conductivity up to 6-8 dS/m), suitable for cultivation in Odisha, Uttar Pradesh, Bihar, West Bengal, Andaman and Nicobar Islands and Karnataka.

Sweet potato Bhu Sona

Sweet potato Bhu Krishna

Spices: IISR Pragati is a short duration (180 days), nematode tolerant turmeric variety with high yield

Ajmer Fennal 2

(35 tonnes/ha fresh, 6 tonnes/ha dry) and high curcumin (5%) content. It is suitable for cultivation in major turmeric growing tracts of India like Andhra Pradesh, Telangana, Maharashtra, Tamil Nadu, Odisha, Kerala, Karnataka and Madhya Pradesh. Ajmer

Asalio RVA-1007

Fennel-2 (AF-2) was released for high yield (17.9 q/ha) with moderate resistance to *Ramularia* blight disease.

Vallabh Isabgol-2 (VI-2) and Vallabh Isabgol-3 (VI-3) varieties of isabgol were identified for early maturity (100 days) with improved seed yield of 9.16-13.6 q/ha and 8.97-14.4 q/ha, respectively.

Asalio, RVA-1007, has seed yield potential of 11.27–18.27 q/ha, while HLS-4 has seed yield potential of 12.44-17.25 q/ha.

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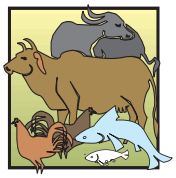

6. Livestock Improvement

Cattle

Holstein-Sahiwal crossbreds: The project envisages evolving a National Milch Breed Frieswal, a Holstein-Sahiwal cross, yielding 4,000 kg of milk with 4% butter fat in a mature lactation of 300 days by utilizing the Frieswal herds available at Military Dairy Farms of Ministry of Defence.

The total population of Frieswal females at 36 Military Farms located in various agro-climatic regions of the country was 20,675 including 1,314 elite Frieswal cows. The overall average age at first calving was 31.76 months (965.36 days). The overall least squares means of 300 days milk yield, total milk yield, peak yield and lactation length were 3,312.25 kg, 3,321.74 kg, 15.11 kg and 322.02 days, respectively. The least squares means of service period, dry period and calving interval were 164.59, 119.76 and 440.30 days, respectively. Genetic evaluation of ninth set of bulls, carried out based on the first lactation records of the progeny, had 0.58% genetic superiority over the population mean.

Improvement of indigenous cattle breeds through selection: This project was conceptualized for the genetic improvement of some important native cattle breeds, viz. Gir, Kankrej and Sahiwal in their home tracts. Bulls of Gir (24), Kankrej (26) and Sahiwal (26) were inducted in three different sets for progeny testing. The total number of inseminations carried out in Gir, Kankrej and Sahiwal units were 2,510, 2,573 and 1,195 with the conception percentages of 48.44, 47.76 and 34.72, respectively. Since inception of the project (year 2010), 4,623 Gir, 1,537 Kankrej and 734 Sahiwal daughters were born.

The average age at first calving in Gir, Kankrej and Sahiwal were 1343.5, 1273.44 and 1189.55 days respectively. The average first lactation 305 days or less milk yield, first lactation length and first peak yield were 2,392.1 kg, 499.1 days and 13.7 kg in Gir and 2,295.27 kg, 312.13 days and 10.53 kg in Kankrej cattle. In Sahiwal the average first lactation 305-day milk yield and total first lactation milk yield were 1,850.70 and 2,001.11 kg, respectively.

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 cross cows.

A total of 284, 268, 260 and 70 bulls have so far been introduced in GADVASU, Ludhiana; KVASU, Thrissur; BAIF, Uruli-Kanchan; and GBPUAT, Pantnagar; respectively. During the year, a total of 5718, 4755, 9125 and 4761 AIs were carried out in GADVASU Ludhiana; KVASU, Thrissur; BAIF, Uruli-Kanchan; and GBPUA&T, Pantnagar with the conception percentages of 46.4, 42.7, 44.5 and 53.5, respectively. The number of daughters completed their first lactation in GADVASU, Ludhiana; KVASU, Thrissur; BAIF, Uruli-Kanchan; and GBPUA&T, Pantnagar were 3,549, 1,658, 3,366 and 369, respectively. The average 305-days milk yield of daughters ranged from 1,958 to 2,835 kg at KVASU, Thrissur; 2,698 to 3,841 kg at GADVASU, Ludhiana; 2,930 to 3,117 kg at BAIF, Uruli-Kanchan; and 2,459 to 3,181 kg at GBPUAT, Pantnagar in different sets. In all the four centres, the first lactation milk production showed an increasing trend over the years while the age at first calving has decreased.

The average breeding values of bulls of seventh set at KVASU, Thrissur; GADVASU, Ludhiana; and BAIF, Uruli-Kanchan were 2,697.8, 3,578.95 and 3,159.13 kg, respectively, with an overall average of 3,144.37 kg. Bulls of eighth set were evaluated on the basis of their daughters, and the overall breeding value was 3012.58 kg.

Semen collection and freezing: Frozen semen doses of Frieswal (573,179), Gir (68,407), Kankrej (2,995) and Sahiwal bulls (20,974), were produced at respective Germ plasm units; and 78,739 doses were distributed to Military Farms and 63,826 sold to para vets, State Animal Husbandry Departments, Livestock Development Boards and State Agriculture Universities. Semen doses are available for Frieswal (1,937,000), Gir (121,848), Kankrej (111,690) and Sahiwal (83,802).

Buffalo

Network Project on Buffalo Improvement (NPBI): Bulls (15) of XVI set were used in herd for test mating. In addition 6 bulls from CIRB Hisar, were tentatively selected for XVII set for test mating under progeny testing. NDRI Karnal; CIRB Hisar; GADVASU Ludhiana; and LUVAS Hisar produced >2,400 kg average standard lactation milk yield (SLMY) during the period, where LUVAS Hisar, recorded the highest 305 or less day milk yield (2,967 kg) among all centres. Except for Mamnoor centre, average age at first calving and calving intervals ranged between 39 and 45 months and 428 and 481 days, respectively. Nili-Ravi, Bhadawari and Swamp breed centres are functioning as conservation and improvement units, whereas, Jaffarabadi, Pandharpuri and Surti breed centres are concentrating on field progeny testing along with maintaining the elite herd for bull production and a breedable herd of 567 (Nili-Ravi-243, Jaffarabadi-167, Pandharpuri-26, Swamp-27, Surti-53, and Bhadawari-59) is being maintained. Semen doses (123,559) were produced from Jaffarabadi, Surti, Pandharpuri, Bhadawari, Nili Ravi and Swamp breeds.

Field progeny testing (FPT) of bulls: During the period, 3,807 artificial inseminations using semen of 15 Murrah test bulls of 16th set were done with conception rate of 55.48% in 10 adopted villages. In this period, 2,112 pregnancies were confirmed and 1,661 calving (864 males, 797 females) were recorded. In addition monthly test day milk yield were recorded of 170 progeny of 12th, 152 of 13th and 3 of 14th set that calved during this period. Average age at first calving for these 170 daughters was 42.04 months.

CIRB Hisar - Murrah herd: Semen doses (126,008) were frozen and semen straws (54,546) were sold in the field for insemination. At CIRB Hisar, the highest ever (since inception of the Institute) 305 days or less average lactation milk yield of 2,457 kg (n=133) and average total lactation milk yield of 2,567 kg (n=133) were achieved. The highest ever lactation milk yield of 4,063 kg in 305 days and highest peak yield of 23.2 kg in a single day was recorded.

CIRB Sub-campus - Nili-Ravi Herd: Semen straws (18,790) were produced and 9,450 straws were sold. As per MoU signed between ICAR-CIRB and the Department of Animal Husbandry, Punjab, quality Nili Ravi semen straws were produced to supply frozen semen in the Nili Ravi tract of Punjab.

Buffalo breeding herd analyser: A novel tool "Kalrumpscale" was designed for measuring 3D angular and linear orientation of buffalo external rump/ pelvic surface.

Sheep

In Muzaffarnagari sheep, the overall least-squares means of body weights of lambs at birth, 3, 6, 9 and 12 month age were 3.40±0.04, 15.13±0.25, 24.93±0.39, 27.22±0.60 and 35.18±0.60 kg, respectively. Male lambs gained higher body weights as compared to female lambs at all growth stages.The average daily gain of Muzaffarnagari lambs during 0-3, 3-6 and 6-12 months were 130.17±3.87, 100.04±3.35 and 63.83±1.93g/day, respectively, under semi-intensive feeding management.

Muzaffarnagari Rams

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

In Marwari and Deccani sheep, an improvement of 3.94 and 10.48% in six-month body weight was recorded over the last year. Progeny born from quality Magra rams had higher body weight at birth (3.08 vs 2.90 kg), weaning (16.24 vs 14.97 kg), six-month (23.92 vs 22.01 kg) and twelve-month (29.03 vs 27.56 kg) than progeny born from farmers' ram. In Magra sheep, the average fibre diameter, medullation and staple length were 34.20µ, 35.48 % and 6.34 cm, respectively. In Deccani sheep, average ewes' age at first service, age at first lambing and ewes' weight at first lambing were 481.23 days, 630.03 days and 30.77 kg, respectively. Inter-lambing period was 316.71 days. In Muzaffarnagri breed, average weight at first service, age at first service, age at first lambing and ewes weight at lambing ewes were 36.1 kg, 488 days, 649 days and 36.4 kg, respectively, and lambing rate was improved by 3.30% over the last year. Overall flock survivability improved in farm flock and was 98.00% in Marwari, 97.81% in Muzaffarnagri, 92.67% in Deccani and 94.20% in Nellore breed.

Marwari sheep

Mega Sheep Seed Project: The project has two inter-linked components: (i) Development and maintenance of nucleus flocks of the indigenous sheep breeds in the Institutional farm located in the respective breeding tracts, their genetic evaluation, selection and production of superior males, (ii) distribution of superior breeding males and other necessary inputs to the registered farmers and evaluation of progenies of the distributed rams in the field. Oestrous synchronization and artificial insemination with fresh liquid diluted semen are being implemented for faster propagation and wide coverage with semen of superior germplasm.

Chhotanagpuri Sheep Unit, BAU, Ranchi: The flock has 668 Chhotanagpuri sheep including 419 breedable females for production of high performing sheep seed. Superior rams (108) were distributed to cover 1,640 breedable ewes of the registered farmers for improvement.

Madras Red sheep

Deccani Sheep

Mandya Sheep Unit, KVAFSU, Bidar: A flock of 487 Mandya sheep including 279 breedable females was built up for production of superior seed stock. Breeding rams (50) were distributed to cover 2,103 breedable ewes.

Mandya sheep flock

Mecheri Sheep Unit, TANUVAS, Chennai: The nucleus flock strength of 606 Mecheri sheep including 350 breedable females was achieved. Breeding rams (59) were distributed to the field units to cover 3,568 breedable ewes.

Sonadi Sheep Unit, RAJUVAS, Bikaner: A flock of 373 Sonadi sheep including 241 breedable females was built up for production of superior rams. Breeding rams (54) were distributed to the registered farmers to cover 2,662 breedable ewes.

Malpura Sheep Unit, ICAR-CSWRI, Avikanagar: A flock of 873 Malpura sheep including 450 breedable females was built up. Breeding rams (51) were supplied/ sold to cover 2,628 breedable ewes.

Goat

Genetic Improvement Programme: Selective breeding of goats have shown significant improvement in body weights and milk yield. In Barbari goats, the overall least squares means of body weight of kids at birth, 3, 6, 9 and 12 months of were 1.91±0.01, 7.71±0.08, 12.34±0.15, 16.47±0.22 and 21.94±0.34 kg, respectively, during the reported period. The estimates of heritability (h^2) for body weight of kids at birth, 3, 6, 9, and 12 month of ages were 0.106±0.045, 0.230±0.073, 0.210±0.07, 0.267±0.077 and 0.171±0.066 indicating moderate level of additive genetic variance for growth traits in Barbari flock. The milk yields at 90 days and 140 days were 52.71±1.00 and 67.65±1.44 liters, respectively. Higher lactation performance of Barbari goats was obtained from second parity and this superiority persists up to sixth parity. The overall mortality and culling was 2.9 and 6.8%, respectively.

Barbari Goat Unit at CIRG Makhdoom

In Jamunapari goats, the least squares means of body weights of kids at birth, 3, 6, 9 and 12 months of age during the year were 3.167±0.096, 10.005±0.220, 17.814±0.254, 22.460±0.465 and 27.164±0.901 kg, respectively. The least squares means for body weight under intensive management at 12 months of age was 45.154 kg, and the highest body weight was 52.0 kg. The means for milk yield at 90, 140 days and total milk yield were 80.2, 114.0 and 124.8 kg, respectively. The average lactation length was 179.5 days, which was longer than other Indian breeds. Jamunapari goats were productive until seventh parity.

The genetic trend in Jamunapari goats at 9 and 12 months of age was 0.14 kg and 0.19 kg/ year. A positive genetic trend was also observed for milk yield at 90 days, 140 days and total milk yield (TMY).

In Jakharana goat, least squares means for body weight at birth, 3, 6, 9 and 12 months of age were 2.38±0.04, 8.51±0.19, 13.21±0.52, 16.91±1.90 and 24.13±2.23 kg , respectively, during the year. Average lactation milk of Jakharana does was 205.93±11.8 litres during the reported period.

Superior Jamunapari (154), Barbari (308) and Jakhrana goats (126) were supplied to farmers during the year.

Pig

Improved crossbred pig varieties: Faster growing pig varieties, namely Rani and Asha were developed and released. The Rani variety was developed by crossing exotic parental lines of Hampshire (male) with indigenous Ghungroo (female) pigs to produce F_1, followed by *inter-se* mating for five generations to stabilize the heterosis effect whereas, exotic Duroc breed was used as terminal cross for developing Asha. These varieties are expected not only to benefit socio-economically weak communities in terms of their

Breeding buck production through multiplier flocks

Multiplier flocks of Barbari goats were adopted to popularize scientific goat farming. Various interventions were provided to these flocks for development of livelihood model and agri-business models for breeding and goat production. These flocks were established in Uttar Pradesh, Haryana and Rajasthan. Majority of these farms are practising stall feeding with optimum feed inputs. All improved management practices (breeding calendar, feeding, housing and health care) were adopted. Overall survivability at multiplier flocks was 93.3%. These farms have mostly focussed on increasing flock size; and sale restricted to 15-40%. The cost of production per goat/year varied from ₹ 3,260 to ₹ 7,800 and profit from ₹ 4,300 to 9,600 with an average of ₹ 5,280.

AICRP on Goat Improvement

Improving goat productivity in farmer's flock under different agro climatic conditions: 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. The project is covering 13 registered breeds and 3 local genotypes (lesser-known goats) in different parts of the country. The project has contributed in increasing population growth, milk production and body weight. Preventive health care measures with farmers' support have reduced morbidity and mortality in field flocks. There is a significant increase in the income of goat farmers and enhanced food security of all the stakeholders. AICRP on Goat Improvement is operational at 464 villages covering 3,010 farmers. The performance recording was carried out in 25,622 animals during the year. The increase in body weight at 12-month age over the units varied from 0.9 to 6.2%. Similarly, the increase in milk yield at 90 days varied from 3.4 to 8.8% over the units. The average pashmina production of Changthangi goats was 269.11 g in Laddakh region. Preventive health care, provided to 97,546 animals in farmers' flock, resulting in lower mortality rates ranging from 2.78 to 11.15%, thus increasing population growth and improving farmers' income from 22 to 35%. A higher population growth amongst breeds resulted into increased selection intensity, thus realized genetic gains could be higher. Farm units have distributed improved animals to different agencies for breed improvement as well as up-gradation of local germplasm. AICRP units conducted 202 training programmes for skill development of goat farmers. Elite does were identified producing more than 200 litre of milk in 140 days in different units. Twenty success stories have been recorded during the period. AICRP on Goat Improvement has bagged Breed Survivor Award for Malabari, Jamunapari and Surti breeds. The project covered 13 tribal villages and contributed for a better livelihood security for tribal peoples as goats are major source of income to poor people in tribal areas and NEH region.

sustainable livelihood security but also to address the issues of pig production system under changing climatic scenario by improved production and productivity. In addition, through its sub-scheme on AICRP on Pig centres located in different parts of the country, the institute has facilitated the release of six more location specific pig varieties namely HD-K75 (Assam Agricultural University), Jharsuk (Birsa Agricultural University), Mannuthy White (Kerala Agricultural University), Lumsniang (ICAR-Research Complex for NEH Region, Umiam, Meghalaya), TANUVAS KPM Gold (Tamil Nadu Veterinary and Animals Science Univeristy) and SVVU-T17 (Sri Venkateswara Veterinary University).

Rani piglets

Asha piglets

Poultry

Jharsim: Jharsim, a multi-colour dual purpose bird suitable for rural poultry production was developed under AICRP on Poultry Breeding at BAU, Ranchi, Jharkhand. The body weight of birds at sexual maturity is 1.6-1.8 kg. The annual egg production of Jharsim is 120-130 eggs under backyard condition, which is almost double than that of local native chicken (55 – 60 eggs/ annum).

A pair of Jharsim bird

Improvement of germplasm: Two male lines of chicken, PD-1 (Vanaraja male line), GML (Gramapriya male line); two female lines, PD-2 (Vanaraja female line) and PD-3 (Brown egg layer line) were maintained for use in developing rural chicken varieties. In PD-2 line, the egg production up to 52 weeks of age was improved by 2.2 eggs as compared to the previous generation. In PD-3 line, the egg mass up to 40 weeks of age was improved by 334 g over previous generation. Native chicken breeds Aseel and Ghagus were conserved and PD-4 (i.e. Improved Aseel) was under improvement program for higher body weight and egg production. Nicobari breed was maintained for evaluation of disease resistance. In PD-4 line, there was an improvement of 75 g in body weight and 4.14 mm in shank length at 8 weeks of age in S-7 generation. The genetic and phenotypic responses in 5 weeks body weight in PB-1 (broiler male line) over the last 5 generations were 17.3 and 5.8g, respectively.

In PB-2 (broiler female line), the phenotypic and genetic responses to selection for the 40 week part period egg production over the last 10 generations were 0.68 and 1.28 eggs/generation.

Six layer lines (IWH, IWI, IWK, IWD, IWF and control) were maintained and evaluated. The egg production up to 64 weeks in IWH, IWI, IWK and control was 254.7, 258.0, 232.0 and 224.6 eggs, respectively, and the corresponding egg weight was 56.1, 55.2, 57.5 and 57.7g. The IWD and IWF lines were regenerated through random mating and the egg production up to 32 weeks was 51.9 and 52.5 eggs, respectively.

Under the conservation mode, Aseel birds were characterized phenotypically with multi-colour plumage and dark red colour pea comb. The age at sexual maturity in Aseel was 219 days while the egg production up to 72 weeks of age was 59 eggs with an egg weight of 50.1 g.

Broilers: The colour synthetic male line (CSML) and synthetic male line (SML) are undergoing long

term selection based on body weight at 5-weeks of age. In 15th generation of selection, the gains in 5-week body weight in SML were 14.60 and 12.69 g/ generation on phenotypic and genetic scale, respectively. Corresponding values in CSML were 17.56 and 15.23g/ generation. These values were significantly different from unselected control. Similarly, in Colour synthetic female line (CSFL) the phenotypic and genetic gains in body weight were 19 and 16 g/generation. Corresponding values in synthetic dam line (SDL) were 13.0 and 11 g/generation, which were significantly different from unselected control. The age at first egg for CSML was 177.25 days with 52 week egg production as 108 egg. Corresponding values in CSFL were 176 days and 110 eggs. The fertile eggs of desi germplsm procured from nearby villages were hatched and reared. The body weight at 8, 12 and 20 weeks of age were 510.44, 1,307.50 and 1,483.56 g, respectively.

Layer: The overall fertility of selected strain of Rhode Island Red (RIRs) and the control population (RIRc) for 33rd generation was in the range of 83.2 to 91.2 %. The RIRs females recorded significantly higher 40th week egg production (by 40.83 nos) and 40th week egg weight (by 2.27 g), but lower age at the first egg, AFE (by 36.4d) as compared to that of control population (RIRc).

AICRP on Poultry Breeding: Under AICRP on Poultry Breeding, all the twelve centres are working on the development of location specific rural chicken varieties utilizing the local native chicken germplasm and elite layer and broiler chicken lines developed earlier under AICRP program.

Egg: In the S-1 generation of native chicken germplasm being evaluated at KVASU, Mannuthy centre, the egg production up to 40 weeks of age was 72 eggs with average egg weight of 41.8 g. Average genetic response for 64 weeks hen housed egg production in IWN and IWP strains (elite layer germplasm) was 4.77 and 1.65 eggs, respectively, during last 10 generations (S-20 to S-29). The hen housed annual egg production in IWN and IWP was 310 and 304, respectively. The genetic response for egg production up to 64 weeks of age in IWN and IWP strains were 0.43 and 0.78 eggs, respectively, over the last 10 generations at AAU, Anand. Egg production up to 72 weeks was 121.5 and 98.7 eggs under farm and field conditions, respectively, in BND cross [(Broiler × Native) × Dahlem Red]. Narmadanidhi birds produced 171 eggs up to 72 weeks of age at farmers' backyard. Kamrupa birds produced 71.6 eggs up to 52 weeks of age in field condition. Egg production up to 64 weeks was improved by 6.97 eggs as compared to previous generation in native population whereas egg production up to 64 weeks of age was more in DNB [(Dahlem Red × Native) × Broiler] cross (101.4 eggs) than BND [(Broiler × Native) × Dahlem Red] cross (93.2 eggs) under farm conditions.

The DND [(Dahlem Red×Native)×Dahlem Red] cross showed 65.7 eggs hen housed egg production in farm and 39.5 eggs in field conditions up to 40 weeks. This cross produced 148.5 eggs up to 72 weeks of age under farm condition.

Meat: The average phenotypic and genetic response for body weight at 5 weeks over 9 generations in PB-1 (elite broiler male line) was 6.43 and 5.34 g, respectively. The phenotypic and genetic responses for 5-week body weight in PB-1 over the last 9 generations were 10.07 and 24.50 g. The phenotypic and genotypic responses per generation for 5-week body weight were 15.9 and 15.8g, and 14.3 and 14.2g, respectively, in Coloured Synthetic Male Line (CSML) and Coloured Synthetic Female Line (CSFL) lines (Broiler male and female lines). The phenotypic response of CSML and CSFL lines over 4 generations was 111.8 and 68.35 g, respectively, while the genetic responses in respective lines were 94.64 and 51.18 g.

Poultry Seed Project: The twelve centres located at West Bengal University of Animal and Fishery Sciences, Kolkata; Bihar Agricultural University, Patna; Chhattisgarh Kamadhenu Viswa Vidyalaya, Durg; ICAR Research complex, Nagaland Regional Centre, Jharnapani; ICAR-National Organic Farming Research Institute, Gangtok; ICAR Research complex, Manipur Regional Centre, Imphal; Tamil Nadu Veterinary and Animal Sciences University, Hosur, Tamil Nadu; ICAR-Central Coastal Agricultural Research Institute, Panaji, Goa; ICAR-Central Island Agricultural Research Institute, Port Blair; ICAR-IVRI Regional Station, Mukteswar, Uttarakhand; Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar and ICAR Research Complex for NEH Region, Umiam; have distributed improved birds in their respective regions/states during the year 2016-17.

Desi chicken-crosses: In a diallele cross involving Ankleshwar (AN) and Nicobari (NC) and CARI Red (CR) breed, the cross of Nicobari (male line) and CARI Red (female line) was adjudged as the best cross combination for dual purpose i.e. egg and meat production, with annual egg production

NC X CR female birds

Guinea fowl-breaking seasonality in breeding behavior

The Guinea fowl is a seasonal breeder and breeds in hot season (Apr-Sep) due to photoperiod effect, thus limiting its production and reproduction. In an effort to break the seasonality and to achieve round the year production from guinea fowl, different combinations of dietary protein and photoperiod were evaluated during winter (Oct – Feb) in Pearl guinea fowl. Birds (23) fed with 20% dietary protein and reared under18 hr photo-period produced 533 (HHEP 25%) eggs during Nov-Feb with a fertility of 53.5 and hatchability as 89%. This is for the first time that seasonality has been successfully broken in breeding behaviour of guinea fowls.

as 224 and body weight of 1427 g at 20 weeks of age.

Quails: Japanese quail lines CARI Uttam, CARI Ujjawal, CARI Pearl, CARI Sweta, CARI Suneheri, CARI Brown, Cross line and Control line were conserved.

Augmenting reproductive efficiency in ducks: Fertility and hatchability (TES and FES) improved significantly in Khaki Campbell (45-week old) when artificially inseminated with semen added with 10µg $PGF_{2\alpha}$/ml. The physical parameters, viz. volume, spermatozoa concentration of semen collected with and without pre-ejaculatory fluid (PEF) were examined. Poor fertility (18.9%) was noticed when the semen collected without PEF was inseminated.

Fish

Captive breeding and seed production: Seed production technologies of Indian pompano (*Trachinotus mookalee*), pig-face bream (*Lethrinus lentjan*) and orange-spotted grouper (*Epinephelus coioides*) were successfully developed. These are the potential species for cage/coastal aquaculture due to their fast growth rate, easy adaptability to culture conditions, quick acceptance of artificial feed, good meat quality and high consumer preference. This will ensure uninterrupted supply of quality fish seeds for coastal mariculture and open sea cage farming.

Trachinotus mookalee

Epinephelus coioides

An alternative to exotic white-leg shrimp: The farming of Indian white shrimp, *Penaeus indicus* is being popularized by ICAR-CIBA, Chennai to have an alternative suitable shrimp species for large-scale brackishwater aquaculture. Pilot scale farming demonstrations conducted in 6 coastal states namely, West Bengal, Odisha, Andhra Pradesh, Tamil Nadu, Kerala and Gujarat, revealed an average production of 4.4±0.8 tonne/ha at a stocking density of 35 PL/m^2 and 1.142±0.20 tonne/ha at 10 PL/m^2. Shrimp attained body weight of 28-30 g and 17-20 g at lower and higher stocking densities, respectively, after 135 days of growing period. The comparative growth performances of Pacific white shrimp and Indian white shrimp for 120 days revealed that the growth pattern of both the species was similar until 14 week duration. Thus, the Indian white shrimp can be farmed as an alternative to exotic white-leg shrimp (*Penaeus vannamei*).

Captive rearing of Hilsa, *Tenualosa ilisha* broodstock: Hilsa, *Tenualosa ilisha*, is an important food fish of Indian sub-continent and presently caught from the natural resources. As the population of hilsa is declining rapidly, the importance of captive breeding and grow-out production has become necessary. To undertake broodstock development in captive conditions, ICAR-CIBA, Chennai, collected fry of hilsa from river Muriganga, West Bengal and reared in brackishwater earthen pond. Hilsa fry (1.37 g, 52.97 mm) grew up to 383.80g /339.33 mm within 32 months period. Significant number of matured females (358.18-425.52g/352-370 mm) with oocyte diameter (570 µm) corresponding to fifth stage of oocyte maturation were obtained along with matured males (139.35 g/260 mm) during the period November to February suggesting the possibility of captive maturation and reproduction for seed production.

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7. Crop Management

PRODUCTION

Cereals

Wheat and tillage interactions: A long-term tillage experiment in maize-wheat and rice-wheat system indicated that the wheat crop was not affected by tillage in rice or maize. The farmer field demonstration also revealed similar wheat yield in conservation agriculture (CA) and conventional tillage wheat. However, the economics is in favour of conservation agriculture. The performance of maize was better in CA system compared to conventional system of cultivation. In rice, there was non-significant effect of tillage in wheat but no-tillage rice transplanting gave significantly lower yield compared to puddle and un-puddle transplanted rice. Result on residue management revealed that rice straw incorporation coupled with 25 % more N application enhanced the wheat yield.

Crop modeling in *rabi* sorghum: A study was conducted to understand the utility of additional N applications to enhance *rabi* sorghum production using Sorghum module of APSIM platform (v7.6). The module was used to simulate the yields of *rabi* sorghum in 83 districts of central India. Crop simulation studies indicated that on-station N practice (OS; 150 kg DAP/ha as starter dose and 100 kg urea/ha as top dressing) would enhance the stover production across the post-rainy cultivation region of central India. However, in low yielding environments (average yield <1,500 kg/ha), there was significant loss in grain yield due to OS practice (~15%).

Oilseeds

Comparative performances of linseed varieties in adaptation to climate change: Sowing of linseed PKV NL-260 in 47th standard week (19 November - 25 November) produced highest seed yield under limited irrigation, which was significantly higher compared to other sowing dates and varieties, under Nagpur condition. The variable response of varieties was observed at different locations.

Pulses

Summer greengram in rice-wheat systems under conservation agriculture: To study the effect of resource conservation technology in pulse based cropping system, experiments carried out for sixth year revealed that system productivity in terms of chickpea equivalent yield was higher in zero tillage and residue incorporation. In cropping systems, highest system productivity in terms of chickpea equivalent yield (CEY) was obtained in rice-chickpea-greengram (5,113 kg/ha) followed by rice-wheat (3,190 kg/ha) and lowest in rice-chickpea (2,501 kg/ha). Higher soil dehydrogenase activity was recorded under residue retention and rice-wheat-greengram system.

Sprinkler irrigation scheduling in summer greengram: Enhancing crop yield per unit water use through improved agro-techniques involving sprinklers in summer greengram indicated higher order stability in Samrat (with significantly higher seed yield) over IPM 205-7. Narrow row spacing of 22.5 cm yielded significantly higher over farmers' practices of 30 cm row spacing. As a result, higher net returns, BCR (Benefit cost ratio), and WUE (Water use efficiency) were with the closer row spacing and Samrat following sprinkler irrigation. In addition, sprinkler irrigation resulted in less water use (26.3%) with higher water productivity (43.2%) and net return (28.4%) over flood irrigation.

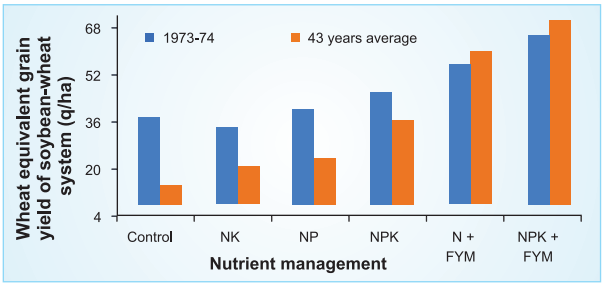
Agronomic fortification of micronutrient in greengram and blackgram: Pot experiments on relative performance of ferti-fortification revealed that foliar spray of Zn (0.2-1.4% at pre-flowering) enhanced its concentration in leaves, stem and grain from 7-16% both in greengram as well as blackgram. Similarly, soil application of Zn (0.5-3.5 ppm) showed 6 to 14% improvement in Zn concentration in root, shoot, leaf and grain. Zinc nutrient through seed coating (1-7 g Zn/kg seed) had positive and marked effect on both blackgram and greengram especially under lower levels. Moreover, seed coating beyond 5.0 g Zn/kg seed in greengram and 6.0 g Zn/kg seed in blackgram showed toxicity symptoms at germination stage. Further, seed coating with zinc oxide was superior over zinc sulphate.

Synergy of conservation tillage and sprinkler irrigation in lentil: Productivity of lentil could be sustained with one supplementary sprinkler irrigation at pod initiation stage if sown under zero tillage (with higher soil moisture) and was confirmed from higher crop growth, biomass and grain yield over flood irrigation. The study confirmed that significantly higher grain (10.8%) and biomass yield (17.8%), net return (13.1%), BCR (9.3%) and PPD (productivity per day, 11.3%) were in sprinkler irrigation provided only at podding over that in branching alone. A similar and significant increase in water saving (23.2%), WUE (26.1%) and WP (27.2%) with sprinkler at podding was evident from the yield level (1.84-1.87 tonnes/ha) than that in flood irrigation. The study also suggested important role of appropriate rainfall forecast and the quantum of precipitation received for appropriate irrigation scheduling decision(s) in lentil.

Enhancing residue use efficiency (RUE) in soybean/pigeonpea based cropping system in central India: Significantly higher productivity was realized

under broad bed furrow (BBF) over flat planting. Single supplementary irrigation to lentil due to scanty rainfall and/or its uneven distribution could enhance RUE over the rainfed crop. Thus to enable soybean-pulse system (soyben + pigeonpea - lentil) sustainable through inter/multiple cropping, the suggested strategies are- (i) Sowing of short duration pigeonpea with soybean by mid-June or June (possible with 1st few pre-monsoon showers of rain); (ii) Switching to more appropriate pigeonpea variety (TJT 501, TT 401, JKM 189 and other short duration varieties); (iii) Managing crop optimally under rainfed condition (with restricted crop growth and dry matter) on BBFs; (iv) Relatively narrow spacing for pigeonpea (a row spacing of 50-70 cm); (v) Planting of *rabi* pulses (lentil) by 1st week of December under residual moisture so as to avoid yield loss as a result of delayed sowing; and (vi) Provision of a supplementary irrigation, if possible during *rabi* for realization of higher yield in case of rain fails.

Productivity evaluation of soybean-wheat crop rotation under long-term fertility management: The analysis of grain yield data after 43 years of experimentation under rainfed soybean-wheat system confirmed that only the FYM treated plot provided an increase in the wheat equivalent grain yield than the first year (1973-74). The average yield with application of 10 tonnes/ha FYM along with the recommended NPK (6,730 kg/ha) recorded 106% higher wheat equivalent grain yield than recommended NPK, which confirmed that the application of chemical fertilizers only is not sustainable.



Comparative wheat equivalent yield of rainfed soybean-wheat system

The different soil enzyme activities were estimated after 43 years of rainfed soybean-wheat system with different nutrient management systems. The activities of different enzymes are collectively quantified as unit-less soil enzyme activity index (SEAI). Addition of 10 tonnes FYM/ha to recommended NPK provided 18 and 161% higher SEAI and sustainable yield index (SYI) compared to the application of recommended chemical fertilizer only. As SEAI has a very good relationship (R^2 = 0.985) with SYI, hence, the former strongly influence latter, which clarified SEAI is a good indicator of SYI.

The SEAI and SYI had quadratic co-relation with soil organic carbon (SOC) status of soil. It indicated that SOC plays a significant role for SEAI and ultimately sustainability of crops.

Commercial crops

Sett priming for early and higher germination in sugarcane: Among many reasons, late (45-55 days) and poor germination (30-35%) are main reasons of low cane productivity in subtropical part of the country. Sugarcane being vegetatively propagated crop, 8-10 tonnes of canes/ha is required for its planting. This actually amounts to almost 10-15% of the cane produced from one ha of land. To minimize the requirement of cane (sett), use of ethephon or ethrel [2-chloroethylphosphonic acid (CEPA)] was found promising which not only improved the germination but also advanced the germination by 15-20 days. When 3 or 2 bud setts were soaked overnight in 100 ppm solution of ethrel, germination of setts was improved by 55-65% along with its advancement of 15 to 20 days. It helped in better tillering, leaf area index and growth of the crop. The primed setts were planted as per normal agronomical practices. With this technology, 20-25% higher cane yield over control was observed in subtropical India.

Priming of setts with ethrel @ 100 ppm causes early and higher germination

Addressing physiological barriers through ethrel and GA_3 induced architectural changes in sugarcane plant and ratoon crops: Overnight sett soaking with ethrel @ 100 ppm before planting and foliar applications of GA_3 at 90, 120 and 150 DAP in sugarcane plant crop (CoLk 94184) led to improvement in sett vigour, enhanced ability to sprout for establishing uniform and robust settlings rapidly, early canopy coverage, improvement in dry matter production and increased tiller numbers and their growth. The changes in leaf angle to 28-30º from 60-70º increased leaf area duration, radiation use, dry matter production and its diversion more towards internodes than leaf laminae. The alterations obtained due to early and enhanced germination and GA_3 induced improvements in source-sink development, reduced the critical gap in obtainable and theoretical yields, causing significant increase in crop harvest index. Foliar applications of ethrel @ 100 ppm at 60 DAP and GA_3 at 90, 120 and 150 DAP in first ratoon crop reduced tiller cessation induced through dense tiller population and increased stalk extension rates. This led to an increase in cane yield by 66.5 tonnes/ha against control. Along with, *in-situ* decomposition of sugarcane trash (dispersed in field after harvest of plant crop @12 t/ha) with Pusa compost inoculant (@ 300 g/t of trash) increased Tmax (6.73 l/ha), reduced tiller mortality (54.5 %) and sustained NMC and cane yield to 3.06 l/ha and 183.2 tonnes/ha (per cane weight of 598 g), respectively against Tmax of 4.59 l/ha, tiller mortality of 66.7 %, NMC of 1.53 l/ha and cane yield of 99.8 tonnes/ha (per cane weight

of 501 g) in absolute control (without trash and without GA_3 application). *In-situ* decomposition of trash along with foliar application of GA_3 increased ratoon cane yield by 16.9 t/ha. The effects were also assessed at Regional Centre, ICAR-IISR, Motipur, Bihar. The induced architectural changes increased Tmax to 5.64 l/ha and NMC to 3.02 l/ha with cane yield of 258 t/ha (per cane weight of 853 g) against Tmax of 3.02 l/ha, NMC of 1.67 l/ha and cane yield of 108 t/ha (per cane weight of 643 g) in control.

Forage crops

Manuring schedule for organic forage production: In hot, dry, semi-arid and monsoon climatic conditions of Bundelkhand agro-ecoregion, a minimum 0.62% soil organic carbon (SOC) is required to sustain perennial guinea + (cowpea-berseem) based organic forage production. This level of SOC can be achieved in minimum 4 years by annual application of 65 tonnes FYM/ha (50 tonnes/ha to guinea + 15 tonnes/ha to berseem). Afterwards, maintenance dose of 12.5 tonnes FYM/ha in guinea +7.5 tonnes FYM/ha in berseem is required, and with proper forage conservation measures this production level can fulfil total dry matter requirement of 9-10 ACUs. This production system can be integrated with livestock based farming system to make carbon neutral footprint of the production system since it can sequester 0.96 to 2.51 t carbon/ha/year.

Guinea grass + cowpea performance under 75% reduction in dose of FYM

HORTICULTURE

Plant production

Fruit crops: Intervention with center opening of the canopy and cutting the cross branches, 40-year-old sapota, Cricket Ball, trees recorded higher yield (35.5 kg/tree with 375 fruits/tree having 80g fruit weight) compared with the control (18.5 kg/tree with 280 fruits/tree having 68.5 g fruit weight) at Arabhavi. Similarly at Gandevi, rejuvenation of 36-year-old sapota, Kalipatti, trees topping terminal growth of 1 m recorded higher yield of 178.27 kg/tree with 2,790 fruits/tree having fruit weight of 64.1 g as compared to the control (138 kg/tree with 2,225 fruits/tree having 62 g fruit weight). The same intervention at Palghar gave higher yield of 146 kg/tree with 1,815 fruits/tree having 80.3 g fruit weight as compared to control (101.6 kg/tree with 1,469 fruits/tree having 68.8 g fruit weight).

Vegetable : Integrated application of FYM@ 25 tonnes/ha + biofertilizers (PSB + Azotobacter/rhizobium) increased the yield of okra, cowpea and bottle gourd in *zaid* by 27.5, 40.1 and 8.33 %, respectively.

In *rabi* season, integrated application of NADEP compost @ 25 tonnes/ha + biofertilizers (PSB+ Azotobacter/rhizobium) increased the yield of cabbage and pea by 12.8 and 23.5 %, respectively over conventional inorganic system.

There was significant improvement (61.5% more) in number of fruits (16.7/ plant) and yield (3.03 kg/plant; 27.03 t/ha) in cucumber with potassium nutrition at 80 kg/ha in two splits, viz. 25% in soil (pre-sowing) and 75% (post-mergence) through drip irrigation.

Cucumber under drip fertigation

Pre-emergence application of pendimethalin 30 EC before planting and one hand weeding 45 days after transplanting showed 340% more yield than the control and 127% more yield than recommended practice (Oxyflurofen 23.5% EC application before planting + one hand weeding 40 days after transplanting) in onion.

Tuber crops: Drip irrigation in cassava at 100% of cumulative pan evaporation (CPE) resulted in 400% increase in tuber yield of cassava (44 tonnes/ha) compared to rainfed crop (11 tonnes/ha) in summer. Drip irrigation resulted in 30% increase in tuber yield (44 tonnes/ha) as well as 50% saving in water consumption compared to surface irrigation (32 tonnes/ha). The water productivity and water requirement of cassava was estimated to be 8.2 kg/m^3 and 3 mm/day, respectively.

Based on QUEFTS (Quantitative Evaluation of Fertility of Tropical Soils) model, **c**ustomized fertilizer formulations for cassava and sweet potato were developed and validated at 35 farmers' fields in Kerala and seven farmers' fields in Odisha. The customized fertilizer treatment (51.2 tonnes/ha) resulted in 24% higher yield over farmers' fertilizer practice (41.3 tonnes/ha) in cassava in Kerala and at par with farmers' practice in sweet potato (11.5 tonnes/ha) in Odisha.

Spices: Insect-proof net covered walk-in-tunnel gave maximum seed yield of 22.7, 25.4 and 8.2 q/ha in fennel, dill and cumin, whereas plastic sheet covered walk in tunnel gave maximum seed yield of 28.73 q/ha in fenugreek.

Vertical walls of plastic sheet were also effective to reduce the frost damage and improve seed yield of coriander (18.73 q/ha) and fenugreek (30.32 q/ha).

The green and black shaded net were more effective for off-season leafy coriander and fenugreek production than white and red shaded nets during June and July. About 90% shading intensity of green shaded net or 75% black shaded nets were equally effective for higher leafy biomass production in off-season for both coriander and fenugreek. Three crops of coriander were taken from 1 June to 30 September with crop duration of 45 days which gave cumulative biomass yield of 167.23, 162.83, 139.80 q/ha of green leafy coriander under 90 % green, 75 % black and 75 % green shaded net in off-season.

Similarly, three crops of fenugreek were taken from 1 June to 30 September with crop duration of 30 days which gave cumulative biomass yield of 146.20, 128.57, 113.2 q/ha of green leafy fenugreek under 90 % green, 75 % black and 75 % green shad net in off-season.

Higher seed yield of fennel (23.3 q/ha) was recorded from soil application of zinc @ 5 kg/ha, followed by soil application of iron 10 kg/ha (22.6 q/ha).

Maximum fresh root (1,583 kg/ha) and dry root (762 kg/ha) yield of ashwagandha was recorded due to application of castor cake @ 2.5 tonnes/ha.

Mushroom: Spent Mushroom Substrate (SMS) of button and oyster mushroom were successfully recycled for compost making for button mushroom cultivation. The conversion ratio of wheat straw to ready compost ranged from 3.67 (30% wheat straw substituted with oyster mushroom SMS without N balancing) to 2.96 in the control (standard formulation) with reduced cost for production of one tonne of compost (₹ 2,903 in 30% wheat straw substitution) with button mushroom SMS in comparison to ₹ 3,348 (control).

Culture of king oyster mushroom

The biological efficiency (BE) of different strains of shiitake mushroom on wheat straw based substrate revealed strain DMRO-327 to be the best with maximum BE of 60.23%.

The production technology of king oyster (*Pleurotus eryngii*) on saw dust based substrate supplemented with organic nitrogen materials with a biological efficiency of 30% was standardized.

CROP PROTECTION

Yellow rust of wheat and barley (*Puccinia striiformis*): During 2016-17, 401 samples collected from seven different states of north India of yellow rust of wheat and barley were analyzed. Total 11 pathotypes were identified based on Indian wheat differentials. The frequency of *Puccinia triticina* (pt.) 46S119 (virulent to *Yr2, Yr3, Yr4, Yr6, Yr7, Yr8, Yr9, Yr17, Yr18, Yr19, Yr21, Yr22, Yr23, Yr25* and *YrA*) was maximum (54.5%) followed by pt. 110S119 (33.0%). Barring 238S119, which was identified in 6% of the samples, remaining 6 pathotypes were observed in few samples only. It was also true for *Puccinia triticina* 78S84 which was predominant up to 2010-11, occurred in one yellow rust sample only. *Puccinia striiformis* f. sp. *Tritici* (*Pst*) population was found a virulent on *Yr*5, *Yr*10, *Yr*15, *Yr* Sp and *Yr*Sk. In barley, frequency of *Puccinia triticina* 57 and M was nearly same as was evident from the 13 samples of barley yellow rust analyzed during the year.

Development and commercialization of Bio NPK formulation: A liquid Bio NPK formulation containing nitrogen-fixing (*Azotobacter chroococcum*), P-solubilizing (*Paenibacillus tylopili*) and K-solubilizing (*Bacillus decolorationis*) bacteria was developed and validated for performance. The three microbs are compatible and coexist in the liquid formulation with an extended shelf-life of 12 months. Bio NPK has been validated for its yield contributing attributes for cereals, millets, pulses, vegetables, fibre and oilseed crops. The formulation was found well suited for soils with pH in the range of 6.5 to 8.5. The formulation can help augment 25-30 kg N, 20-25 kg P_2O_5 and 10-15 kg K/ha resulting in a net saving of about ₹ 2,500/ha. The yield increase through application of consortium was 5-30% in rice, 10-12% in wheat and 57% in maize. The technology has been validated in 22 centres of AICRP-Maize, IGFRI, Jhansi, KVK, Mau, ICAR-NBAIM, farmer's field on wheat, rice etc. The formulation has been licensed to M/S Arihant Naturecrop Pvt Ltd, Patna.

Development of biopriming technology for rice: An effective biopriming technology was developed for coating rice seeds with a cyanobacterial consortia containing *Plectonema* sp., *Anabaena* sp., *Nostoc* sp. in equal proportion. Rice cultivars (PR 118, PR 113, MTU 1010, MTU 7029, HUR 105, PB 1, PB 115 and BPT 5204) coated with individual and composite cultures of cyanobacteria (5g, moisture content 20±2%; CFU 1.6×10^6), dried for 24 hr and grown in field showed enhanced germination percentage (10-16%) and primed plants showed increase in root length (5-

Control; ½ RDF | RD of NPK fertilizers | 1/2 RDF+ Bio NPK

9%), shoot length (12-17%) and seed vigour compared to non-primed plants. Increase in agronomic parameters was recorded in bio-primed plants and the yield was enhanced by 5-9% in primed plants than non-primed plants in different varieties and remained viable for about a year.

Microbial formulation for drought alleviation: Microbial formulations of BioNPK + Archaea helped alleviate water stress in wheat under field conditions. Wheat grown under non-irrigated condition, resulted in 90% yield reduction while crops with one irrigation resulted in 85% yield reduction. Application of BioNPK + Archaea could supplement 8% yield loss where no irrigation was given while with one irrigation, the microbial treatment could supplement 26% of the yield loss. This microbial technology showed excellent potential to combat water stress and is currently under validation.

Identification of host plant resistance traits for maize germplasm against the cob borer: Husk extension from the tip of the cob and husk tightness emerged as promising host resistance factors, against *H. armigera*. Screening of thirteen sweet corn hybrids showed that these two traits exhibited significant negative correlation of -0.84 (P=<.0001) and -0.69 (P=0.005), respectively with percent ear infestation of the pest. While husk extension showed significant differences among genotypes, genotypic variation were non-significant with respect to tightness of the husk. The usefulness of husk extension as a host plant resistance trait was confirmed in 22 normal corn genotypes of medium maturity and 26 genotypes of late maturity as well.

Effect of zinc, copper and silver nanoparticles against *Macrophomina phaseolina* and *Rhizoctonia bataticola* in jute: ZnO nanoparticles (NPs) were synthesized by base hydrolysis of 1 mM zinc acetate. Copper oxide (CuO) nanoparticles were synthesized by standard chemical precipitation of 0.5 M copper chloride dehydrate and silver nanoparticles were synthesized by chemical reduction of $AgNO_3$ (20 µM) by sodium borohydride ($NaBH_4$). The synthesized nanoparticles were characterized through UV visible spectrophotometry, powder X-Ray diffraction (XRD) and scanning electron microscopy (SEM). The average diameters of ZnO, CuO and silver nanoparticles were around 10 nm, 30 nm and 6.5 nm respectively as found in SEM images.

The seeds of *tossa* jute (*Cv* JRO 524) and chickpea (Cv. Mahamaya I) were soaked in the colloidal suspension of nanoparticles of 0.01, 0.1, 0.5, 1.0 and 2.0 ppm concentration for 30 min. Seed treatment with silver nanoparticles @ 2 ppm could contain the fungal infection at 33.33% in jute and 10% in chickpea seedlings under challenged inoculation compared to 90% and 96.66% infection in untreated plants of jute and chickpea, respectively. Absolute check on disease incidence through CuO nanoparticles was observed @ 0.5 ppm and @ 1 ppm in jute and chickpea, respectively. The nanoparticles of ZnO were most effective which could completely supress the pathogen even at 0.01 ppm concentration.

Bacterial endophytes with antagonistic potential against fungal pathogen: A total of 32 bacterial endophytes were isolated from different cultivated rice varieties grown in Chhattisgarh namely, IR 64, Swarna, Vishnubhog, Tulsimanjri, Jaigundi, and Dubarj. These endophytes were characterized using morphological and biochemical attributes. Gram staining of bacteria showed 19 Gram positive and 13 Gram negative bacteria. Twenty four isolates revealed the presence of enzyme cytochrome oxidase and thus ability of bacteria to use oxygen for energy production. Isolated endophytes were also screened for their potential to produce indole from degradation of the amino acid tryptophan. All the 32 bacterial endophytes were screened for antibiotic sensitivity using 14 multispectral antibiotics, among them most of isolates revealed resistance to methicillin. While, most of the isolates were found sensitive to gentamicin, streptomycin, tetracycline and gatifloxacin. Molecular characterization of bacterial endophytes using PCR amplification of 16s rDNA region showed significant genetic diversity among the microbes isolated from different tissues and varieties of rice. Isolated bacterial endophytes were identified as the *Bacillus*, *Enterobacter* and *Klebsiella* genera. 16S rRNA gene sequences of 32 bacterial endophytes have been submitted and accessioned at NCBI with Accession Nos (i) stem-7 sequences: KY927393-KY927399; (ii) Root-16 sequences: KY911276; KY930702-KY930716; (iii) Leaf-5 sequences: KY927847- KY927850 and (iv) Grain-4 Sequences: KY930332-KY930334, KY962816. Bacterial endophytes isolated from rice, were screened for their efficacy against the stem rot caused by pathogenic fungi *Scleratium rolfsii* showed variable inhibition of pathogen growth.

Minimizing pesticide residues in agricultural produce

A total of 246 multi-location supervised field trials were conducted to evaluate persistence and dissipation of new and existing pesticides on various crops in different agroclimates. The data were utilized to fix maximum residue limit (MRL) for 10 pesticide-crop combinations by the Food Safety Standards Authority of India (FSSAI).Their safe waiting period and label claims were approved by the Central Insecticide Board and Registration Committee. After monitoring 22,270 samples of food commodities and water pesticide residues were detected in 4,289 samples (19.3%) while 473 (2.1%) samples exceeded FSSAI MRL. Based on the data submitted to Joint Meeting of Pesticide Residues (JMPR), the Codex Committee on Pesticide Residue (CCPR) adopted the MRL of 19 pesticides on spices.

Managed honey bee pollination in *Bt* and non-*Bt* cotton for increasing productivity: The effect of managed honey bee pollination on yields of *Bt* and its non *Bt* cotton counterparts revealed no significant differences in the foraging activity of the bees and

nectar rewards. Percent boll setting, number of seeds/boll, seed cotton yield/boll and yield/plant were same in *Bt* and non-*Bt* cultivars. Among the different pollination modes, the quantitative and qualitative yield parameters were significantly higher in bee pollinated plots compared to open and pollinator excluded plots. The yields of *Bt* and non *Bt* cotton was 9-11 % higher as a result of managed pollination with *Apis mellifera* bees.

Artificial nesting sites for conservation of native pollinators for increasing apple productivity: Installation of wooden blocks and stem bundles as artificial nesting sites in apple orchards in Shopian and Budgam districts of Kashmir Valley resulted in conservation and increased activities of some native bees. Seventy percent of the wooden blocks were found inhabited by wood dwelling *Mega chilid* bees and 65% of the stem bundles were preferred by *Osmia* spp. for nesting. Soil dwelling *Lassiog lossum* bees occupied 95% artificial soil mounds maintained in apple orchards.

Technologies for winter management of honey bees: Insulation of the bee colonies from the cold winds in high altitudes of Kashmir, Himachal Pradesh and Uttarakhand is very essential for preventing high mortality of brood and workers during winters. Low cost technology for winter packing and artificial diets for winter dearth feeding were developed by AICRP (Honey bees and Pollinators) center at SKUAST, Kashmir. Winter packing with thermocol and paddy straw provided good insulation to colonies protecting the brood and adult bees from cold winds without affecting the colony performance. Artificial diets prepared with jaggery + sugar + bengal gram flour @ 1:4:1 was found suitable for dearth period feeding during winter. The technology helped local beekeepers of Kashmir and avoiding huge economic burden on migration of their honey bee colonies outside the valley during the severe winters.

Foraging behavior and floral rewards of bumble bee flora under mid-hill conditions of Himachal Pradesh: The quantification of the floral resources supporting indigenous bumble bee, *Bombusha emorrohdalis* at Nauni, District Solan of Himachal Pradesh by melisoplaynogical analysis indicated that 43 plant species belonging to 21 families were visited by bumble bees for nectar and/or pollen classified as major flora. Six plant species belonged to family Fabaceae followed by Solanaceae (5), Lamiaceae (5) and Asteraceae (4). Thirty three plant species of the major flora provides both nectar and pollen while seven species provide only pollen and three species were the exclusive source of nectar. Twenty two plant species under 13 families were less frequented by the bumble bees for the rewards and were classified as minor flora. Out of these 14 species provided pollen and nectar, 6 nectar and 2 pollen only. The ornamental crops were frequented more by bumble bees for the floral rewards followed by medicinal plants and vegetable crops. Annual herbs constituted important source of nectar and pollen for the bumble bees followed by trees, shrubs and climbers.

HORTICULTURE

Plant protection

Fruit crops: Wilt disease, an emerging problem of mango was found severe in mango cultivation belt of Lucknow, Eastern Uttar Pradesh, Amethi, Faizabad, Kanpur, Sitapur, Aligarh, Amroha and Bulandshahar. Apart from wilt, twig/branch drying/mortality due to *Lesiodiplodia theobromae* was also observed as another factor responsible for reduction in productivity in mango (Dashehari, Chausa and Mallika). There is 80% loss in canopy in one season. Trees exhibiting typical initial symptoms of *Ceratocystis* wilt/decline at different locations, when treated with Thiophanate methyl soil drench @ 50-150g/tree and aerial spray with propiconazole @ 0.1 % treatments at nine locations exhibited significant recovery of 1 out of 8 and 69 out of 71 treated trees affected with sudden wilt and decline, respectively.

The consecutive vegetable cultivation in guava orchards in view of getting higher income has led to emergence of root knot nematode (*Meloidogyne enterolobii*) as potential threat in Uttar Pradesh and Rajasthan. Targeted surveys revealed nursery as important source of dissemination. Conventional practices adopted in nursery industry through seedlings raised in bed having cultivation of tomato, brinjal, okra etc. have led to the emergence of this nematode as one of the high risk factors in guava cultivation belt. Nurserymen have been made aware of the impending danger through farmers-scientists interaction.

Mass multiplication protocol for talcum powder based *Trichoderma harzianum* NRCfBA–44 strain was standardized in citrus. It is a talc based formulation of a native strain (NRCfBA-44, isolated from soils of Vidarbha region of Maharashtra) of biocontrol fungus *Trichoderma harzianum*, useful for the management of *Phytophthora* root rot of citrus. This is an eco-friendly component of management. Under pot culture studies *T. harzianum* talc formulation could control root rot disease up to 80% and in field trial, it reduced the root rot disease up to 65%.

For integrated management of citrus greening, treatment with 50% more than recommended dose of phosphorus + tetracycline hydrochloride 600 ppm + $ZnSO_4$ and $FeSO_4$ (200g each) was effective in reducing the severity of disease at Akola (30.33% against 45% severity in the control), Periyakulam (19.44% against 31.94% severity in the control), Rahuri (18.75% against 63.62% severity in the control) and Tinsukia (20.96% against 35.77% severity in the control). Whereas, thiamethoxam (0.3 g/l) and after a 15-day interval imidacloprid 200 SL (0.4 ml /l) was effective with minimum Citrus greening incidence (9.88% against 14.02% severity in the control) at Tirupati.

Plantation crops: Fruit setting in cashew is influenced by several group of pollinators. Surveys

CIARI Bio-Consortia

The talc based bio-formulation with consortia of antagonistic bacteria was developed and tested in different field conditions for management of bacterial wilt in brinjal. Soil application of bio-enriched FYM with CIARI-Bioconsortia at 15 days regular intervals could successfully control the bacterial wilt disease and increase the yield of brinjal. Soil application of bio-enriched FYM was also considerably good in protected cultivation.

conducted in cashew plots indicated 13 bee species as active pollinators of cashew, of which 9 are wild bee species. *Braunsapis picitarsus* and *Ceratina hieroglyphica* were nested on dried thin cashew stubs on trees. In order to conserve and build-up the population of these non-Apis bees, artificial nesting sites, bundles of dried sticks of cashew, bamboo twigs, lantana, *Cenchrus* sp. as well as wooden blocks with smoothly drilled holes (2-4 mm diameter × 8-10 cm length) were placed in cashew plantations on ant-well stands. Most of the drilled holes were successfully occupied by variety of bees,viz. *Braunsapis picitarsus*, *Ceratina hieroglyphica*, Megachilids and a large number of wasps including parasitoids. Thin sticks were readily occupied by *B. picitarsus*, thereby enhancing pollinator activity in cashew plots considerably.

Vegetables: An integrated module for management of vector and enation leaf curl and yellow vein mosic disease of okra was standardized with reduced jassid (92.83%) and whitefly (78.57%) population with minmum fruit damage (9.67%), resulting into maximum marketable fruit yield (106.8 q/ha). The technology consists of using bajra as border crop, use of black reflective mulch, seed treatment and field spray with chemical and botanical pesticides, sticky trap, application of micronutrients and drenching the soil with humic acid.

A solitary koinobiont, pupal endoparasitoid *Brachymeria lasus* from fruit borer of bitter gourd, *Diaphania indica*, with 19.2% parasitization during third week of October was identified. An endoparasitoid, *Pristomeru seuzopherae*, with maximum parasitization (12.48%) during July from brinjal stem borer, *Euzophera perticella* was identified.

Mirid bug, *Nesidiocoris cruentatus*, was observed to be an emerging pest on bottle gourd. Among different neonicotinoid insecticides, thiacloprid was most effective against miridbug with 87.04% reduction in population with maximum fruit yield (218.5 q/ha).

A technology comprising seed treatment (@10 g/kg) and foliar spray (@1%) of *Trichderma asperellum*, with reduced Cercospora leaf spot (PDI - 46.64) and increased yield (66.49 tonnes/ha) of bottle gourd was standardized.

Weather based forecast model for thrips

Weather based forecast models were developed for each date of planting (01-Nov, 15-Nov, 01-Dec, 15-Dec, 01- Jan and 15- Jan) for *rabi* onion using weather indices and crop growth and thrips infestation attributes for reliable forewarning of thrips.

Potato: The Indo-Blightcast model developed previously for prediction of appearance of late blight has been embedded in the Decision Support System (DSS) that will enable the farmers to decide the number of sprays as well as the interval between sprays and the fungicide to be used based on the Disease Severity Values (DSVs) of 15 days prior to the selected date. Application of ametoctradin + dimethomorph (0.2 %), famoxadone + cymoxanil (0.1%), cymoxanil + mancozeb (0.3%), and dimethomorph + mancozeb (0.3%) has been found effective against late blight. The dsRNA based fungicide technology has been developed for management of potato late blight.

Spices: An entomopathogenic fungus, *Lecanicillium psalliotae*, is so far first report on its application in management of cardamom thrips in India. It is recommended as 3-4 times soil application (10^8cfu/g) during May – September, for effective control of thrips. Application of this fungus combined with 3 sprays of Spinosad 0.0135% (derived from *Saccharopolyspora spinosa*) during March, May and August can substitute synthetic chemical insecticides and could successfully be integrated with organic production.

Drenching of carbosulfan 0.1 % @ 50 ml/poly bag containing 1.5 kg potting mixture is recommended for the management of plant parasitic nematodes in black pepper in nursery. Drenching 0.1% carbosulfan 25 EC (0.125 a. i.) @ 5 l/plant at the base of plant twice a year (pre-monsoon -May and post-monsoon - October) in field controls nematode.

A new artificial media for the mass production of infective juveniles of entomopathogenic nematodes such as *Steinernema* spp., *Heterorhabditis* spp. and *Oscheius* spp.was standardized. By this technique around 23 lakh infective juveniles of EPN can be recovered from a single flask (250 ml) costing ₹ 2/ flask.

Fenugreek leaf blight caused by *Alternaria alternata* can be effectively managed by three foliar application of propiconazole (0.05%) or difenoconazole (0.05%) at 15 days interval. Foliar application of copper oxychloride (0.2%) and hexaconazole (0.1%) was most effective against downy mildew and powdery mildew diseases of fenugreek, respectively.

❑

8. Livestock Management

LIVESTOCK

Nutrition

Biogeography of gut microbes in animals: Efforts were made to explore the composition of rumen microbiome in large and small ruminants. The number of species detected in the rumen metagenomes ranged from 897-1468, which was highest in goat and lowest in buffalo. The phyla Fermicutes and Bacteroides dominated the cattle, buffalo and sheep rumen microbiome, but in goat the abundance of Fermicutes, Bacteroides and Proteobacteria was found in equal proportions. The population of archaeal was highest in buffalo as compared to the other three species.

Cattle

Dried rice distillers grain with solubles (*RDGS*): Distillers grains (DG) are considered good sources of protein for dairy cattle. Fibre, protein and fat are concentrated approximately 3-fold in DG when starch is fermented to produce ethanol; hence, DG can replace the protein source in diets of cattle. In a study, soybean meal (SBM) was totally replaced by RDGS in concentrate mixture. There was no significant difference in total DM and CP intake. The average milk yield though higher in the treatment, was not statistically significant. The average percentage of milk fat, milk protein, SNF, total solid and ash showed no significant difference due to treatment. There was no adverse effect of replacing SBM by RDGS on intake, milk yield or composition and thus cost of ration can be economized in view the much lower cost of RDGS in comparison to SBM.

Feed and fodder technology

- The supplementation of molasses based multi-nutrient supplement (MMS) (250 g/buffalo/day) improved milk yield by 16-18 %. MMS can replace 7.5 % of the concentrate mixture without having any adverse effect on the performance of lactating Murrah buffaloes.
- Inulin and polyphenolic extracts of Jerusalem artichoke-have positive synergistic effect on gut health in terms of improvements in hindgut microbial metabolites, antioxidant status, immune response and selected metabolic indices in rats.
- Tea seed meal, a waste byproduct of tea oil industry, can be added up to 9.8% of concentrate mixture (2.88% of diet) without any adverse effect in the diet of adult Gaddi goats.
- A bacteria having probiotic potential (*Pediococcus acidilactici* FT28) isolated from pig faeces was characterized and submitted to VTCC.
- Six sulphur reducing bacterial isolates (*Desulfovibrio vulgari* strain SRBB 101-106) were characterized and submitted to VTCC.

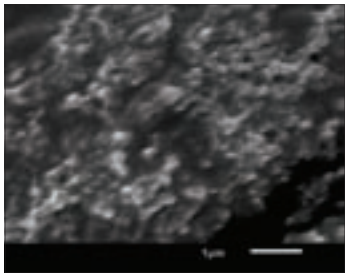
Sheep

Conjugated linoleic acid (CLA) enriched mutton: Supplementation of 10% linseed and 5% Ca-soap in the diet of finisher lambs resulted in 16.3 and 12.2% improvement in weight gain and 7.5% in FCR as compared to control. It significantly increased ω-3 fatty acids and CLA content in adipose tissue and ω-3 fatty acids and CLA in *longissimus dorsi (LD)* muscle of lambs. CLA enriched mutton possesses numerous health benefits, including anti-cancer properties.

Camel

Evaluation of nutritional plane: Feeding of camel calves (male and female) with 20% higher protein and energy rations improved growth rate and attained early maturity. The male experimental animals accordingly were ready for mating at 2.5 years age than conventional age at mating of 4.5 years. Female calves attained body weight of 300- 350 kg at 2 years than conventionally attained at 4 years.

Nano-calcium supplement: Nano calcium carbonate and nanocalcium phosphate prepared as calcium supplement showed 15-20% better absorption than conventional calcium supplements used in camels.



Scanning electron microscopic picture of prepared calcium carbonate nanoparticles

Pig

Chelated trace minerals were indigenously developed and supplemented @ 0 level and low level (Cu-M: 6ppm, Zn-M:46ppm, Co-M:1.6 ppm, Fe-M:75ppm) in the pig ration. Metabolic trial was conducted at the middle of the experiment. The lysine and methionine were balanced in all the rations as per requirement. Supplementation of trace minerals in the chelated form significantly increased their bio-availability and tissue mineral balances.

Yak

Nutrition management: To mitigate winter feed crisis and supplement green fodder in the form of silage to yaks, maize silage was prepared in polythene bags (500 kg capacity) at an altitude of 2,800 m above msl for feeding of yaks. The quality of silage prepared was comparable to the traditionally prepared silage in silos based on the chemical composition and acceptability by the growing yaks. Silage making in polythene bags is advantageous due to ease of carrying and flexibility in making small batches of silage as per the availibility of green fodder.

Poultry

Nutritional manipulations for optimising performance: Supplementation of selenium (0.3ppm) in either organic or inorganic forms in combination with vitamin E (200 mg/kg) improved shell quality and activities of superoxide dismutase (SOD), glutathione peroxidase and glutathione reductase in broiler breeders. When tocotrienol, a precursor of vitamin E was evaluated in broilers against vitamin E, it was found that tocotrienol was more effective in improving the anti-oxidant responses in broilers even at much lower concentrations (4-8 mg/kg) compared to those fed vitamin E (100 mg/kg).

Supplementation of nano-zinc at reduced levels in diet (80-7.5 mg/kg) improved feed efficiency, reduced lipid peroxidation and improved glutathione peroxidase activity and SOD in spleen and liver in broiler chicken.

Antibody titres against New Castle disease (ND) increased, lipid peroxidation decreased and activity of glutathione peroxidase improved in broilers fed moringa leaf meal (500-1,000 mg/kg) or pomegranate peel meal (250-500 mg/kg).

In the process of clean poultry production, efficacy of synbiotics (mixture of probiotics *Bacillus subtilis* and *Bacillus amylo liquifaciens* @ 10^6 cfu/g and mannan-oligosaccharides -–MOS @) 1% in diet), improved feed conversion ratio (FCR), immunity, and survivability of poults than those fed either prebiotics (mannan-oligosaccharides @ 1%) or probiotics (*Bacillus subtilis* and *Bacillus amylo liquifaciens* @ 10^6 cfu/g) in growing turkey poults (0-6 wk of age).

Inclusion of *Kappaphycus alvarezii* and red sea-weed based formulations (AF-KWP) at 1.25% level in broiler diet improved performance, gut health (both microbial and structural), breast yield, physio-biochemical characteristics and reduction of microbiological counts in fresh and storage (14 d) meat.

Milk metabolomics of indigenous cows

Milk metabolite profile from *Bos indicus* cattle raised in intensive system of management was compared with that of indigenous cattle maintained under extensive system. In the milk of indigenous cattle maintained in extensive system:

- Significantly higher concentration of zinc, iron, phosphorous and copper is present but calcium, magnesium and potassium were not found affected by the management conditions
- Total amino acid content was highest
- Significantly higher essential amino acids compared to all the three categories in the intensive system of management
- Lowest level of saturated fatty acid
- Significantly lower concentrations of atherogenic (C12, 14 and 16) fatty acids
- Unsaturated fatty acids highest mainly due to higher levels of mono unsaturated fatty acids (MUFAs), higher milk polyunsaturated fatty acids (PUFAs) level (7.18%) and total ω3 and ω6 fatty acids
- Lower atherogenic index (33.90)
- ß carotene concentration was more than two-fold.

Hence, grazing cattle have favourable milk composition characteristics and can be assigned special value, which can become important tool to maintain native genetic resources characterized by low production levels.

Animal physiology and reproduction

Cattle

Feed supplement comprising a source of energy, protein and an antimicrobial agent, increased average milk fat from 2.59 to 3.85%, and resulted in conception in 76% animals that had reproductive problems such as repeat breeding, delayed puberty and postpartum anestrus.

The 'Doublesynch' and the 'Estra-doublesynch' estrous synchronization protocols along with fixed time artificial insemination were carried out at fields with more than 80% success in conception rate in problematic cows and buffaloes.

Buffalo

Species-specific remen extender: The average post-thaw motility and fertility of frozen-thawed buffalo spermatozoa are substantially low compared to that of cattle sperm. Over the decades, the protocols for cryopreserving buffalo semen were similar to that of cattle. There is a need to develop a species-specific semen extender for buffalo based on its sperm structure and seminal plasma composition. Cryopreservation induces significant bio-molecular changes in proteins and lipids of buffalo sperm and this may be one of the causes of reduced post-thaw motility and fertility of buffalo semen. IGF1 as additive, improved post-thaw sperm functional parameters and reduced oxidative stress of spermatozoa and can be used as sperm motility enhancer for developing a species-specific semen extender for buffaloes.

Cloning: During this period, 43 cloned blastocysts were transferred to synchronized female buffaloes for conservation and multiplication of superior buffalo germplasm. Two pregnancies were obtained, which continued only for five months and aborted thereafter. Epigenetic studies for understanding pregnancy losses are under progress.

Sheep

Assessment studies were conducted to reveal the influence of dietary Se on the expression of selenoprotein genes and its implications on the antioxidant and immune functions and meat quality in lambs. The results indicated that the dietary supplementation of organic Se at supranutritional levels improved the antioxidant capacity of liver and muscle tissues.

Goat

Ultrasonographic demonstration of embryo in goat: Chimeric goat embryos (3-4 embryos) developed to morula and blastocyst stages were transferred surgically at the tip of uterine horn ipsilateral to the ovary containing corpus luteum of 19 naturally synchronized surrogate does. Two recipients were initially diagnosed pregnant on day 35 post-transfer by ultrasonography. In first recipient, the pregnant uterus was having an embryo proper in a fluid filled cavity without amniotic ring. The morphological appearance of the foetus did not resemble a normal foetus; rather resembled a solid mass. In another view of ultrasonogram, a very thick and hyperechoic amniotic ring was visible. It indicated that the 2N cell from parthenogenetic embryonic stem cells developed into embryo proper and the 4N cell of tetraploid embryos participated in the formation of foetal membranes. These structures were present till day 49. Thereafter, the fetal membranes started resorption and by the end of day 56 it was completely reabsorbed and the uterus returned to its normal pre-gravid stage. In second recipient, the pregnant uterus was having a fluid filled cavity at day 35 post-transfer in ultrasonographic examination. The foetus and fetal membranes started resorption by day 58 with the uterus returning to its normal non-pregnant stage on day 73 post-transfer.

Poultry

Supplementation of boron (40 ppm) to the diet with inadequate Ca improved egg production and shell thickness and reduced the number of cracked eggs. Immune response was also found better in the birds that were fed B supplemented diets.

Light stimulation is one of the effective ways to modulate the reproduction and growth in poultry. The exposure to monochromatic green LED light (575nm) during *in ovo* and *ex ovo* effectively stimulated the hypothalamic-pituitary-gonadotrophic-somatotrophic-thyrotrophic axis resulting in low feed consumption, better FCR and increased muscle mass and body weight gain in broiler chicks. In conclusion, the somatotropic axis hormones (GH and IGF-I) are the most important contributors for growth and body weight gain when promoted by green light stimuli during embryogenesis.

Cryopreservation of chicken semen: Cryopreservation of chicken semen using cryoprotectants, viz. dimethyl formamide (DMF) and dimethyl acetamide (DMA) were evaluated. DMF and DMA at 6% concentration resulted in higher sperm motility, but fertility rates with cryopreserved semen were very low. Addition of vitamin C (10 mg), vitamin E (100 µm) and $CaCl_2$ (4 mM) to semen diluent BPSE (100 ml) moderately improved fertility in PD-1 roosters.

Single semen diluent for diversified poultry species: A single semen diluent was developed for diversified poultry species, viz. chicken, duck turkey and guinea fowl, which is capable of storing chicken semen for 24-48 hr at 8°C without compromising fertilizing ability. This technology can help in easy transportation of elite poultry semen throughout the country as well as internationally by air and hence may prove vital in maximizing the multiplication of elite germplasm. During the entire fertile period (1-10 days) dilution rate 1:2 expressed high fertility than others. Evaluation of air volume in contact exhibited that during 1-5 days of fertile period higher fertility resulted from semen stored in 5 ml capacity glass vial.

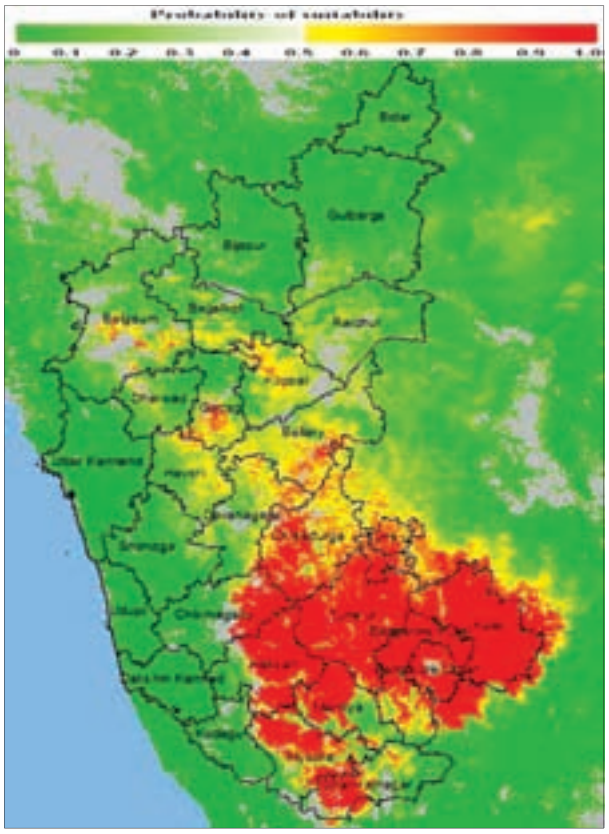
Salivary fern patterns and RNAs - new tools for estrus determination in buffaloes

Saliva was tested for estrus determination in buffaloes. Estrus was determined by the estrous symptoms, ovarian ultrasonography and the salivary oestradiol levels. Salivary smears, prepared with 20µl of the cell free saliva on clean glass slides, showed different crystallization patterns, including typical fern-like, branch-like, fir-like, combinations of fir-fern-branch, dotted and none at different stages of estrus cycle. Saliva at estrus showed a typical symmetrical fern-like pattern with significantly lower fractal dimension values. The proportion (0.84) of oestrus detection by the salivary fern patterns was higher than the proportion of oestrus detection in the field conditions. Direct saliva transcript analysis showed a significant higher expression of Heat shock protein 70 (*HSP70*) and Toll-like receptor 4 (*TLR4*) at estrus than diestrous period in buffaloes. There was a significant increase in the salivary presence of miR-16, miR-191 and miR-223 on 6^{th} and $18\text{-}19^{th}$ days of the buffalo estrous cycle, but no such significant difference in their levels among estrus (0 day), 10^{th} day and the following consecutive estrus day.

Livestock protection

Epidemiology

The monthly disease forewarning information about the occurrence of important livestock diseases was sent to DADF and other state animal husbandry departments two months in advance to take up suitable preventive measures. As per the NADRES report, foot rot, hemorrhagic septicemia (HS), black quarter (BQ), enterotoxaemia (ET), glanders and anthrax were the predominant bacterial diseases; *peste des petits ruminants* (PPR), capripox, bluetongue (BT), rabies and classical swine fever (CSF) were major viral diseases; and fasciolosis, amphistomosis, anaplasmosis, babesiosis, coccidiosis and trypanosomosis were



Risk map for anthrax in Karnataka showing high risk and low risk areas

frequently reported parasitic diseases from the country.

PCR samples, viz. blood (32), nasal swabs (16) and tissue (30: heart, liver, spleen, bone marrow) from large and small ruminants, collected from Odisha, Madhya Pradesh and Karnataka during outbreak investigation, revealed that 8 samples were positive for *Pasteurella multocida*. N-terminal gene of *P. multocida* encoding for NanB-Nt protein (~94 kDa) was expressed and characterized by SDS-PAGE. Two whole genome sequence of *P. multocida* strain and *Mannheimia haemolytica* isolated from yak were carried out and reported from India. Screening of 157 yak nasal samples for respiratory pathogens revealed detection of *M. haemolytica* (17.9%), *P. multocida* (3.9%) and *Histophilus somnil* (2.5%). Study on epidemiology of HS in livestock vis-à-vis foot and mouth disease (FMD) revealed the high cumulative outbreaks of HS than FMD in Gujarat, and followed by more FMD than HS in West Bengal, respectively. The risk factor analysis showed that Kolar, Tumkur, Hassan, Mysuru, Chamarajanagara, Raichur, Belagavi, Gadag, Koppal, parts of Mandya in Karnataka were at high risk for anthrax.

In order to evaluate diagnostic antigen in ELISA for bovine brucellosis, a multi-epitope recombinant protein antigen of *Brucella abortus* was designed, synthesized, cloned in the vector and expressed in addition to expression of individual immuno dominant proteins BP26, BLS, SodC, VirB12, etc., and these recombinant proteins are to be evaluated either single or cocktail proteins. Random serum samples (4,767) received from 18 centers were screened for brucellosis and high prevalence was observed in pigs (40.19%) followed by sheep (20.82%), cattle (2.73%), goats (2.18%) and buffalo (1.11%) with an overall prevalence of 7.69% among all species. Validation of in house developed protein G ELISA kit against commercial Priocheck Brucella Ab 2.0 iELISA kit showed 95% agreement indicating high sensitivity and specificity of in-house developed kit. Fluorescent polarization assay (FPA) for sero-monitoring of brucellosis in livestock was developed and validated. The kit was transferred to ADMaC core Lab-I to generate the epidemiological data on brucellosis in North Eastern States.

The extended spectrum of beta lactamase producing multi drug resistant *Escherichia coli* isolated from subclinical mastitis milk, were identified and characterized. The multidrug resistant *Proteus mirabilis* carrying multiple efflux pumps detected in apparently healthy pig fecal samples. Whole genome shotgun sequencing of isolated *E. coli* strain SCM-21 and *P. mirabilis* strain NIVEDI3-PG74 was carried out to study the epidemiology of pathogen.

On screening of 119 human samples received from PUO cases for leptospirosis by MAT with 18 reference leptospira serovars, 41.17% showed sero-positivity with reactive major serovars Hurstbridge, Tarassovi, Javanica, Bataviae Pyrogenes, Shermani, Icterohaemorrhagiae, Kaup, Hardjo, etc. Out of 1,116 livestock samples tested in MAT at 1:100 titre, 617 showed sero-positivity. Out of 297 human serum samples received from Kerala, Karnataka, Dadra and Nagar Haveli, 55 samples showed positivity for IgG antibodies against *Toxoplasma gondi*.

The outbreak data of avian influenza (AI) from 2006 to 2015 were collected and analyzed with related risk factors namely normalized difference vegetation index (NDVI). normalized difference water index (NDWI), normalized difference moisture index (NDMI), land surface temperature (LST), rainfall and other anthropometric variables like distance from highways and rivers waterbodies, spatial heat map of AI outbreaks in eastern and north eastern states from 2008-10 and plotted.

Estimation of economic losses due to pox infection in sheep and goats at assumed 1% annual incidence levels revealed the total estimated loss as Rs 480.72 crore. The PPR clinical score card, used for assessing the severity of disease patterns in sheep, revealed that PPR outbreak remains in mild to severe form and mild to moderate form in the places nearby regularly vaccinated and all severe form in the places where the vaccination was not conducted. In another survey in Karnataka, 8.31% PPR incidence was observed. The estimated mortality loss, cost of treatment, distress sale and opportunity cost of labor among the infected flock was ₹ 3,231, 108.2, 3,040, and 15.7/animal, respectively. Further, a questionnaire was developed to assess the risk factors for occurrence of porcine reproductive and respiratory syndrome (PRRS). Sero-positive samples (62) were screened for PRRSV by

RT- PCR, out of which 22 samples were found positive. Clinical samples received from different regions of India were screened by PCR and 61 clinical samples (3/20 from Sikkim, 1/2 from Kerala, 1/2 from Telangana, 3/10 from Karnataka, 2/27 from Madhya Pradesh) were found positive for torque teno virus (TTSuV) infection.

Out of 2,008 serum samples received from NER states screened for the prevalence of classical swine fever virus (CSFV) antibodies revealed prevalence in Asom (20.54%), Mizoram (37.13%), Meghalaya (21.3%), Manipur (44.07%), Sikkim (36.11%) and Tripura (10.57%). Meta-analysis of 10 CSFV study data from seven states of NER with 1,323 samples revealed the seoprevalance of CSFV as 31% and for bluetongue (BT) as 35% prevalence.

Three multiplex PCR for detection of BTV serotypes 5 and 9, 3, 13 and 16 and 10 and 24 were developed, optimized, and specificity was confirmed by nucleotide sequencing. The predominant isolates in Karnataka belonged to BTV 1, 2, 3, 4, 5, 9, 16, 23, and 24. From small ruminants, 411 serum samples were received from the NE states and on screening 88 samples were found positive for BTV antibodies by C-ELISA. Highest prevalence was in Manipur whereas the lowest in Asom. In another study 8,000 *Culicoides* specimens from 31 sites near the wildlife sanctuaries were entrapped; among them 13 major *Culicoides* species were found. The selected *Culicoides* species were DNA bar coded and BTV was detected in *C.oxystoma* and *C.imicola* samples. The results indicated that there is a circulation of *Culicoides* species in forest habitats and presence of BTV in some *Culicoides* species. During this period, 9,923 bovine sera samples from different states of India were screened for the IBR antibodies using Avidin-Biotin ELISA– in Chhattisgarh showed the highest prevalence rate with 50.54%; whereas, Nagaland showed the least with 6.80% with overall 33.79% positive on screening of 2,418 bovine samples from NE states.

Isolates (16) of bovine herpes virus (BoHV) from Karnataka, Odisha, West Bengal and Uttar Pradesh were maintained in virus repository. Screening of 2,077 *Lymnaea* spp. snails collected from 25 waterbodies covering 11 districts of Karnataka for infection of *Fasciola gigantica* by PCR targeting ITS 2 region, revealed the 5.1% of snails were positive for *Fasciola gigantica*; Deccan plateau of Karnataka showed the highest positivity with 5.79% followed by 5.22% in Western Ghats and 3.95% in Coastal region. Seasonal prevalence of infection was more in winter (6.22%) followed by the rainy (4.61%) and summer (4.35%) seasons, respectively.

In another study, 968 bovine samples from Tamil Nadu, Madhya Pradesh, Karnataka, Bihar and Andaman and Nicobar island, Himachal Pradesh, Uttar Pradesh, Sikkim, Odisha, Asom, Mizoram and Puducherry were screened for the prevalence of *Trypanosoma evansi* antibodies using recombinant VSG based indirect ELISA, of which 732 (75.62%) animals showed positivity with the highest (94.5%) in Puducherry, and the lowest (25.58%) in Odisha.

Vaccine

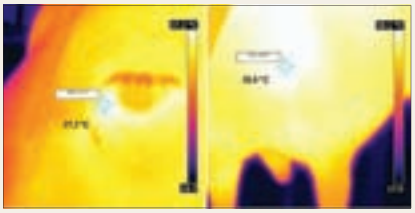
- The thermo-stable FMDV serotype O candidate strain (Ts-O IND R2/1975) virus was successfully adapted to BHK-21 suspension cell lines. One thermostable mutant virus (O IND R2/1975_Ts1) had similar replication kinetics compared to the parental virus.
- Phage lysate candidate vaccines against *Brucella abortus* and *Pasteurella multocida* were developed. *Brucella* phage lysate induced a protective response in mice and guineapig against challenge with *B. abortus* 544 at a significantly low dose than the dose of S19 vaccine. *P. multocida* lysate protected birds against all 3 prevalent serotypes A:1, A:3 and A:4 of the pathogen causing fowl cholera.

Diagnostics

- Indirect IgG ELISA kit for serodiagnosis of Japanese encephalitis infection in pigs.
- Latex agglutination test for sero-diagnosis of Japanese encephalitis in pigs was standardized with diagnostic sensitivity and specificity of 82.24 and 87.83%, respectively.
- Peptide-recombinant protein based antigen capture immunoassay for detection of rotavirus group A

Early detection of subclinical and clinical mastitis

Increasing dairy farm size and automation in dairy herd management require new methods and technologies to monitor udder health status in dairy cows. To evaluate the ability of infrared thermography (IRT) technique for the early detection of mastitis, 200 quarters of lactating Karan Fries (Holstein Friesian × Tharparkar) crossbred cows (50) were monitored for body temperature (i.e. eye temperature) and udder skin surface temperature (USST) prior to milking using FLIR i5 (forward-looking infrared) camera. Milk samples were collected from each quarter and screened for mastitis using somatic cell count (SCC), electrical conductivity (EC) and California mastitis test (CMT). Incidence and early detection of subclinical and clinical mastitis was successfully done in eleven quarters out of 200 udder quarters screened by IRT technology and the diagnostic reliability was also well correlated with result of SCC, CMT and EC. Infrared thermal imaging technology could be used as a potential non-invasive, quick cow-side diagnostic technique for screening and early detection of subclinical and clinical mastitis in crossbred cows.



Infrared thermogram of eye and mastitis affected udder quarter surface

infection in animals.

- An alternate model for *in vivo* protection studies for FMD, virus neutralization test (VNT)-based statistical model was developed for serotype O. Its testing in two different laboratories showed accuracy ranging from 72.4 to 79.7%. Liquid Phase Blocking ELISA (LPBE) based statistical model developed for serotype O showed accuracy of 85.4%.
- A sandwich, ELISA based technique was developed for quantification of Newcastle disease virus in the vaccine formulation; the diagnostic specificity was 100% and diagnostic sensitivity 95%.
- A multiplex PCR (m-PCR) based kit for detection of four extraneous agents MDV, EDSV, CIAV, and avian mycoplasma in poultry as well as cell lines of avian origin were developed. The kit was stable up to one year at 4°C and –20°C.
- An indirect-ELISA based on the recombinant E2 protein of classical swine fever virus (CSFV) was developed for detection of CSFV antibody in the serum samples. Relative diagnostic sensitivity was 85% and specificity 92%.
- A multiplex PCR assay was developed for accurate diagnosis of haemoparasitic diseases, viz. *Babesia vogeli*, *B. gibsoni*, *Hepatozoon canis* and *Ehrlichia canis*.

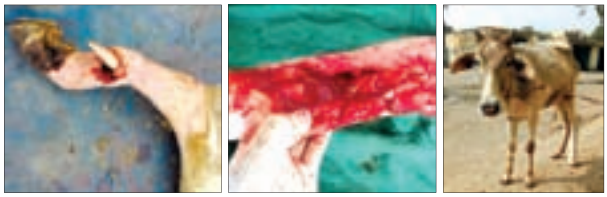
Characterization of pathogens

- ESBL producing *K. pneumoniae* isolates carried the genetic platform- ISEcp1-blaCTX-M-orf477. A new variant of blaCTX-M was detected in an isolate from Jharkhand.
- Overall occurrence of ESBL producing *E. coli* and *Klebsiella* spp. in bovine milk from Asom and Haryana were 13.28 and 9.67%, respectively.
- Of the 623 *E. coli* isolates from neonatal calves, 341 (54.73%) were pathogenic. EPEC was the predominant pathotype (26.16%), followed by STEC (14.12%), EHEC (10.27%), ETEC (3.04%) and EAEC (1.12%).
- Prevalence of *Clostridium perfringens* was 37.97% (259/682) in neonatal calves. The type A was the most predominant with a prevalence rate of 59.45%.
- Among the ESBL genotypic positive *E. coli* isolates, BlaCTX-M was the most prominent gene (456/525), followed by blaAMPC (391/525), blaTEM (311/525) and blaSHV (28/525). Carbapenem resistance was observed in 129 (21.39%) *E. coli* isolates.
- Silencing of Ferritin-2 (FER2) and Tropomyosin (TPM) genes of *Haemolytica anatolicum* had significant effects on feeding and fecundity of ticks.
- IVRI-IV tick line, the first established deltamethrin and cypermethrin resistant tick line of India, was registered in the national registration system (NBAIR-IVRI-BM-4-2009).
- Country specific multiple mechanisms conferring resistance in *R. (B.) microplus* isolates against synthetic pyrethroid (SP) and organophosphate (OP) compounds was established.
- The sequence information of *Malassezia pacchydermatis* (animal source) from India submitted first time in NCBI database.

Clinical and surgical interventions

Composite scaffolds for bone and tendon repair: Bone and tendon biomaterials were prepared for the healing of the lost bone and tendon tissues through use of tissue engineering techniques**.**

In a clinical case of contracted flexor carpi ulnaris and flexor carpi radialis tendon in a heifer (1.5 year old), tenotomy and grafting (7 cm) was performed with acellular xenogenic graft. Normal walking was observed after 42 days.



The compound fracture in a heifer treated by bone resection and grafting employing acellular xenogenic bone graft

Therapeutics

- Kaempferol pretreatment attenuated the level of lipid profile, infarcted area and oxidative stress in ISP-induced cardiomyopathy in rats.
- Nano structured hybrid polymer of catechin increased *in vitro* antioxidant property, enhanced bioavailability and drug releasing property denoting its potential use as a hepatoprotectant.
- Suitability of metallic circular external skeletal fixator for the treatment of compound fractures in large ruminants and epoxy pin fixator for small ruminants was validated.

Goat

Detection of *Mycobacterium avium* subspecies *Paratuberculosis*: Nano-based test was standardized as colorimetric detection test for the detection of

Wild life: Disease monitoring and surveillance

Genotyping of different *Trichinella* parasites recovered from wild animals revealed mixed infection of *Trichinella nelsoni* and *T. britovi* in 8 big cats (1 tiger, 7 leopard) and single species infection (*T. nelsoni*) in 3 leopards. The important conditions diagnosed in wildlife were canine distemper in lion, tiger, leopard and palm civet cat; rabies in leopard, tiger and spotted deer; rota viral infection in sloth bears; lymphoid leucosis in pied horn bill; sero-prevalence of foot and mouth disease in sloth bears, elephants and black buck; tuberculosis in bison and sloth bears; seroprevalence of leptospirosis in sloth bear, lion, tiger, leopard and elephants.

Mycobacterium avium subspecies *Paratuberculosis* (MAP) in milk samples. The minimum detection limit is 10 MAP cells/ml and minimum 3 days are required to complete the detection of viable MAP bacilli. The specificity was 100% in comparison to three alternate tests namely dot-ELISA (70%), latex agglutination (70%) and indirect fluorescent antibody test (93.5%).

Regulating the PPR virus replication: Despite the availability of suitable vaccines, *peste des petits ruminants* (PPR) is the leading cause of livestock morbidity and mortality. To develop antiviral therapeutics against PPR, a library of host cell's kinase and phosphatase inhibitors was screened. At a noncytotoxic concentration, one of the inhibitors [sarco/endoplasmic reticulum Ca2+-ATPase (SERCA) inhibitor] significantly inhibited replication of PPRV by interfering with the localization (transport) of the viral proteins from cytoplasm to the plasma membrane. Thus, a host target (SERCA) for development of antiviral therapeutics against PPRV, was defined.

LFA kit for diagnosis of equine piroplamosis

Equine

Equine infectious diseases: Sero-prevalence of equine piroplamosis, equine herpesvirus 1 (EHV1), surra and Japanese encephalitis (JE) was 43.4, 10.8, 4.7 and 4.6%, respectively.

Glanders: Glanders a fatal infectious notifiable zoonotic disease of equines caused by *Burkholderia mallei*, was confirmed in 323 samples out of 25,997 sera tested from 9 states during the reported period. Emergence of glanders outbreaks in newer regions is a cause of concern. Whole genome sequencing of two Indian *Burkholderia mallei* isolates revealed that the genome is 5.6 Mb comprising 4,713 genes.

Refined vaccine against EHV1: Earlier used EHV1 vaccine (Equiherpabort) was further refined by using montanide. It provided the best response as adjudged through better immune responses, low virus shedding and better protection in terms of reduced clinical signs, early weight gain and lower gross and histopathological lesion scores.

Generation of gE deletion mutants of EHV 1: To develop modified live vaccines, EHV1 bacterial artificial chromosome was used to generate EHV1 deletion mutant of gE gene. The mutant deleted gE-BAC construct was confirmed by PCR and RFLP analysis employing *Hind*III and *Bam*HI.

Generation of reverse equine influenza virus: Reverse genetics technique was used to develop recombinant equine influenza virus, which can be used as a vaccine candidate. The virus was grown in bulk in embryonated chicken eggs and purified, quantified and inactivated with formalin for immunization in BALB/c mice for the challenge studies.

Lateral flow assay (LFA) diagnostic kit for equine piroplasmosis: Equine piroplasmosis, a tick-borne disease, showed prevalence of about 35% in Indian equids. A field test kit, was developed, which is rapid and a farmer friendly lateral flow assay (LFA) for diagnosis of equine piroplasmosis (*T. equi* infection). The kit has 0.945 diagnostic sensitivity (Dsn) and 0.916 specificity (Dsp).

Differentiation of EHV1/4 infection: The differential diagnosis of EHV1 and EHV4 viruses is often complicated due to antigenic cross-reactivity between the two viruses. A recombinant antigen based ELISA kit for differential diagnosis of EHV1 and EHV4 infections, was developed. Out of 659 sera tested, 6.4 and 64.5% were tested positive for EHV1 and EHV4, respectively.

Rapid diagnosis of trypanosomosis: A lateral flow assay for the diagnosis of trypanosomosis was developed using flagellar recombinant protein. LFA is a rapid, simple and easy to use, cost effective, portable, highly sensitive and specific method in which the diagnosis is completed within 15 min using 1-2 drops of serum sample.

Updated equine influenza vaccine

An outbreak of equine influenza (EF) occurred during 2008-09 was caused by equine influenza virus of subtype H3N8 belonging to Clade 2 of Florida sub lineage, which was different from the virus that caused EI outbreak in 1986-87. Therefore, previously developed vaccine was updated using A/eq/Katra (Jammu)/06/08 (H3N8) virus with HA content of 20 µg/dose. Field trials resulted in development of protective antibody titres, without any adverse reactions or clinical signs, following booster vaccination after four weeks. The technology was released to the nation. It will be very useful for vaccinating the animals, which are under continuous movement inside and outside the country.

Latent equine herpesvirus 1 infection

Latency is one phenomenon in herpesviruses, which leads to lifelong persistence of virus infection in animals. Once infected, 50-70% horses remain latently infected and reactivation of virus latency may lead to clinical infection. A real-time RT-PCR targeting latency associated transcripts (LATs) and RT-PCR for detection of expression of late structural protein (gB) were developed to detect EHV1 latent infection. The results proved that majority of equines (>52%) in India were latently infected with EHV1 virus.

Pigs

Simultaneous detection of important viral diseases: A multiplex PCR for simultaneous detection of porcine parvo virus (PPV), porcine circo virus type 2 (PCV2) and classical swine fever virus (CSFV) was developed. Pig serum samples and tissue, blood and faecal samples were screened for the presence of CSFV, PCV2, and PPV. Out of 216 serum samples screened, 55 were positive for CSFV antibodies, 22 for PCV and 11 for PPV. Out of 466 samples (blood/tissue/fecal samples) analyzed by PCR, 18, 12 and 7 samples were confirmed to be positive for CSFV, PCV2 and PPV, respectively.

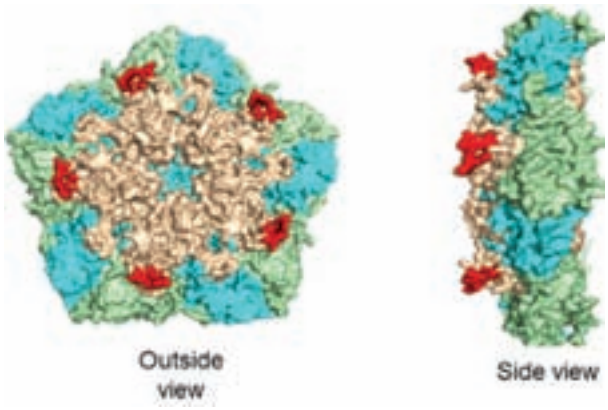
Poultry

Diagnostics and prophylaxis: The major causes of mortality among the DPR flocks were heat stress, colibacillosis, chronic respiratory disease (CRD), coccidiosis, laryngotracheitis and gout. The avian leukosis virus (ALV) incidence among the tested pureline breeders was 5.3%. Maternal antibody titer for infectious bursal disease (IBD) intermediate vaccine was 125 that was noticed on 12th to 13th day of age, when vaccination is to be done. The maternal antibody titer against New Castle (ND) virus in chicks was 8.3 on day 1, which decreased to 3.5, 1.8 and 0 at 14th, 21st and 31st day of age. The infectious bronchitis virus (IBV) variants such as IBV-QX and IBV nephropathogenic were prevalent in major poultry producing areas of India. The validated concanavalin A based sandwich ELISA showed high rate of correlation with the results of commercially available indirect ELISA. Alternate antibiotic growth promoter containing herbal formulation improved FCR, decreased mortality and improved gut health in Krishibro chicks.

Foot and Mouth disease

Serotype - confirmed 150 FMD incidences were recorded during the reported period in the country. Maximum incidences were recorded from the North eastern region, which was not covered under FMD-CP. In the southern peninsula, maximum incidences were recorded in Karnataka. Andhra Pradesh, Telenganam, Tamil Nadu, Punjab and Maharashtra had no incidence of FMD during the period. Serotype O was responsible for all the incidences recorded during the year. For the first time, there was no incidence of serotypes A and Asia1 in the country

Vaccine matching exercise was carried out to evaluate antigenic relationship of field isolates with currently used vaccine strains to monitor antigenic variation, if any, and to assess appropriateness of in-use vaccine strains. This vaccine strain is able to provide optimal antigenic coverage over the circulating field strains. Phylogenetic analysis based on VP1 (1D) coding region was carried out to assess genetic variations, inter-strain relationships and track movement of the virus. During the year, phylogenetic analysis of serotype O virus revealed extended and exclusive dominance of lineage 'Ind2001' strains. Maximum incidences of FMD



Location of the inserted Asia 1 epitope (red) on the capsid surface of the recombinant chimeric FMD virus ($V^{OR2/1975}$-Asia1-Epi). Outside view (a) and side view (b) of a pentameric subunit in the capsid. VP1 is wheat coloured, VP2 is green and VP3 is cyan coloured.

were recorded during January, February and March, especially in Karnataka, where 30 of 47 incidences were recorded in January and February, and it appears to be extension from one incidence. In May, Asom recorded 9 incidences, which is unusual.

A total of 57 virus isolates (53 serotype O and 4 serotype A) were added to the National FMD Virus Repository. At present the repository holds a total of 2,065 isolates (O-1361, A-323, C-15 and Asia 1-366).

Under National FMD Serosurveillance, 61,297 bovine serum samples collected at random from various parts of the country were tested in r3AB3 NSP-ELISA (DIVA) for assessing the prevalence of NSP-antibody (NSP-Ab) positive animals, which is an indicator of FMD virus exposure regardless of vaccination status. The test revealed overall seropositivity in ~ 22.20% samples/animals, which is comparatively lesser than the previous year's average.

Absorbent cards for FMD diagnosis: Inadequate storage and shipment of suspected clinical samples can compromise the ability to detect and characterise FMDV, thereby, leading to the loss of valuable virological and epidemiological data. A higher proportion of infectious FMDV was rescued from clinical samples collected on FTA® card and subsequent RNA transfection in BHK-21 cells (76%) compared to the conventional cell culture based virus isolation method (56%), suggesting a better performance of the current RNA transfection procedure for rescue of

infectious virus in cell culture. It was possible to rescue live virus by the transfection of RNA extracted from FTA® card impregnated with clinical samples that had been stored at varying temperature (4°–37°C) up to six weeks. The VP1(1D) sequence data and antigenic relationships with the vaccine strains, between viruses rescued by FTA® card fixed RNA transfection and conventional cell culture, were comparable. The results supported the use of appropriate absorbent card for the economic, dry, non-hazardous transport of FMD suspected clinical samples from the site of collection to national/international reference laboratories.

Chimeric foot-and-mouth disease virus: Using reverse genetics, FMDV serotype O IND R2/1975 displaying a FMDV serotype Asia1 B cell epitope at the capsid surface was constructed. The epitope-inserted recombinant chimeric virus was genetically stable up to 10 serial passages in cell culture and exhibited growth properties similar to the parental serotype O virus. Furthermore, the surface-displayed Asia1 epitope was able to react with serotype Asia1 specific antibodies in a competitive ELISA. The recombinant chimeric virus showed neutralizing activity to both serotype O and Asia1 polyclonal antibodies, making this an attractive approach for the design of new generation bi-valent FMD vaccines.

Direct boil RT-mPCR for FMDV detection: A boiling-based RT-mPCR assay capable of detecting FMDV genome in tongue epithelial samples without RNA purification, was developed as an alternative to the expensive and labour-intensive commercial RNA extraction kit. The direct boil RT-mPCR assay allowed far easier, faster and cost-effective detection of FMDV genome compared to the RNA extraction-based assay without affecting the specificity and sensitivity.

Fish

Marine fish production: Marine fish landing during 2016 was estimated by the ICAR-CMFRI, Kochi, as 3.63 million tonnes, asserting an increase of 6.6 % compared to that of 2015. West coast contributed the major share, 64 % to the total landings. Gujarat remained the major producer followed by Tamil Nadu and Karnataka. Landings by West Bengal, Karnataka, Gujarat, Kerala, Maharashtra and Daman and Diu registered a climb, while other states witnessed fall of varying degrees. Pelagic resources contributed 52 % to the total landings with Indian mackerel, oil sardine and ribbonfish as the major contributors. Demersal finfish constitute 29 % with threadfin breams, croakers and *Priacanthus* spp. as the major groups. The share of crustacean landings was 12 % and molluscan resources 7 %. Among the fishing sectors, mechanized sector contributed 82 % of the total landings, followed by motorized sector 17 % and non-motorized sector 1 %. The value of marine fish landings during 2016 at landing centre level was estimated at ₹ 48,381 crore, registering an increase of 20.7 % over 2015. At the retail level, it was ₹ 73, 289 crore with 12.4 % increase over the previous year. The unit price of fish at landing centre was ₹ 133.4/ kg and at the retail market ₹ 201.9.

Tilapia lake virus associated mortalities: Tilapia lake virus (TiLV) is considered as a threat to global tilapia industry. Under National Surveillance Programme for Aquatic Animal Diseases with Lead Centre being the ICAR-NBFGR, TiLV was detected from West Bengal and Kerala. TiLV infection was diagnosed on the basis of RT PCR and sequencing of PCR products

National Centre for Veterinary Type Cultures

National Centre for Veterinary Type Cultures (NCVTC) activities include collection, isolation, authentication and accessioning of microbes of animal and poultry origin. During the reported period, 280 microbial cultures were accessioned in the NCVTC repository. The accessioned cultures include 164 bacteria, 28 viruses, 29 bacteriophages, 10 recombinant clones besides rumen and dairy cultures. The cumulative strength of the accessions in the national repository has reached 3,219 comprising 2,332 veterinary microbes (1,201 bacteria, 198 viruses, 105 bacteriophages, 521 recombinant clones), 354 rumen microbes and 533 dairy microbes.

NCVTC has a repository of about 125 bacteriophages. A novel bacteriophage isolated from river Ganga belongs to family *Myoviridae* and was found to be thermotolerant and pH tolerant. The phage was used for therapeutic trial against *Klebsiella pneumoniae* (MTCC109). The phage was able to completely eliminate established infection in mouse model within 10 days.

Indian Marine Fisheries Code

The Code of Conduct for Responsible Fisheries (CCRF), 1995 sets out international principles and standards of behaviour to ensure effective conservation, management and development of living aquatic resources, marine as well as freshwater, taking into account both the impact of fishing on ecosystems and the impact of ecosystems on fisheries and the need to conserve biodiversity. It is voluntary for a country but its importance has wide consequences. ICAR-CMFRI and ICAR-CIFT jointly developed guidelines to put in practice the FAO's Code of Conduct for Responsible Fisheries (FAOCCRF, 1995), and named it 'Indian Marine Fisheries Code (IMFC)' to give impetus to bring about changes in the manner in which marine fisheries is managed in the country. IMFC explains in detail each sub-article of the FAOCCRF and provides information on how the article can be implemented and by whom. IMFC further proposes several new bodies which are necessary to place fisheries management in the country on an unassailable footing.

and further confirmed by histopathology, infection of fish cell lines and bioassay. Phylogenetic analysis of the partial nucleic acid sequences of segment 3 of TiLV from two locations revealed maximum similarity (96-97%) with Israel strain. This is the first report of TiLV from India. Alerts were issued to State Fisheries Departments and other stakeholders for preventing its spread.

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9. Mechanization and Energy Management

The machinery to enhance productivity and profitability of different farming systems, need-based and region-specific mechanization of production and post-production, and energy management technologies have been developed. These include improved machinery for efficient farm operations, resource conservation, processing; renewable energy technologies; gender-friendly and drudgery reducing tools for women farm-workers; efficient utilization of animal energy for enhancing farmers' income.

MECHANIZATION AND ENERGY MANAGEMENT

Farm mechanization

Tractor operated mulch-cum-drip laying and seedling planting machine: A planting machine, consisting of bund forming unit, fertilizer unit, mulch laying unit, drip laying arrangement, press wheel, punch planting unit and covering device, was developed to carry out all the above operations in a single pass to reduce labour, time and cost as compared to traditional practice. The bund-former forms raised bunds of variable sizes. The fertilizer unit applies fertilizer at the time of mulch laying. The punch planter makes holes in the plastic mulch film and plants seedlings into the soil on the bund. The machine requires 3.6-4.2 l/hr diesel and covers 0.08 to 0.12 ha/hr area.

Tractor operated mulch cum drip laying and seedling planting machine

Tractor operated controlled level puddling system: Controlled puddling helps in maintaining the depth of operation of the puddling machinery by using laser level controller to improve productivity and reduce water consumption. A system of controlled puddling with conventionally available 2WD tractor using a commercially available laser transmitter, receiver and control box was tested. The system covers 0.26 ha/hr. The cost of the modification excluding the laser system and rotary tiller is about ₹ 40,000. The cost of the complete system is ₹ 5.5 lakh and cost of controlled puddling with this system is ₹ 2,300/ha.

Tractor operated controlled level puddling system

Zero till bed planter-cum-residue mulcher: The zero till bed planter-cum-residue mulcher plants maize and wheat on beds (both broad and narrow) under zero till conditions. Inclined plate metering device was used for metering of maize and wheat seeds. After combined harvesting of previous crop bed sown on the residue, first mulched by using mulcher and the next crop is planted in the mulched field condition. This machine is able to form beds with top width and height of 1,200/600/400 and 200 mm, respectively. The optimal speed of planting and mulching is 3.0 and 2.7 km/h, respectively. The field capacity of this machine for making fresh beds and planting is 0.30 ha/h and for reshaping of beds and sowing is 0.45 ha/h. This machine consumes 15 litre fuel for bed making and sowing of 1 ha area. The cost of operation is ₹ 930/h with the precision indices of 0.23 and 0.18 for sowing of wheat and maize.

Zero till bed planter-cum-residue mulcher

Tractor operated cassava stake cutter planter: Planting of cassava is tedious and expensive, usually done manually by women labourers (20 days/ha) by placing stakes in the ridges of ploughed field. A tractor operated single row stake cutter- planter was developed. In laboratory trials, maximum 62 stakes/ min were planted at wheel speed of 1,421 rpm and cutting blade speed of 38 rpm. The average length of stake cut and dia were 16 cm and 31 mm respectively. The estimated cost of the planter is ₹ 95,000 which covers 0.36 ha/ hr@ row-to-row spacing of 90 cm.

Two-row hand cranking type paddy transplanter: The hand cranking type transplanter for root-washed seedlings consists of a seedling tray, seedling picking mechanism, nursery holding and pushing mechanism, nursery shifter-cum-erector, power transmission system, float and handle. The size of transplanter is 550 × 450 × 930 mm^3 with weight of 14.6 kg and costing ₹ 6,500. The field capacity is 0.03 ha/h and cost of transplanting ₹ 2,600/ha (71% less than manual transplanting). The heart rate for male and female workers was 108 and 118 beats/min, respectively. The overall discomfort rating (ODR) was 38 % less than traditional method due to reduced bending posture.

Self-propelled 8 row pre-germinated rice seeder: Pre-germinated rice seeds are broadcast on the puddled soil under wet seeding of rice in most of the developed countries. To mechanize the operation, a self-propelled pre-germinated rice seeder, having cup feed type metering mechanism was developed. The seeder drills seeds in eight rows at a row spacing of 238 mm and hill spacing of 120 mm. The seeder covers 0.25 ha/hr as compared to 0.19 ha/hr for manually drawn 8 row drum seeder. The cost of seeding was ₹ 810/ha.

Hand-held vegetable transplanter: A gender friendly double lever hand-held vegetable transplanter was developed for transplanting of vegetable plug seedlings in soil or plastic mulch bed. For transplanting seedlings, the operator has to lift the equipment with the handle to about 20-30 cm above the soil bed; release it to fall free by gravity and penetrate into the bed by its own weight. A single plug seedling is then placed into the seedling tube to fix the plug/root of the seedling into the pit. The clutch levers are to be pressed by operator simultaneously with upward movement of the equipment to transplant seedlings. The transplanting rate for tomato and chilli with male and female workers was 15 to 17 seedlings/min with two workers.

Mechanical intra- and inter-row weeder for wide spaced field crops: Mechanical control is among the most important classical weed management methods. Mechanical weeding has distinct advantage over chemical weeding i.e. slow growth of weeds and no adverse effect on plant growth. Presently no mechanical weeder is available for intra-row weeding of field crop. Combinations of active and passive tools were used to develop an intra- and inter-row weeder for field crops. Spring tyne (length 260 mm) and sweep (width 250 mm) were used for intra- and inter-row weeding operation, respectively. The intra-row weeding tool rotates around a horizontal axis parallel to the direction of travel, which is positioned directly above the crop row and moves along it. Maximum torque required for operating the intra-row weeding mechanism was 21.6 Nm at a compaction level of 600 kPa. The test results of sweep in inter-rows showed zero percentage of intact weeds. For intra-row, nearly 71% of the weeds were destroyed by uprooting or cutting.

Paddy weeder attachment to six-row self-propelled paddy transplanter: The traditional practice of manual weeding in paddy requires about 300 man-hr/ha, making it labour and cost intensive in addition to human drudgery. To counter these problems a five-row paddy weeder attachment consisting of five flanges with four L-shaped blades on each flange was developed. Test trials after 15, 30 and 45 days of transplanting showed that the operating speed was 0.9 km/hr, width of cut 220 mm and depth of cut 50 mm. The fuel consumption was 1.5 l/hr, effective field capacity 0.1 ha/hr, field efficiency 76% and weeding efficiency 78%.

Paddy weeder attachment to six-row self-propelled paddy transplanter

Low cost SPAD meter: The low cost SPAD meter indirectly measures chlorophyll content of leaves of crops in a field. The SPAD meter is a compact hand held, portable unit and can be plugged to OTG enabled android smartphone for display and data logging of SPAD values. The unit measures the optical density difference at two wavelengths to calculate SPAD value within ± 1 SPAD unit accuracy under normal temperature and humidity conditions. It can measure SPAD equivalent value similar to SPAD meter (with commercial unit costing more than ₹ 1 lakh) at lesser than ₹ 5,000. The SPAD values measured on this unit correlate well to chlorophyll content of the crop. Thus, the developed instrument may be used by the KVKs, SAUs, ICAR Institutes and farmers for indirect estimation of chlorophyll content of crop leaves and subsequent assessment of nitrogen requirement of the crop.

Variable rate vertical boom type air-assisted sprayer: The vertical boom type air-assisted sprayer with sensor attachment was developed to deliver the precise amount of chemicals to match the tree configurations and reduce pesticide use and environmental pollution. During operation, ultrasonic sensor detects the tree, determines its distance from the tip of the sensor, and after receiving signal from micro-controller board the proportional valve opens allowing pesticide flow to nozzles completing the spray. Signal from sensor is sent to micro-controller only after detection of tree, thus nozzle remains shut down when there is no tree canopy. Spraying with variable rate control sprayer significantly reduces quantity of sprayed liquid by 21, 33 and 31% for two- and three-year pomegranate and six-year guava orchards, respectively. These savings can be doubled by spraying on both sides of trees.

Variable rate vertical boom type air-assisted sprayer

Bullock drawn air mist canopy sprayer: A bullock drawn air mist canopy sprayer was developed for control of pests and diseases on tall field crops like cotton, pigeon pea etc. It has two thin high clearance wheels to go through crop rows and provision to adjust them laterally depending on crop spacing. A horizontal and vertical boom consisting of nine spray nozzles target the whole canopy of plants including top and bottom of leaves and stem. The sprayer does not allow improper chemical application underneath the crop canopy, which is a common feature among other sprayers. The trials indicated that discharge rate increased with increase in operating pressure, and discharge varied with type of nozzles. Average field capacity of canopy sprayer was 0.7 and 0.6 ha/h with forward speeds of 2.7 and 2.6 km/hr. For cotton and pigeon pea, the average draft (759 and 769 N), energy requirement (65 and 85 MJ/ha), cost of operation (₹ 355 and ₹ 360/ha), provided saving in time (88%) and operational cost (82%) over manual knapsack sprayer.

Bullock drawn solar powered high clearance sprayer: To utilize available solar energy and save labour, a solar powered bullock drawn high clearance sprayer was devepoed for spraying in cotton and pigeon pea crops. It covers 0.95 to 1.0 ha/hr area and the cost of operation for cotton was ₹ 128 and for red gram ₹ 120/ha. The break-even point and payback period is 123 hr/year and 3.6 years. The percentage monetary and labour saving is 56 and 57 for cotton and 67 and 60 for red gram, respectively.

Tractor-operated front-mounted three-row sorghum harvester: The tractor front mounted hydraulic operated three-row sorghum harvester consists of row dividers, stalk and earhead cutting blades, two sets of conveyors to convey the cut plant in vertical position, windrower conveyor, earhead storage tank, conveyor height adjustment hydraulic cylinders, hydraulic power transmission system and frame. Plant height adjustment is also done. The two-row dividers of the harvester feed the plant to the top as well as bottom conveyor. The plant is gripped in both conveyors, the stalk cutting blade cuts the plant and conveys it in a vertical position. The earhead cutting blade cuts the earhead and drops it in earhead storage tank. The stalk without earhead is fed to the windrower conveyor which conveys the plant and windrow in the field. The cutting and conveying efficiencies of the stalk range from 92-95% to 86-93%, respectively. Similarly, for ear head, the cutting and collection efficiencies are in the range of 83-86% and 77-81%, respectively, at the forward speed of 1.5-2 km/h. Actual field capacity of the machine is 0.23 -0.27 ha/h and field efficiency 80-83%. The cost of the developed harvester is ₹ 400,000 and operating cost ₹ 2,500/ha.

Knapsack type pneumatic cotton picker

Manual cotton picking is cumbersome and time consuming practice requiring 1,560 man-hr/ha. Pneumatic cotton picker was developed and evaluated for saving in labour, time and cost of picking as compared to traditional practice.

The cotton picker with collection drum having circular cotton filter made of wire mesh of 320 mm dia and 550 mm height fixed inside the collection drum vertically on a suitable flange performed the best at 5,200 rpm blower speed for picking efficiency, trash content and output capacity. It has resulted in 3 times increase in output capacity of picker as compared to 9 kg/hr during manual picking. The average picking efficiency varied from 94 to 96%, while the average trash content varied from 5.5 to 6.2% in different pickings. The trash content was less in first picking as compared to second picking due to maturity of crop. The fuel consumption is 0.58-0.63 litre/hr at blower speed of 5,200 rpm. The cost of cotton plucking with knapsack type picker is ₹ 9.66/kg. The saving in cost and time was 36 and 58%, respectively, as compared to conventional method.

Power operated garlic stem and root cutter: The garlic roots and stems from garlic bulbs are traditionally removed manually, with the help of sickle, knives, pruners, axe and scissors. About 5 hr/q is required in manual cutting of both stem and root of garlic bulb by one man. The manual removing of stems and roots

from the garlic bulb is tedious, time consuming, unsafe and laborious process, which increases the production cost of garlic. A cost effective electric motor operated two ways garlic stem and root cutter was developed for reduction of human drudgery with increased output capacity. The power requirement of cutting stem and root is 1.2 kWh. Its capacity with plain type cutter only for one side of the feeder box is 34 kg/h and for serrated type cutter 31 kg/h. The mean cutting efficiency of the equipment is 99.2, 99.1 and 98.9% for small, medium and large size bulbs respectively.

Bullock drawn turmeric and ginger digger for raised bed planting: The bullock drawn digger was developed for digging of turmeric and ginger cultivated on raised beds, and evaluated. The average actual field capacity and field efficiency were 0.2 ha/hr and 81% for turmeric and 0.2 ha/hr and 84% for ginger respectively. The saving in cost of turmeric and ginger digging were 55 and 39 % over traditional ploughing digging method.

Bullock power, rotary mode driven feed-in type sunflower thresher: Rotary mode driven feed-in type thresher was developed for sunflower threshing. It is operated by a pair of bullocks through rotary transmission system. The average output of the thresher is 65 kg/h with threshing and cleaning efficiencies of 99 and 85% respectively. The speed of rotation of the thresher shaft (430 rpm), oscillating screen shaft (360 rpm) and blower shaft (270 rpm) was maintained with the bullock speed of 1.9 km/hr. The overall fatigue score of the bullocks was 13.5 after 1 hr continuous operation, indicating that the equipment could be operated comfortably by them. The average power requirement for threshing is 0.29 kW. The cost of sunflower threshing is ₹ 5.30/kg compared to ₹ 10.40/ kg in conventional method.

Tractor operated sugarcane-cum-potato planter: Tractor operated sugarcane-cum-potato planter was designed and developed for mechanising simultaneous planting of two rows of sugarcane in deep furrows and two rows of potato on ridges as intercrop. Performance of the developed planter was tested in the field in sandy loam soil. Effective field capacity of the planter was 0.127 ha/hr at forward speed of 0.5 m/s. Developed planter saved 511 man-hr/ha (90%) labour and ₹ 10,440/ha (76%) cost of planting compared to conventional manual method. Irrigation water-use efficiency, yield attributes and total yield increased significantly in potato-sugarcane intercropping as compared to relay cropping of potato and sugarcane. Benefit : cost ratio was 2.57:1 in case of mechanized planting with the developed planter, 2.26:1 in manual intercrop planting and 1.84:1 in manual relay cropping of potato and sugarcane.

Settling transplanter: Manual planting of sugarcane settlings is tiresome and laborious as the operation is done in a bending posture for long time. Labour shortage during peak season causes delay in transplanting and related operations which leads to drastic reduction in yields. To overcome all the issues in transplanting a sugarcane settling transplanter was developed. It is equipped with adjustable arrangement for altering row-to-row spacing 90, 120 and 150 cm. The nursery grown with the help of sugarcane bud chips or single buds can be dropped through the metering mechanism by two operators who are seated behind the equipment. The furrow openers open the furrow, in which the settlings with portray mixture or soil are planted with adjustable arrangement for altering depth of planting 2.5 to 7.5 cm. A shoe-type soil opener opens up the soil. The seedling, which is dropped down from the metering mechanism is placed in the opened up soil. The furrow closer which follows the soil opener closes the soil, thereby giving stability to the settling plants. The transplanter will takes 7, 5 and 4 hr at the spacing of 90, 120 and 150 cm, respectively for completing the planting in 1 ha area. The missing of settlings is around 3 to 4% at a working speed of 1.4 km/hr. The plant establishment was more than 95%. The yield and quality parameters are on par when compared with manual planting. The cost of the modified settling planter machine is ₹ 110,000 and the savings in cost of planting is 40 % when compared to conventional planting method.

ENERGY MANAGEMENT

Rapid combustion system for thermal application: A force draft rapid combustion system, comprising a combustion chamber insulated with ceramic fibre blanket, continuous biomass feeding unit with provision for feed control, raiser at the top of the combustion chamber, axial fan for air supply, cladding for thermal safety, and sliding ash bin for easy ash; using briquettes as a fuel source was developed. The unit was tested using 6-8 mm biomass palettes of crop residue (pigeon pea and soybean stalk mixture). The thermal efficiency of combustion system is 35%, as compared to conventional (13%) and CIAE improved (22%) cook stoves of the same capacity. The output of the system was controlled between 5 and 8 kW to suit for cooking and steam generation.

Rapid Combustion System for Thermal Application

Solar powered knapsack sprayer (3 nozzles): Solar photovoltaic (20 W solar panel with 12 DC motor) operated knapsack sprayer was developed for spraying field and vegetable crops over a swath width of 1,050 mm. In this sprayer, lever cranking by operator is not

required unlike conventional knapsack sprayer where the manual cranking is done affecting uniformity of spraying. The tank capacity is 5 litre having field capacity of 0.3 ha/hr as compared to the conventional single nozzle knapsack sprayer (0.11 ha/hr). It also has the benefit of spraying of variable particle size from 5 to 50 micron by adjusting the pressure of nozzles through a valve for spraying on different canopies of field and vegetable crops. Cost of operation of the knapsack sprayer was ₹ 100/ha and the cost of the unit is ₹ 2,500.

Fluidized bed reactor system for bio-oil production: Bio-oil produced from pyrolysis of crop residues is used as fuel oil in boilers and furnaces. Fluidized bed reactor design is the most suitable for higher recovery of bio-oil from crop residues. A fluidized bed reactor developed for 20 kg/hr capacity of biomass for fast pyrolysis comprises main fluidized bed reactor, free board, cyclone, quencher, recycling unit and feeding unit. The system has been evaluated with ground soybean straw and jute stick (particle size of 2 mm). The bio-oil recovery was 37 and 41 % for soybean straw and jute sticks, respectively. During the four months storage, pH of the bio-oil from soybean straw slightly decreased while viscosity increased from 1.43 to 1.74 mPaS. Methanol is better solvent in enhancing storage life than ethanol. Bio-oil from the fast pyrolysis was also synthesized into bio-oil phenol formaldehyde (BPF) resin, a desirable resin for development of phenolic-based material.

Fluidized bed reactor system for bio-oil production

Solar-powered onion curing chamber: An onion curing chamber (200 kg capacity) was developed to remove excess moisture from the outer layers of onion bulbs prior to its storage. The temperature and relative humidity of air inside the curing room were maintained at 30°C and less than 65%, respectively, to maintain quality of onion for good market value. The air was heated using solar air heater and electric heater during sun-shine hours and off-sunshine hours, respectively. Onions were loaded in 20 trays @ 10 kg/ tray. The number of sprouted onions reduced during the curing period. After nine days of curing only about 12% onions sprouted, while for control sample, percentage of sprouted onions increased to 37% with the increase in storage time.

Indirect solar-biomass hybrid system for drying of spices: An indirect type solar-biomass hybrid system of 25 kg drying capacity consists of solar air heater (SAH), biomass combustor-cum-heat exchanger and drying chamber. Cardamom (20 kg) were used for optimizing the drying parameters under varying drying bed thickness (1.0 and 1.5 cm) and air velocities, viz. 8, 10 and 12 m/sec. The drying efficiency of solar-biomass hybrid dryer was 30% as compared to 23 % in conventional biomass dryer. The dried small cardamom in solar- biomass hybrid dryer contained the highest percentage of oleoresin (3%) and volatile oil (7%) by weight when compared with conventional method.

Indirect solar-biomass hybrid system for drying of spices

Use of multi-purpose SORF Machine: An existing machine was upgraded to perform stubble shaving, off-barring, root pruning and fertilizer placement (SORF) operations under trash mulched conditions.

Energy Management

To meet the future requirement of energy and food, an agri-voltaic system was developed in which electricity generation, crop production and rainwater harvesting can be done on a single land unit. Such system of 105 kW capacity was established at Central Arid Zone Research Institute, Jodhpur.

The electricity generated from the system is supplied to local grid through net metering system. About 400 unit of electricity (kWh) can be produced per day from the system. The interspace area and below PV panel area is used for cultivation of crops, which are about 49 and 24 % of the total under the system, respectively. In I season of 2017, moong bean (*Vigna radiata*), moth bean (*Vigna aconitifolia*), clusterbean (*Cyamopsis tetragonoloba*), sonamukhi (*Cassia angustifolia*), *Aloe vera* and *sankhpuspi* (*Convolvulus pluricaulis*) were successfully grown.

Water harvesting system to collect rainwater from top surface of PV module and to store it in an underground water storage tank was also designed and developed in agri-voltaic system. The system of 105 kW capacity installed about 1 acre land has a potential to harvest about 1.5 lakh litres of water from top surface of PV modules in a year at Jodhpur. The stored water will be used to clean the dust deposited on the top surface of PV module as well as to irrigate the crops in the system.

The agri-voltaic system has been installed at the rate of ₹ 49.84 per W_p, thus the cost of installation was about ₹ 52.33 lakh for 105 kW systems. Besides about ₹ 7 lakh cost has been incurred for establishing the rainwater harvesting system and water storage tank. Annual income from the developed agri-voltaic system will be about ₹ 7.5 -8.0 lakh per year.

The use of SORF techniques improved the cane yield up to 30%, NUE by 13% with a net profit of ₹ 50,000/ha (12.6% higher B:C ratio).

Solar systems: Solar pumping systems are less reliant on expensive or unreliable electricity and diesel, and are appropriate to the needs of the marginal (owning < 0.5 ha) and tenant farmers in Eastern Gangetic Plains. Water pumped by solar pumping systems was used for agriculture and for augmentation of the adjoining ponds to be used for fish production. Drip and sprinkler systems of appropriate capacity were used in the fields for ensuring efficient use of pumped water.

Two 3 hp solar pump sets were installed at the farmers' fields in the Bhagwatipur village in the Madhubani district of Bihar. Assessments were carried out on the discharge of the 3 hp solar pump sets in relations with the daily variation in the solar radiation and solar panel angles. The performance of the solar pumping system was assessed at 110°, 180° and variable angle of solar panels. When the panel angle was 180°, the instantaneous discharge reached the maximum value of 1.96 lps at 11.00 A.M. Variable angle (tracking) of the solar panels resulted in the higher volume of water pumped in a day (55.73 m^3/day) as compared to 110° (29.56 m^3) and 180° (54.1 m^3) angles of solar panels. The quantity of water pumped in a day by the solar pump sets was sufficient to provide one irrigation to 0.1 ha of the vegetable cultivation area.

Community-based solar lift irrigation system: A community-based solar lift irrigation system was developed on Kuwari Rivulet, Madhya Pradesh, after increasing existing height of the dam by 1.5 m. Irrigation pipeline was laid in 26 ha of land covering 62 tribal families for minimizing conveyance and application losses of water. The crop yield increased by 61.7 and 45.6%, in *kharif* and *rabi*, respectively, compared with crop grown before installation of solar irrigation system. The income from agricultural crops increased 5-fold due to increase in cropping intensity and productivity. The system also increased the employment of farming operations resulting in reduction of migration. The net income from agricultural crops was only ₹ 6,165/year/family before intervention of irrigation, while it increased to ₹ 32,440/year/household with improved cropping intensity and productivity. Besides, system also generates 10,000 watts electricity through 40 solar panels (each panel of 250 watts) fitted for running of floating submersible pump. The water pumping capacity of 10 hp submersible floating pump is about 50,000 litres/hr. Thus, adoption of such system would also help in conservation of energy and mitigate the climate change. ❑

10. Post-harvest Management and Value-addition

Post-harvest management and value addition is integral to agricultural production for reduction in post-harvest losses, meet consumer requirements, preserve nutritional quality, optimize the utilization of by-products and create employment opportunities. It has the potential to double the income of the farmers. Farmers currently sell raw produce and are deprived of the benefits of value addition to their produce. The current research efforts emphasize on the development of equipment, process protocols and value added products suiting the production catchments and meeting the health requirements of the various sections of the population. The focus is always on development of a number of machines, hand tools, gadgets, process protocols for value added products and their commercialization.

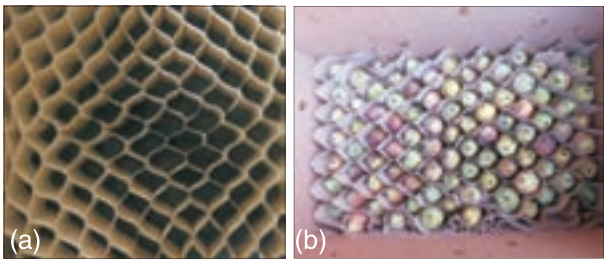
Protein supplements from protein isolate: Protein isolates were prepared from soybean and groundnut. The protein content was 90.9 % (d.b.) and 91.7 % (d.b.) in groundnut protein isolate and soybean protein isolate, respectively. The protein supplements were prepared from isolates by adding other ingredients, sugar 8.5% and cocoa powder 1g/100g. The protein content in protein supplements was 78 to 80 %.

Protein Supplements from protein isolate

Process protocol for extraction and utilization of low methoxyl pectin from citrus fruit residue

***Extraction of pectin from kinnow peel*:** Pectin is widely used in jams and jellies as a gelling agent; and also as a fat substitute in spreads, ice-cream, soluble dietary fibre and *salad* dressings. The fruit, whether used for table purpose or for processing, yields a considerable amount of residue in the form of albedo, flavedo, seeds and fruit pulp. A process was standardized for the production of pectin from dried kinnow fruit waste using organic acid. The process resulted in 10-11% purified pectin as compared to commercial processing (6-7%) using inorganic acid. The process can be applied to any citrus peel with slight modifications. The water: organic solvent mix left after pectin precipitation can be subjected to fractional distillation to recover organic solvent for its re-use and to maintain economy of the process.

***Honeycomb structured packaging technology for fresh fig fruits*:** The honeycomb structured packaging material was designed and developed based on the average size of the fig fruit. The developed machine consists of a paper feeding tray, gum tray and gumming roller. A set of 16 number of papers are cut into strips of desired size (50 mm) and expanded to get the honey comb cavities for placing the individual fruits. The capacity of the machine is about 180 sets/hr and each set could be used for packaging of 20 kg fruits in a CFB box. The honeycomb packaging material was found effective in minimizing the transportation losses (< 2%) in fresh fig fruits and resulted in enhanced shelf-life of 3 to 5 days more compared to the conventional practice of packaging.



(a) Honeycomb structured packaging material (b) Fresh fig fruits packed in honeycomb structured packaging material

Lint opener for preparation of cotton samples for quality testing: A machine for opening up of cotton lint samples for testing micronaire and other quality parameters of cotton was developed. Presently, testing laboratories either employ human labour or use trash analyser for the purpose of opening cotton lint samples for testing. In both of these methods, the extent of lint opening is not uniform or optimum and the speed is also very slow. The Lint Opener gives uniform lint opening at faster rate with appropriate lint opening and without any damage to the cotton fibres.

Mobile fish vending trolley: A Mobile Fish Vending Trolley was developed for marketing fish under hygienic conditions. The trolley is mounted on paddle operated cycle rickshaw for enabling the fish vendors to sell more quantity of fish in a single day and that too in a hygienic way. The trolley costs about ₹ 52,000 and can carry 100 kg fish. The vending unit was fabricated using Fibre Reinforced Plastics (FRP), which reduces the weight, requires lesser draft for motion and enhances

Mobile Fish Vending Trolley

the ergonomics. The specialty of the carriage is that all the facilities and equipment are integrated into it. The main components of the gadget is fish storage chamber, insulated ice-box, water-tank, and fish dressing deck with wash basin, cutting tool, waste collection chamber and tool box and working space. The carriage system was designed considering the maximum weight that a man can pull on rickshaw. The gross weight of the gadget including fish, ice, water, rickshaw and other utilities is 320 kg.

Microencapsulated herbal formulation for mosquito repellent finish

Natural products like citronella oil, clove oil, eucalyptus oil etc. have mosquito repellent properties. Essential oils are complex mixtures of volatile organic compounds present in the plants. Microencapsulation is one of the methods used to trap the active agents present in the essential oil using wall materials like modified starch, gum acacia, sodium alginate etc. and then applied on the textiles. The citronella oil was microencapsulated using complex coacervation technique using gum arabic as wall material. The average size of the microcapsules was in the range of 300-600 nm in size. The citronella based microcapsules were applied on cotton fabric using pad-dry-cure technique using a binder. SEM analysis showed uniform distribution of capsules on the cotton fabric. The treated cotton fabric showed 100% mosquito repellence with finish durability upto 5 washes.

Single locking cotton feeder for double roller gin: Cotton feeding mechanism to Double Roller (DR) gin significantly affects the ginning efficiency. Therefore to improve the feeding, an automatic single locking cotton feeder which regulates feed rate to optimum and ensures single locking of cotton and feed continuous batt of cotton at the ginning points across the knife edges of DR gin was designed. Prototypes of single locking cotton feeder with three designs have been developed.

Cotton rich blended fabric for active wear: A novel product using the blend of cotton and bamboo viscose fibres was produced with multifunctional properties such as smoothness, softness, antimicrobial properties and UV protection ability. The unique *in-situ* synthesis and fixing process of antimicrobial agents within the fabric structure results in enhanced durability of finish that lasts upto 30 washes. The produced garment has better smoothness, softness along with good moisture transport properties. This T-shirt can be used as a leisure wear as well as an active wear.

Cotton, bamboo viscose and PLA fibres: The fibres were spun into yarns using compact ring spinning machine to a count of 40s. The tri-component blended fabric has the functionalities of improved smoothness and softness with better moisture wicking ability suitable for use as high end casual wear. The product produced is environment friendly when compared with conventional ones.

Speciality grade paper pulp technology: The CIRCOT developed a technology for preparing pulp from cotton and linters to produce security grade paper. The properties of the pulp developed through the institute technology are as follows:

Parameters	Requirement as per security paper mill, GOI	Paper from CIRCOT technology
Freeness (°SR)	50-55	50-55
Grammage (gsm)	90	90
Tensile strength (kgf/15mm)	6.0	6.5
Brightness (%)	84.0	84.0
Bursting strength (kg/cm^2)	2.5	3.5
Double fold (nos.)	1200	3000-3500

Tamarind processing unit: The tamarind processing unit, with user friendly mechanism, was developed. This processing unit is equipped with instruments/ machines, viz. tamarind de-huller, pulveriser, seed decorticator and hot air oven, for processing tamarind pod to tamarind kernel powder (TKP).

Value-added products of millets: Six millet-based value-added products namely, pongal mix, idli mix, instant upma mix, *ragi* vermicelli, *ragi* cookies and millet *rava* were successfully developed and commercialized which resulted in augmented demands throughout the country.

Tobacco seed oil: Tobacco is one of the important commercial crops grown in India. Leaf is being used for conventional consumption (Smoking or chewing) purposes. Apart from that, oil from tobacco seed (~35%) is having nutritive, and industrial value, that can be commercially exploited, which will give additional benefit to the farmers.

Tobacco seed oil refinement was carried out by CTRI in collaboration with IICT, Hyderabad. Refining technology, viz. temperature, solvent to seed ratio and time on extraction of oil were standardized with final colour of 12.0 (8Y, 0.8 R), low content of free fatty acids and absence of phosphorus. The quality of tobacco seed oil is better than that of sunflower oil and can be equated with that of safflower oil quality.

Acute pre-clinical toxicity evaluation of tobacco

seed oil (crude and refined) by oral route was carried out in collaboration with National Institute of Nutrition, Hyderabad. The tobacco seed oil (crude and refined) was administered orally to rats at a concentration of 7 ml/kg body weight which was 2.5 times higher than the Recommended Dietary Intake. The test results clearly indicated no adverse effect on (i) pre-terminal deaths, (ii) no significant effects on body weight gain; (iii) normal clinical and behavioural signs, and (iv) no gross necropsy changes in organs collected.

Some of the tobacco varieties have the seed yield potential of 1,200 kg. The total oil output @ 35% is 420 kg/ha. The income that can be realized was ₹ 21,000 which is an additional income apart from leaf, i.e. ₹ 6,5000/ ha.

Tobacco stalks biochar : a potential soil amendment: Tobacco Stalks Biochar (TS Biochar) is a value addition to the tobacco stalks biomass which is otherwise discarded as a solid waste or burned off in heaps. The optimum conditions for preparing the tobacco stem biochar were 500^0C for 90 min. Total organic carbon and N content of the biochar was around 800 g/kg and 12.3 g/kg, respectively and the CEC is 30 C mol (p+)/kg. The per cent inhibition of leaching of applied ammonium and potassium by tobacco stalk biochar in light textured soil was 28.1 and 25.3%, respectively. Experimental results under field conditions revealed that application of TS Biochar (1 tonne/ha) coupled with 100% RDF not only improved tobacco productivity but also caused a significant enhancement in crop nutrient uptake and use efficiency of applied nutrients over 100% RDF alone.

Tobacco Stalk Biochar

POST-PRODUCTION MECHANIZATION

Vegetable mixed-wadi making system: The machine is fabricated with an overall dimension 1.40×1.20×1.10 m^3 with food grade stainless steel body. The outer width of tray table is 300 mm on which five nozzles are pointed to facilitate five droppings of wadi batter in single stroke. The capacity of machine is 150 kg/hr (with each wadi dropping weighing about 5g). The capacity can be increased, if dropping size increases. Different shapes of wadi can be made by changing the shape of the die.

Women-friendly semi-automatic fish cleaning-cum-dressing system: Fish cleaning-cum-dressing station was developed which can be operated either manually by foot or mechanically by electricity. It consists of (i) dressing table (100 mm × 48 mm × 120 mm) (ii) round cutter, (iii) water spraying system, (iv) motor 1/10 hp (9,400 rpm) and PVC pulley (dia 200 mm), (v) foot rotor and pulley (dia 530 mm), (vi) liquid waste disposal and filtration system, (vii) solid-waste disposal system. The machine is useful for steak cutting in fish retail shops and processing plants. The capacity of the machine is 2–3 kg fish (carps)/min.

Mechanical dried chillies compaction-cum-bagging machine: Good packaging of chilli facilitates convenience in transportation and storage and also attracts consumer to pay more. The packaging reduces the marketing cost and protects the quality. Limitations of conventional method are low productivity (3 persons can do only 8 bags/hr trampling and bagging of dried chillies), unhygienic, sometime water is sprinkled on top of chillies to reduce inflammation to feet and involvement of drudgery and pungency during trampling and packing. Hence, to reduce the drudgery involved in the bagging of the dried chilli operation, a mechanical dried chilli trampling-cum-bagging unit having capacity of 20-25 bags/ hr was developed. It saves about ₹ 11/bag.

Turmeric value chain machinery

Turmeric washer: Currently turmeric is harvested and boiled without washing. This practice reduces the efficiency of boiling operation and results in poor quality of turmeric. To overcome this issue a continuous type washer was developed. The maximum efficiency of 99% was obtained at 40 rpm drum speed, 30° inclination and 360 lpm water flow rate.

Turmeric cooking vessel: A vessel of 100 kg capacity suitable for pressure steaming of turmeric was developed. Using the improved cooking vessel 100 kg of turmeric can be boiled in 10 min. compared to 15 min as in conventional cooking vessel.

Turmeric dryer: A batch type agricultural waste fired rotary dryer of capacity 500 kg was developed. Rotary drying of turmeric rhizomes reduced drying time and shrinkage, thus improved the colour of dried turmeric. Complete drying of turmeric was achieved in 30 hr with an air temperature of 70°C and air velocity of 3 m/s and 9 rpm drum speed, respectively, wherein conventional drying takes about 2-3 weeks. During drying, 70% polishing of rhizomes can be achieved, which minimizes qualitative and quantitative loss.

Turmeric polisher: A batch type polisher with 500 kg capacity was developed. To reduce the dust emission the polisher drum was covered by a flexible hood. The dust produced during polishing of turmeric rhizomes in both conventional and dust proof turmeric polisher was recorded. Inhalable and respirable dust concentration was 9.10 mg/m^3 and 4.26 mg/m^3 respectively during polishing with conventional turmeric polisher. In dust free turmeric polisher the

inhalable and respirable dust were 0.007 mg/m^3 and 0.011 mg/m^3 respectively. Only little air-borne particles floated at the rhizomes-discharge end. Pollution resulted from polishing of turmeric rhizomes could be controlled up to 99.4% with the collapsible dust cover.

Value added products

Kalpa Krunch is an extruded snack from coconut, prepared by incorporating coconut milk residue along with rice (60%) and corn flour (25%). The flavours have been formulated with different spices and vegetables (coriander, garlic, turmeric, clove, cinnamon, chilli, mint, cardamom, tomato and celery). Kalpa Krunch is rich in dietary fibres, protein, fat and carbohydrate, and high in antioxidant activity. It is crispy and puffy in nature.

Kalpa dark chocolate is a coconut sugar-based dark chocolate purely from plant-based ingredients without any dairy ingredients. It contains cocoa powder, coconut sugar, natural vanilla extract and GMO free sunflower lecithin. It is low in glycemic index and does not contain any added artificial ingredients. It can be stored under room temperature and does not melt. It is available in 30 g slabs.

Kalpa drinking chocolate is an instantized blend of low GI coconut sugar, crafted from fine cocoa powder formulated to produce delicious drinking chocolate. The product is produced by a unique technology of instantisation and agglomeration technique that makes the product soluble instantly in hot or cold milk releasing the chocolate aroma. The product is filled in 200 g PET jars duly sealed.

The VCO cake-based muffins is a formulation of muffins made by replacing refined wheat flour (RWF) with virgin coconut oil-cake. The standardized formulation contains VCO cake (15.6 g/100 g), RWF (10.4 g/100 g), sugar (26 g/100 g), egg (21 g/100 g), full fat milk (13g/100 g), shortening (12 g/100 g), sodium bicarbonate (1.1 g/100 g) and salt (0.1 g/100 g). It is enriched with protein (8.49 g/100 g), fat (18.46 g/100 g), crude fibre (1.14 g/100 g) and minerals (1.15 g/100 g).

A coconut water-based jelly has been prepared with the addition of a gelling agent. The heating regimen was optimized at 85°C for 10 min. Mature coconut water, obtained during the production of copra, virgin coconut oil, coconut milk and desiccated coconut powder, can also be used for the preparation of jelly. It contains 73.3 g moisture, 12.8 g total sugar, 0.2 g protein, 171.1 mg potassium, 1.5 mg vitamin C and 16.2 mg GAE phenolics.

The fruiter of Goma Priyanka *jamun* treated with calcium chloride @ 1.5% and kept in zero energy cool chamber recorded 4 days shelf-life against 2 days at the control with comparatively better fruit quality. However, zero energy cool chamber alone recorded 3 days shelf-life.

Wine lees dead or residual yeast and other particles that precipitate obtained from 10 different grape varieties were evaluated for functional and nutritional properties. Lees from Cabernet Sauvignon had maximum tannin (11.98 mg/g) and anthocyanin (840 mg/g) contents. Similarly, pomace collected from red grape varieties was rich in functional components like phenolics, tannins and anthocyanins. Pomace obtained from Medika was rich in phenolics (44 mg/g), tannin (39.61 mg/g), and anthocyanin (78.39 mg/kg). Cookies

Success Story

Kusmi lac-cultivation on *ber* transforms livelihood of tribal farmers in Asom

Dhemaji district of Asom has a huge population of other backward classes and schedule tribes. Missing Autonomous Council (MAC) observed large number of *ber* trees in this district and approached Indian Institute of Natural Resins and Gums (IINRG), Ranchi, for the economic use of available *ber* trees. The IINRG planned, designed and executed the scientific interventions through lac cultivation activities. At various platforms, discussion were made with the local representatives, farmers, processors / manufactures / wholesalers, traders, experts and other concerned officials to promote lac cultivation activities in the area. Workshops, trainings, field demonstrations, exposure visits and interactive sessions for feedback were conducted to enhance the knowledge of farmers on scientific lac cultivation on *ber* trees and improving livelihood through the use of available *ber* trees. MAC initiated pruning process in July 2014 and tender shoots were ready for inoculation in January 2015. Ten quintal *kusmi* broodlac was inoculated on 3,000 *ber* trees at various places of Dhemaji and Chirang district of Asom. Simultaneously, about 5,000 lac host trees were pruned.

Experts from IINRG executed crop monitoring and provided technical support and diagnostic services. Various activities like baseline survey of potential areas, selection of trees at a site, training and technical guidance, exposure visits, pruning, backward market linkages for broodlac and pesticide supply, selection of broodlac, bundling of broodlac, broodlac treatment through dipping method, timely inoculation, *phunki* removal, forward market linkages for disposal of the output, spraying, harvesting and scraping or self-inoculation were introduced among the stakeholders. Resource poor tribal farmers became confident in lac cultivation after these interventions and were able to harvest a good crop without affecting other activities. Low input based lac culture may be a promising activity for additional income.

Farmers were exposed to various modern management practices and trained in package of practices of lac cultivation activities, and care and maintenance of broodlac in new systems. The interventions added average annual ₹ 5.0 lakh to ₹ 8.0 lakh during 2015-16 and 2016-17. Enthused with the results, the Bodoland Territorial Council, The Karbi Anglong Autonomous Council, other Councils and TRIFED showed the interest for interventions through scientific lac cultivation activities during the reported period.

Scientific lac cultivation activities were introduced in the tributaries area of river Brahmaputra to utilize the broodlac carrying capacity of existing lac host trees. This enhanced income in the partner villages as compared to pre-intervention period.

Kokum

The osmotically infused *aonla* segments in kukum juice (4-5 kg *aonla* fruits and 1 kg sugar for 1 kg osmotically dehydrated segments) having combined qualities of both fruits, easy to eat with good natural red colour, flavour and texture were prepared. The dried product (moisture 12-14%) is microbiologically safe and meets the dehydrated fruit requirements standards of FSSAI.

prepared from Medika pomace also had highest anthocyanin (56.34 mg/kg) and antioxidant property (225.2 mg/g). Pasteurized juice of Medika could be stored upto 4 months without any change in colour intensity and sensory characters. Minor decline in these properties was observed after four months.

The seed samples were pre-treated in microwave oven at microwave power levels of 360, 540, 720 and 900 watt for pre-treatment time of 30, 60, 90, and 120 s. Oil was extracted with three levels of extraction time (3, 4 and 5 hr). The extraction yield increased with increase in wattage and pre-treatment time. Microwave pre-treatment did not affect oil quality parameters such as per cent free fatty acid, acid value, saponification value, ester value, per cent glycerin and antioxidant capacity. Microwave pre-treatment on pomegranate seeds showed disruption of aleurone cell, loosening of cell walls containing lipid body and release of lipid bodies. The optimum conditions for microwave pre-treatment were 720 watt, pre-treatment time of 60 s and extraction time of 4 hr.

Dried guava (pink fleshed) slices with 15% moisture were packed in plastic punnets and can be stored at room temperature between 6 and 12 months. About 7-8 kg ripe guava fruits and 2 kg sugar is required to prepare 1 kg of dehydrated slices.

Papaya fruit bar has been prepared by reducing water content in pulp and using the same for bar making with very good appearance and taste. It is safe and meets dehydrated fruit requirements standards of FSSAI. Ten kg of fruit pulp gives 2.5 kg of fruit bar. This technology has potential to encourage small-scale processing units in rural areas.

The technology consists of pre-treatment of freshly harvested, trimmed coriander leaves with 50 ppm kinetin and packaging using 25ì, semi-permeable polypropylene film for coriander cv. Arka Isha. The product has 21 days shelf-life at 8°C.

The technology consists of treating freshly cut carrot slices/cubes/ sticks with edible coating (pectin), air drying and packing. The product has 21 days shelf-life at 8°C storage.

The technology has potential to prevent browning of cucumber rings with a shelf-life of 6 days at 8^0C and consists of pre-treatments of freshly-cut cucumber with ascorbic acid and packaging using semi-permeable cling film.

The garlic cloves are pre-treated in hot water and packed in BOPP films or equivalent and high humidity and modified atmosphere is maintained. The product has a minimum 3 days shelf-life at ambient temperature (approximately 28ºC), and upto 15-18 days at low temperature storage (8ºC). It reduces problems of sprouting, browning and softening of garlic cloves.

A technology for extension of shelf-life of small (300 g ± 10%) and large (900g±10%) broccoli upto 49 days by packing in 30µ Flexfresh™ biopolymer in modified atmosphere storage (3ºC with 90-95% relative humidity) was standardized.

Potato starch-based films were prepared with varying concentrations of antimicrobial agents. Thus, potato starch cannot only be used for film making, but can also be utilized as replacement of polypropylene due to its higher strength. The assessment of physiological and pathological observation showed mean total of 2.75 and 6.13% losses during harvesting and at curing, sorting, grading and packaging stages, respectively. Mean losses during storage in heaps following farmers' practice without CIPC treatment up to 90 days (12-31°C, 58-78% RH) were higher (21.05%) due to prevailing high temperatures and low humidity. Losses were minimum (3.77%) due to potatoes stored at 10-12 °C up to three months, followed by 5.28% at 2-4 °C up to 6 months of storage. The results also confirmed that potatoes treated with CIPC may result in lower losses even during transportation and marketing.

Natural gums and resins: Agroforestry models (four at farm and two at farmers' fields) based on gums and resins yielding trees for livelihood security, sustainability and horizontal dissemination of technologies were established. The performance of *Acacia nilotica* was better than *Acacia senegal* on farm, however, at farmers' fields *Acacia senegal* was better. The *A. nilotica* (40.2 g/tree) and *A. senegal* (58.7 g/tree) planted at farm started exuding gum after 5 year, whereas gummosis in *A. senegal* at farmers' fields was observed after 7 years. Gum tapping techniques of *Butea* were standardized. Out of four types of incisions, simple knotching yielded maximum gum.

Gum production technology for additional income in arid region

Under natural condition, about 10-15 g gum arabic is generally harvested from each tree of *Acacia senegal*. Gum arabic is considered as the best edible gum and is used in preparation of variety of sweets, confectionary items, ice-cream, herbal medicines etc. And, commands high market price (₹ 1,000-1,200/ kg). A technique was developed, which enhanced gum production by more than 10-time from each tree. The technique is widely accepted by farmers. In last decade, farmers in more than 45 target villages have earned additional income of more than ₹ 4.32 crore through the sale of gum arabic. During the reported period, *A. senegal* trees (20,180) were treated by CAZRI gum inducer resulting in production of approximately 8.72 tonne gum arabic.

SUCCESS STORIES

A cooperative venture to large-scale goat farming in Uttar Pradesh

Mohd. Mujassim of Muzaffarnagar (Nansurpur) Uttar Pradesh along with friends decided to start a large-scale goat farm. After visiting CIRG, Makhdoom, Uttar Pradesh in December 2015, their motivation level gets higher and found more possibilities in the sector. After proper training at CIRG, they invested about ₹ 25 lakh in INDIAN GREEN FARMS (goat farm). *Pucca* shed with all necessary facilities was constructed as per CIRG model. Sirohi, Jamunapari and Barbari goats were purchased in three phases from Kanpur, Ajmer and Nagaur. Upto March 2017, 200 kids were born (80% twins, 5% triplet and 15% single) at farm. Kid mortality (less than 15 days age) was higher in early days but CIRG intervention led to reduce mortality below 5%. Animals are reared under semi-intensive condition with 3 full-time and 2 part-time labours. Preventive measures were adopted at farm. Goat dung is used in agriculture farm. *Bakri Id* was target market and 50 animals were sold at average price of ₹ 12,000/goat with range of ₹ 8, 500-26,000. Body weight of the animals varied from 32 kg to 57 kg. Net benefit per goat was calculated as ₹ 7,500. Major constraints faced were vaccine availability, local veterinary aid and trained manpower. They are planning for expanding the farm for 200-500 goats during next year and play an active role in secondary goat farming sector.

For inducing more gummosis in *Butea* trees, application of 390 ppm ethephon as spray on tree surface before knotching was most effective. Similarly, maximum gum exudation in *Anogeissus pendula* was observed with application of 1,170 ppm ethephon as injection at the base of tree trunk in October. To provide alternative livelihood option to people of poverty stricken Bundelkhand, studies were undertaken to cultivate lac along with tapping gum from *Butea*. Simultaneous production of gum and lac yields more gum (251 g/tree) but less lac (1.3 kg/tree) compared to sole gum tapping (75.3 g/tree) and lac cultivation (2.1 kg/tree). The B:C ratio of lac cultivation was 1.82. Survival of lac insect on *Butea* trees during hot summer is a challenge in Bundelkhand and complete mortality of lac insect was noticed, if temperature goes beyond 45°C coupled with relative humidity below 12%.

***Prosopis juliflora* pod-based mixture to cattle**: A low-cost balanced concentrate mixture containing *Prosopis juliflora* pod powder, *guar* (*Cyamopsis tetragonaloba*) *korma*, *til* (*Sesamum indicum*) seed-cake, wheat-bran, maize grain, common salt and mineral mixture was tested at farmers' fields. The balanced concentrate mixture had 20% crude protein and 73% total digestible nutrient (TDN) and costed ₹ 2.75/kg only. The cattle were fed with *Prosopis*-based concentrate for four months. An increase in milk yield of 6.14% over the control was recorded which provided a total benefit of ₹ 11,733 to farmers.

Milk

Paper strip for rapid detection of pesticide residues in milk: The existing conventional chromatographic methods (LC/GC-MS) are time-consuming and laborious. Currently, new standards for pesticides have been developed by FSSAI and implemented for regulatory compliance in different food products including milk. For routine monitoring of pesticides under field application, spore enzyme sensor on paper strip has been developed based on 'spore germination and enzyme inhibition principle'. In case where analyte i.e. pesticide is absent, specific marker enzyme (s) are produced by spores during germination which will act specifically on chromogenic substrate resulting in coloured end product on paper strip, whereas complete inhibition of marker enzyme will take place when pesticides are present in food sample. The developed sensor (Application no. 3819/ DEL/ 2015) is a novel alternative IP and has been protected. Strip sensor is rapid, cost effective, reproducible, selective and sensitive to larger groups of pesticides at their regulatory limits. Sensor has been connected with milk successfully through novel extraction process and can be applied in dairy industry after its comprehensive validation.

Milk protein-nanocellulose based biodegradable packaging material: Packaging dairy products made up of Sodium caseinate and starch as composite film forming material, was studied. Cross linking (formaldehyde) and reinforcing (nanocellulose) agents were also used to improve the mechanical properties. Hard grade *sandesh* packaged in polystyrene trays and sealed with bionanocomposite film (sodium caseinate-starch-formaldehyde and nanocellulose) was acceptable at the end of 10 days of storage at refrigeration temperature.

Caseinophosphopeptides mineral complexes: Caseinophosphopeptides (CPPs) are multifunctional bioactive peptides derived from milk casein. A new method for enrichment of CPPs along with mineral (iron and zinc) was developed FTIR spectroscopy and UV-Vis spectroscopy confirmed the structural modification upon mineral binding with CPPs. CPP-mineral complexes were stable at different processing conditions.

LC-MS-based method for typing of A1 and A2 milk

An LC-MS-based method was developed for measuring the intact mass of β casein variants (A1 and A 2 type) in milk on the basis of 40 Da mass differences. This method studies the patterns and masses of the casein proteins in cow milk. The caseins are extracted from milk with a denaturing 8 M urea protocol, which breaks apart the micelles and solubilizes the proteins. Chromatography of proteins in urea extract separates the various phosphorylated variants of α, β and kappa forms of casein. Other non-casein proteins from the milk are also observed. Peak identification is based on the protein masses in the deconvoluted spectra.

The *in-vitro* caco-2 cell model established the effectiveness of these complexes to increase the bioavailability of mineral as compared to mineral salt. CPP-Fe complex showed 80.47% uptake significantly higher than inorganic iron salt (48.26%) and inorganic zinc salt showed 61.46% uptake much lower than CPP-Zn complex (89.12%). The CPP-Fe complex significantly increased ferritin synthesis (41.82 ± 0.79 ng of ferritin/mg cell protein) in caco-2 cell as compared to iron salt (13.54 ± 0.32 ng of ferritin/mg cell protein). These samples were also able to increase serum mineral level in rat model during replanishment in CPP mineral fed group as compared to their respective inorganic salts fed group. The antioxidative enzymes viz. catalase, superoxide dismutase activities in liver homogenate increased significantly in CPP-Fe and CPP-Zn complex fed groups as compared to their inorganic salts fed group.

Naturally fruit flavoured camel milk: A naturally flavoured camel milk having freeze dried sapota fruit powder at 5% level was found to have better physicochemical, sensory and antioxidant properties with better storage stability in aerobic packing condition at refrigerated condition compare to 3 and 7% enrich sapota fruit powder-based natural camel milk. The product with 5% level has better overall acceptability score.

Milk and meat products

- Developed PCR assay using species-specific primers to detect adulteration of more than 5.0% cattle/buffalo tallow into milk fat (cow *ghee*).
- Developed Taqman real time PCR assay for detection of DNA from cattle and buffalo tallow at 1% level.
- Developed in-gel and OFFGEL-based proteomic method for authenticating raw and cooked water buffalo-sheep- and goat- meat and their mixes. The study demonstrated that authentication of meat from a complex mix of three closely related species requires identification of more than one species-specific peptides due to close similarity between their amino acid sequences.
- Isolation of DNA from sarcocysts extracted from buffalo-meat/oesophagus and PCR-RFLP showed the presence of *S. fusiformis*, *S. taeniata* and *S. buffalonis*. The zoonotic *S. hominis* could not be established in the survey.

SUCCESS STORY

All-weather biogas production exclusively from poultry excreta

Industrialization and intensification of poultry farming has led to generation of poultry wastes to the tune of 28 to 30 million metric tonne/annum. These wastes are posing many environmental and health threats due to lack of proper utilization technologies/ disposal methods. A novel 'DAC' *technology* was developed for all-weather biogas production exclusively from poultry excreta. This technology was tested on a pilot biogas plant comprising anaerobic digester (200 litre) with various common components like inlet pipe, outlet pipe, gas collector, biogas compressor, gas cylinders etc. The poultry biogas burns like LPG with blue flame. The composition of poultry biogas revealed that the methane (%,V/V) was 60.02 which is equal to or better than biogas available from other methods and substrate.

The signifying point of this technology is that only poultry excreta is required for biogas production. There is no need to add cow-dung, which is commonly being mixed for biogas production from poultry excreta in other methods. This technology also helps in conservation of water as used slurry of digester is reutilized again and again as dilutor for poultry excreta. Round the year i.e. both during summer and winter biogas production is possible from this technology. It is pertinent that most of the biogas plants in India become non-functional during winter due to lower ambient temperature. In 'DAC' technology 12-13 to 19-20 kg poultry excreta is required for production of about 1m^3 of biogas during summer and winter, respectively. This quantity of biogas is sufficient for cooking three meals of an average family of 4-5 members. This can also be used as heat source at poultry farm. Spent slurry of poultry biogas has good manure value and germination potential and can be easily applied in agricultural fields for organic crop production without burning effect on plants which is a common problem with crude poultry excreta.

This technology may be helpful in self-sustainability of rural poultry farmers in terms of their energy demand. The excreta of 5,000 layer birds has capacity to produce approximately 4,100 kg biogas/annum whose market value will be around ₹ 1.31 lakh, if cost of biogas is considered @ is considered ₹ 32.00/ kg. There is potential to produce around 128 tonnes of manure from spent slurry. The value of this manure will stand around ₹ 2.56 lakh on urea, phosphate, potash and micronutrient equivalence basis. Therefore, this technology has great potential of value addition to the tune of 5-6 times from invaluable poultry excreta. Besides, generating the financial gains to the poultry farmer, this technology has enormous positive impact on environment by drastically reducing pollutants, bad odour and flies thereby also helping in accomplishing the '*Sawachch Bharata* Mission'.

Meat

Plant-based quality and time-temperature indicator sensors were developed to assess the change in quality and temperature abuse conditions of chicken meat stored at different temperatures. The visible colour changing pattern in the developed sensors was highly correlated with the changes in quality parameters.

Mutton cookies: They are rich source of proteins and energy and were prepared with 34% mutton. The ratio of meat and binders is kept at 40:60. The binders include all-purpose flour. The other non-meat ingredients were added over and above total meat and binders. The product is shelf-stable and can be stored at room temperature. The sensory evaluation of the product revealed high overall acceptability i.e. from extremely like to very much like by the panelists on 8-point hedonic scale.

Goat-meat nuggets: Effects of *aonla* and curry leaves extracts incorporation by 1 to 2% was evaluated on the physicochemical, colour, textural, sensory characteristics as well as storage stability of goat-meat nuggets. Goat-meat nuggets with *aonla* and curry leaves extracts received significantly higher organoleptic scores as compared to control. The colour characteristics of products with *aonla* and curry leaves extracts showed higher stability than control during aerobic refrigerated storage. Products with *aonla* and curry leaves extracts showed significantly higher resistance to lipid peroxidation when compared to control. *aonla* extract was more protective against lipid peroxidation of the products than curry leaves extract.

Spent hen meat: Value-added chicken meat products (chicken meat chips and chicken meat waffles) were developed utilizing tough spent hen meat incorporating whole grain flours, fruit by-products and natural antioxidants (Oregano, Basil and Vitamin-E). These products contained higher content of dietary fibre, total phenolics, α-carotene and α-tocopherolacetate which exerted health benefits in animal model trials in terms of reduced blood LDL-cholesterol and total cholesterol and had higher HDL-cholesterol level and antioxidant enzymes activities.

Lactobacillus plantarum, one of the most effective probiotic bacteria which is known for its antioxidant and antimicrobial property, exerted antimicrobial action against *E. coli* and *Salmonella typhimurium* in tryptic soy-broth at temperatures of 18°, 20° and 22°C in chicken suasages.

Calpains (μ and m) are the key proteolytic enzymes of calpain system that greatly influence the tenderness of meat. So, based on the activity of μ-calpain the post-mortem ageing for meat from different species of animals was standardized.

Quilt from coarse wool: Processing technique was developed for the preparation of light weight quilt using coarse wool. This quilt of a size 7ft × 5ft (2.1 m × 1.5 m) has a total weight of 975 g. For the preparation of quilt, first a sheet of coarse wool was prepared and then it is laid inside a cotton cloth and stitched manually. Closely woven compact fabric is used to reduce the protrusion of fibres through fabric surface. The thermal insulation value of coarse wool assessed using thermal conductivity apparatus showed that it has Tog value of 3.23. This showed that the prepared quilt is useful to protect the user from cold during winter. It's cost is 2.5-fold lower than cotton quilt.

Organic Animal Husbandry

Organic certification of fodder was carried out and after due inspection and auditing, third year organic scope certificate was awarded for the fodder as per the NPOP standards of India. NRC on Meat developed the protocols for organic sheep production and recently received organic livestock certification from Organic India.

Wool

Home furnishings: In the country, 34% of wool produced comes from southern states and majority of this wool is of coarse quality with diar >40µ. Coarse wool is difficult to spin due to high fibre dia, high bending rigidity and torsional rigidity. To mitigate this problem, a braiding process technology was developed for the use of coarse wool in preparation of furnishing items like picnic mat, yoga mat, doormat, bathmat and handle for bags. In this method, coarse wool is hand twisted and sliver is prepared. This sliver is fed into the core of the machine and covered with wool/polyester/nylon for making braided cord. The braided cord is hand sewn to convert into doormats, bath mats, picnic mat and yoga mat.

Yak hair with jute fibre

Blend of yak coarse hair with jute was used to manufacture various value added products like Jackets, cardigans, bags, file folders and table runners.

Organic manure using poultry excreta: The best C:N ratio for aerobic composting of poultry excreta during winter was 30:1, which resulted in organic manure having NPK value (%) of 2.15, 2.05 and 3.91, respectively, with very less TBC and *E. coli* count, about 70-72% germination potential and value-addition to the tune of 2.25-time based on fertilizer value.

Chitosan for oil reduction in battered and breaded fish products: Chitosan is a natural polycationic linear polysaccharide derived from partial deacetylation of chitin from the exoskeleton of insects, crustaceans (mainly shrimps and crabs) and cell walls of fungi. Due to its muco-adhesive properties, it has been used in the form of micro-/nano-particles, polyelectrolyte complexes or coatings as antibiotic encapsulation systems. Chitosan's use as a hydrocolloid in batter to enrobed fish fingers was evaluated by CIFE.

Fatty acid profile of important food fishes

Omega-3 (w-3) polyunsaturated fatty acids (PUFAs) namely, eicosapentanoic acid (EPA) and docosahexanoic acid (DHA) play significant roles in human health. Fishes are important source of both EPA and DHA but their quantity varies from species to species and season to season. To assess the EPA and DHA levels of important food fishes, the CIFRI carried out fatty acid profile study of important food fishes of India. In this context among the fish species studied *Tenualosa ilisha*, *Sardinella longiceps*, *Nemipterus japonicus* and *Anabas testudineus* are the fish species which are very rich sources in DHA and EPA and can be considered of immense utility in public health nutrition.

Food fishes classified based on their fat content

Lean fish (<2% fat)	Low fat fish (2-4% fat)	Medium fat fish (4-8% fat)	High fat fish (> 8% fat)
Finfishes: *Euthynnus affinis, Ailia coila, Rastrelliger kanagurta, Rita rita, Katsuwonus pelamis, Stolephorus commersonii, Stolephorus waitei, Epinephelus* spp., *Sperata seenghala, Xenentodon cancila, Thunnus albacares*	Finfishes *Leiognathus splendens, Oncorhynchus mykiss, Clarias magur, Trichiurus lepturus,Mugil cephalus, Neolissochilus hexagonolepsis, Cyprinus carpio, Catla catla, Cirrhinus mrigala, Heteropneustes fossilis, Labeo rohita, Lates calcarifer, Schizothorax richardsonii, Harpodon nehereus*	Finfishes: *Anabas testudineus, Gudusia chapra, Nemipterus japonicas, Puntius sophore, Etroplus suratensis, Amblypharyngodon mola, Tor putitora*	Finfishes: *Tenualosa ilisha, Sardinella longiceps*
Shellfishes: *Perna viridis, Fenneropenaeus indicus, Penaeus monodon*	Shellfishes: *Crassostrea madrasensis*	Shellfishes: *Macrobrachium rosenbergii*	

Incorporation of chitosan gel in the batter had a significant effect on coating pickup, adhesion degree and cooking yield of the product. The oil reduction in pre-fried samples were 36.84, 65.05, 73.83, 77.65%, respectively for 0.5, 1.0, 1.5, 2.0% chitosan added batter samples. Hence, inclusion of chitosan at 1.0% in batter can improve functional and other quality aspects of battered fish fingers.

Nutraceutical for dsylipidemia and obesity from seaweeds

CMFRI developed an anti-obesity nutraceutical product named Cadalmin^{TM} Antihypercholesterolemic extract (CadalminTM ACe) using bioactive ingredients from selected seaweeds. The product is effective in combating dyslipidemia and obesity. Cadalmin^{TM} ACe is a unique blend of 100% natural marine bioactive ingredients from selected seaweeds developed with an eco-friendly ‘green technology’. The product is devoid of any side effects, as established by detailed pre-clinical trials. The technology has been commercialized.

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11. Agricultural Human Resource Development

The identified thrust areas continued to receive financial, technical and monitoring support from Agricultural Education Division, ICAR. The Agricultural Education Division is mandated for maintaining, upgrading 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 and Central Agricultural Universities (3 CAUs) under the National Agricultural Research and Education System (NARS) to address the challenges of agricultural growth and upgrading quality of higher agricultural education. The Division, through the implementation of Scheme-Strengthening and Development of Higher Agricultural Education in India, assists the AUs to plan, undertake, aid, promote and coordinate agricultural education in the country with the total outlay of ₹ 448.00 crores. It has helped in building excellence in specific strategic areas in education, research and capacity building through Niche Area of Excellence, Centres for Advanced Faculty Trainings, Summer/Winter Schools and Short Courses, promoting holistic higher education through Experiential Learning Modules, assuring quality and relevance of higher agricultural education through accreditation, periodic revision of courses, emphasis on student amenities, scholarships, and competency enhancement through extramural research projects, National Fellow and National Professor schemes and capacity building of farmers through Pandit Deen Dayal Upadhyay Unnat Krishi Shiksha Yojna (PDDUUKSY).

GOVERNANCE AND QUALITY ASSURANCE

Accreditation of Agricultural Universities

As of now 60 AUs have been accredited. During the reported period, the National Agricultural Education Accreditation Board (NAEAB) accredited 10 agricultural universities, viz. MAFSU, Nagpur; MSKUA&T, Banda; TNAU, Coimbatore; SKUAST, Jammu; NAU, Navsari; SDAU, Dantiwada; UAS, Dharwad; Faculty of Agriculture, BHU, Varanasi; School of Agriculture, SHUATS, Allahabad; and Faculty of Fisheries, KUFOS, Cochin.

Revision of UG Course Curriculum

The status of implementation of Fifth Deans' Committee recommendations was reviewed by conducting review meetings with the respective Deans from all the Agricultural Universities.

First review meeting was held during 25– 26 May 2017 for the disciplines of Agriculture, Horticulture, Forestry and Sericulture; second meeting during 2-3 June 2017 for Agricultural Engineering, Biotechnology, Food Technology and Dairy Technology; and third meeting during 29-30 June 2017 for the disciplines of Home Science and Fisheries.

Several aspects related to credit load, distribution of courses among different semesters, conduct of various components under Student READY were deliberated and the necessary clarifications were provided to the Deans for smooth implementation of the Fifth Deans' Committee recommendations.

Ranking of Agricultural Universities

Agricultural Universities Ranking was made to improve ranking of Indian universities in World University Rankings. The emphasis on 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 considered while evaluating the agricultural universities. Based on the evaluation, 57 agricultural universities have been ranked and the following top three universities (ICAR-National Dairy Research Institute, Karnal; ICAR-Indian Agricultural Research Institute, New Delhi; Punjab Agricultural University, Ludhiana) were honoured on ICAR Foundation Day Award Ceremony held on 16 July 2017.

Student READY Programme

Experiential Learning is a major component of the Student 'READY' programme as per the Fifth Deans' Committee recommendations. Skill oriented training to the undergraduate students is being imparted to promote entrepreneurship, knowledge as well as marketing skills through practical end–to-end approach

Honey processing unit at NAU, Navsari

Food Industry Centre at PAU, Ludhiana

in product development. Till date, 426 modules have been developed/supported by the Council including 10 new modules established during the year. New modules were supported in Makhana production, processing for value addition, protected cultivation of high value horticultural crops, commercial floriculture, quality seed production, bee keeping and honey production, etc. The students were benefited through the programme in the following ways:

- Operation and maintenance of the processing plants, knowledge on production of value-added products and insights into post-harvest techniques, including honey production.
- Trainings were imparted for production and collection of Makhanas.
- ELP on seed production helped students acquire experience on hybrid seed production in various crops, including guava layers, rice, sweet corn, soybean, etc.
- ELP on protected cultivation of high value crops enabled the students to learn construction of polyhouses and growing vegetables with the knowledge about best package of practices. They also developed skills for growing vegetables under protected conditions and nursery management.

Protected cultivation of high value crops

Rural Awareness Work Experience (RAWE)

The knowledge about crop protection methods was imparted along with the components of organic farming in certain villages. Experience on managing commercial horticultural farms was also gained in some villages. The students were given rigorous orientation and familiarization on various issues and problems anticipated on farmers' field which helped to gain competence and confidence for solving problems related to agriculture and allied aspects. As per the requirement, students gained tremendous experience through industrial attachment and 11,970 students benefited under RAWE through Council's support. Soil testing and awareness on soil health cards was also made as an integral part of RAWE by the students.

Students working in field

HUMAN RESOURCE DEVELOPMENT

Teaching, research and capacity building

Niche Area of Excellence: For strengthening capacity building and creating excellence in specific cutting edge areas, a support of ₹ 4.60 crore to 14 ongoing and one new centre of Niche Area of Excellence (NAE) on "Candidate gene assisted breeding of rice for the improvement of yield and tolerance against stress and nutrient deficiency using land races of Bengal" at BCKV, Mohanpur, was extended during the year. The XI Annual review meeting to review the programmes was organized at New Delhi on 22 August 2017.

The NAE programmes are being supported in the areas of drought resistance, organic farming, reduction of spongy tissue in mango, production of seedless kinnow, management of ravines, insect taxonomy, development of biosensors for disease detection and toxins in milk, pet food improvement, quality assurance in fishes, zoonotic diseases, wildlife forensics and technology enhanced learning etc.

Significant achievements

- A conceptual mini-lysimeter phenomics platform for precise imposition of moisture stress was established at UAS, Bengaluru.
- The PAU Kinnow-1 showed stability for seedlessness in 3 vegetative cycles and is differentiable from seeded Kinnow.

Mini-lysimeter facility

Kinnow-1 showed stability for seedlessness

- The centre at CSKHPKVV, Palampur demonstrated effective organic technologies and package of practices on the farmers' fields in villages in Bilaspur and Hamirpur districts of Himachal Pradesh.
- A unique E-learning portal was developed integrating all forms of educational interactive courses, viz. distance education, MOOCs, vocational, open access, regular courses for effective course management.
- Biosensor assay for detecting PPR virus using anti-peptide antibodies was optimized. In addition, SPR biosensor assay was optimized for detecting pregnancy associated proteins in bovines for detection of pregnancy.
- The repeatability and reproducibility of developed paper strip assay for testing pesticide residues in milk was standardized along with shelf-stability study of functionalized paper-strips under vacuum-packed condition. Third party validation of developed sensor work on paper strip based assay was carried out at NABL accredited SGS laboratory, Gurgaon.
- Two novel synbiotics based on probiotic-polyphenol combinations consisting of *L. johnsonii* CPN23 and PP- / JA- derived polyphenols (PPE and JAE) were formulated.

The NAE centres organized 78 long (>10 days) and short (1-10 days) duration training programmes / awareness workshops / camps /workshops leading to capacity building of 581 faculty and 180 students. About 1,580 farmers and 260 other stakeholders, viz. industry personnel, extension workers, veterinary officers of State Animal Husbandry Departments were imparted knowledge for adopting the technologies generated through farmers' meets demonstrations and workshops. In addition, 1,005 faculty were trained online through the training programme entitled "MOOC on Competency Enhancement for Effective Teaching". Distance education programme in complete online mode, and 18 participants across the country got the benefit of getting certified online. New course,viz. Food Safety and Quality Assurance (FSQA) was introduced at PG level (M. Tech / Ph.D.) to help industry/regulators in the country to ensure safe food to the consumers.

The support has resulted in 29 publications in peer-reviewed journals, including papers in journals assigned NAAS rating of 7 and above. Two patent applications were filed and a revenue of ₹ 15.89 lakh was generated during the year. The ITS2 sequence of 14 species of mites were deposited in NCBI gene bank. The centres generated recombinant proteins and peptide specific antibodies.

Two technologies were commercialized: (i) organic nutrient management (insect pest management, disease management, weed management, compost preparation and enrichment that benefited more than 2,500 farmers), and (ii) Paper Strip Assay (rapid detection of pesticide residues in milk).

Extramural Research Projects

To address acute and felt needs for enhancing the quality of Agricultural Education in India, 63 projects were sanctioned on different thrust areas which hold scientific merit in terms of importance and urgency in judging impact and bringing quality improvement in Agricultural Education in India. The sanctioned projects were distributed under the following thrust areas; Avenues for mitigating faculty shortage in SAUs and DUs; Improving visibility of SAUs; Agricultural education for sustainable growth, Entrepreneurial skills and self-reliance; Success stories of agricultural graduates converted to entrepreneurs; Attracting competent faculty in NARES; Educational needs for promoting innovations in agriculture; Movement of agricultural graduates; Global scenario of agricultural education in India; Impact of international collaboration of SAUs; Evaluation of present examination system and its suitability; Assessment on retention of students admitted through AIEEA during XII Plan; Comparative performance of students admitted through various exams/means in NARES; Comparative assessment of private and constituent colleges for quality of agricultural education.

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

During the year, 120 summer winter schools comprising 70 Summer/Winter Schools of 21 days and 50 Short Courses for 10 days were organized at various ICAR institutes and SAUs. The number of CAFT centres were increased from 31 to 40 with the addition of nine new centres during the year.

Training of scientists/faculty members from the NARS system

Training certificates being given to traines

The 40 Centres of Advanced Faculty Training provided training to about 1,800 scientists/faculty members from the National Agricultural Research System through 74 training programs in cutting edge areas of agriculture and allied sciences. The training programmes were monitored through workflow based online management system. A capacity building program vortal was developed to provide information on all training programmes, training proposal submission and evaluation, submission of application by a trainee, availability of e-books/lecture notes of a training and reports for all categories of users and several other features.

Attracting talent

All-India entrance examination for admission to UG: The 22nd Undergraduate Examination for admission to 15% seats of degree programme in agriculture and allied subjects, other than veterinary sciences, including the award of National Talent Scholarship (NTS) was conducted on 10 June 2017. The examination attracted a record 1,59,522 applications, out of which 1,20,318 candidates appeared and 1,450 candidates were finally recommended for admission in 55 AUs through counselling. All the candidates, who joined a university outside their State of domicile, were awarded NTS of ₹ 2,000/month.

All-India entrance examination for admission to PG: The examination was conducted on 11 June 2017 for admission to 25% seats in PG programmes at 59 accredited AUs, including award of ICAR PG scholarship. Out of 23,015 candidates 2,252 were finally recommended for admissions. In all, 469 students were awarded PG scholarship in 20 major subject groups. Non-PG scholarship candidates who join the Master degree programme in the allowed university are eligible to get NTS (PGS) of ₹ 3,000/ month for two years subject to fulfilment of prescribed terms and conditions of NTS (PGS).

All-India competitive examination for Ph.D. admission and award of Junior/Senior Research Fellowship: The examination was held on 11 June 2017 and 3,713 candidates appeared in the examination; and 486 candidates were finally admitted for Ph.D. admissions in 51 accredited AUs. Based on the merit, 139 Junior/Senior Research Fellowships (PGS) were awarded in 16 major subject groups.

National Talent Scholarship (NTS): Merit based support through National Talent Scholarship to under graduates (UG) in AUs was provided to the candidates admitted in AUs located in a State other than the State of domicile, through ICAR All India Entrance Examination (AIEE). This year 2,430 UG and PG students were provided NTS.

Globalization of agricultural education: ICAR/ DARE successfully implemented the fellowship programme to support agricultural human resource development in Africa, Afghanistan and Nepal, through formal education of scientists/faculty and students in India. During 2016-17, 162 students from 32 countries like Afghanistan, Bangladesh, Bhutan, Egypt, Ethiopia, Fiji, Guyana, Ghana, Kenya, Liberia, Mozambique, Namibia, Nepal, Nigeria, Rawanda, Sudan, Sri Lanka, Syria, Tanzania, Zambia, South Africa, Cameroon, Yemen, Burundi, Myanmar, Kazakhstan, Malawi, Lesotho, Somalia, Angola and Uganda, exercised their preference to join various agricultural universities under different fellowships or as self-financed candidates.

National Fellowships

ICAR Fellowships for post-graduate students: For recognition of talent and promotion of merit in general, 469 and 139 students have been awarded ICAR-PG scholorships and ICAR-JRF/SRF(PGS) scholarships in different disciplines of agriculture and allied sciences for Master's and Doctoral studies, respectively, during 2017-18.

Merit-Cum-Means scholarship: Scholarships to meritorious under-graduate students belonging to below poverty line families to study Agriculture, Agricultural Engineering, Community Science (erstwhile Home Science), Dairy and Animal Husbandry subjects, are awarded annually on the basis of merit-cum-means. During the year, 543 students were awarded this scholarship.

Post-Matric scholarship: It is provided to Scheduled Caste and Scheduled Tribe students for pursuing Bachelor Degree programme in various branches of Agriculture. During the year, 30 students got the benefit of this scheme.

International Fellowships

Netaji Subhas-ICAR International Fellowships: Based on the priority areas of study related to plant sciences, animal sciences, social sciences, fisheries, agricultural engineering, food processing and natural resource management, 30 candidates were selected for Ph.D. study including 24 Indian candidates at universities in USA, UK, Germany, Belgium, Korea, Australia, Canada, Netherlands, Sweden, Norway, France, Greece and Philippines and 6 candidates from Ghana, Ethiopia, Nepal and Syria at Indian SAUs/ ICAR DUs. During this year, 22 candidates have joined overseas laboratories for pursuing Ph.D.; and 39 candidates have completed their degree programmes so far.

Fellowship Programme under India-Africa Forum Summit (IAFS): India-Africa Fellowship Programme has been implemented by Government of India under India-Africa Forum Summit (IAFS). Under IAFS-I, 183 candidates (114 Master's and 69 Ph.D.) have successfully completed their programmes. The India Africa Fellowship Programme has been revised under IAFS-III with allocation of 500 scholarships. For academic session 2017-18, 102 applications (79 PG, 23 Ph.D.) have been recommended.

India-Afghanistan Fellowship Programme: India-Afghanistan Fellowship Programme has been implemented since 2010-11 for providing fellowships

to Afghan nationals for attaining higher education in Agriculture and allied sciences in identified Indian Agricultural Universities (AUs). To attain maximum enrolments in India-Afghanistan Fellowship Programme, the tenure of programme has been extended up to 2020-2021 with the available slots of 614 fellowships for Bachelor's (50%), Master's (30%) and Ph.D. (20%). During 2017-18, a total of 112 Afghan students (9 Bachelor's; 97 Master's; 6 Doctoral) have been recommended to pursue higher agricultural education in Indian AUs.

Nepal Aid Fund: Ten students from Nepal have enrolled in nine SAUs this year for postgraduate studies under this component.

Promotion of Excellence

ICAR National Professor: ICAR operates National Professor programme with the twin objectives to promote excellence by recognizing outstanding scientists with proven output and outcome for creating a culture of basic research through their project work in the National Agricultural Research System (NARS) and establishing and nurturing a novel school of thought around the recognized person. 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, 7 National Professors are in position including 1 new National Professor who joined during 2017-18. Their areas of specialization were: Crop Sciences (4), Animal Sciences (1), Natural Resource Management (1), and Economics, Statistics and Management (1).

Salient achievements

- Feeding of rumen modifier (RM-7, a blend of seven plant parts) to buffalo calves, resulted in 14.5% higher gain in body weight and 14.8% reduction in methane production.

Varieties Developed

Brassica juncea cv RLC 3 (first canola mustard variety in India), *B. napus* cv. GSC 7 and *B. carinata* cv. PC6 (first determinate *Brassica* variety in the world) were released and got notified. Cases for obtaining PVR for these varieties were submitted to Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA), New Delhi.

- Total gene expression profile upon infestation by pod borer in a mild resistant (ICC-506EB) and susceptible (JG11) cultivars of chickpea was studied. Defence related genes (defensin, cysteine protease inhibitor and NRHSPRO protein) were found up-regulated in the mild resistant cultivar (ICC-506EB). Major genes (FHG and MADS box Transmission factor) were highly expressed in the flower and pod wall.
- CSSLs are an important pre-breeding resource to discover genes of interest. Swarna/*O. nivara*: 74 CSSLs from IRGC81848 population and 60 CSSLs from IRGC81832 population, both in BC_2F_8, were identified. Two major effects, stable QTLs *qDM2.1* and *qPH1.*1were identified. Seven CSSLs showed significantly increased panicle weight, yield and biomass. In F_3 of BIL166s/ BIL14s, one major effect QTL *yld4.1* and 4 families with significantly higher yield were identified.

ICAR National Fellow: ICAR operates National Fellow programme with the twin objective to promote excellence at national level in agricultural research and education and to recognize the meritorious contribution of individual agricultural scientists/teachers and facilitate their research and related activities in agriculture. There are 25 positions of National Fellows across National Agricultural Research and Education System. During the period under report, 22 National Fellows are in position including 8 new National Fellows who joined during 2017-18. Their areas of specialization include Horticulture (3), Animal Science (7), Fishery Science (5), Natural Resource Management (3), Agricultural Engineering (2) and Economics, Statistics and Management (2).

Salient achievements

- Collagen hydrolysate prepared from shark skin (*Sphyrnae mokkaran*) was demonstrated to possess hypolipidemic activity in high fat-fed Wistar rats. Fish collagen based composite scaffolds for wound healing and skin tissue engineering applications,chitosan-based gel sol useful for curing calluses and corns and chitosan-based

Germplasm Registration Information System (GRIS)

The Germplasm Registration Information System (GRIS) was developed to make the entire process of germplasm registration—submission of application, evaluation by experts and decision by Plant Germplasm Registration Committee—a web-based system. The GRIS was launched by DG, ICAR on 2 August 2017.

The system is expected to provide genebank managers, breeders and plant researchers with a hands-on-tool for management of germplasm registration process, and to policy makers with a reliable source of information. To register and use GRIS, one can log on to *www.nbpgr.ernet.in/registration*.

balm with squalene as an active component with pain relieving potential were developed.

- The vaccine potential of ribosomal P0 protein of *A. siamensis* was tested in rohu. A reduced and delayed mortality of 59% (15 days post-infection) in immunized group was noticed as compared to 75% mortality in control.
- Sodium-bentonite nanoclay was successfully synthesized and was applied in bioremediation of aquatic environment for reducing heavy metals, pesticides, nitrites and ammonia contamination.
- Employing the nucleic acid-based assay, novel enteric viruses (rotavirus C, picobirna virus, astro virus and Kobuvirus) from different animal species were identified and characterized. Rotavirus C strains from sloth bears and highly divergent picobirnaviruses in camels were also identified.
- Expression profiling of bone morphogenetic protein 3 (*BMP3*), bone morphogenetic protein 4 (*BMP4*), fatty acid synthase (*FASN*) and acetyl-CoA carboxylase alpha (*ACACA*) genes during embryonic and post-hatch period up to 6 weeks of age were established in layer and broiler chicken.
- The ATPase Na+/K+ transporting subunit alpha 1 (ATP1A1), an important candidate gene for heat tolerance traits was characterized in different breeds of Indian riverine buffaloes and native cattle. The analysis helped to identify several variations/SNPs that can be used as resource for genomic studies targeting thermo-tolerance trait in Indian dairy species.
- Four types of biscuits and three types of breads rich in nutrients known for bone strengthening were developed for children. The protein and calcium content of the biscuits was significantly higher than the control biscuits. The nutritional content of the salty biscuits was higher in comparison to sweet biscuits for all parameters. Process parameters for bread development were optimized for naturally fortified calcium enriched breads with combination ingredients like sesame, cumin and moringa; ragi and sesame; and milk and sesame.
- ^{137}Cs inventory for depth increment profile revealed that soil erosion of around 5.8 tonnes ha^{-1} yr^{-1} is occurring at slight eroded phase in North-west Himalayan region. A close relationship between ^{137}Cs and SOC content of the soil was found. Erosion induced C-loss ranged between 94 to 120.7 kg ha^{-1} yr^{-1} leading to 20-25 kg ha^{-1} yr^{-1} C as net C-source to atmosphere.
- Bioassays with volatiles induced from the fruit upon oviposition by Oriental fruit fly, *Bactrocera dorsalis* and guava fruit fly, *Bactrocera correcta* proved that the flies are attracted to conspecific induced volatiles compared to heterospecifics, indicating that egg deposition induced specific volatiles and are the reasons for mediating niche partition in these flies. Smell of red weaver ant, *Oecophylla smaragdina* repelled gravid female *Bactrocera dorsalis* from oviposition, indicating the scope for potent ovipositional reprellents.
- Small area estimation (SAE) method was developed for count data under an aggregated level version of spatial dependent generalized linear mixed model (GLMM). This method was applied to generate reliable and representative district-level estimates of incidence of indebtedness in rural areas of Uttar Pradesh using debt and investment survey data 2012-13 collected by NSSO and the secondary data from the Census 2011. The district-wise estimates and spatial map of incidence of indebtedness are expected to provide valuable information to policy-analysts and decision-makers for identifying the regions requiring more attention.

Competency enhancement: To tap brain and skill bank potential, 35 outstanding superannuated professionals of NARES were selected as Emeritus Scientist. The aims were to complete the work in hand for its fruitful conclusion, utilize their talent in teaching specialized courses, and use their experience in addressing nationally important issues in different ICAR-Institutes and SAUs. It was also aimed to use their expertize for launching a movement in science for remedifying regional imbalance in agricultural development.

Salient achievements

- Research carried on the livestock data in Karnataka indicated that the NADRES software can be improved by incorporating statistical models, viz. Random Forest model, Adaptive boosting model and Generalized linear model (GLM) as applicable to individual disease.
- Spatial distribution of risk of selected diseases in Karnataka has been prepared.
- The software, india.admas Epitrak, was developed and released to teach basic epidemiology to undergraduate veterinary students. It can be procured from Director, ICAR-NIVEDI, Bengaluru.
- The methane emission pattern in paddy soils of conventional and SRI system was assessed and found to be higher in conventional system. The mass multiplication of methanotroph strains was done and the multiplied culture shall be used for evaluating methane emission.
- Museum galleries: Sunboard panels of varying sizes on animal keeping and veterinary medicine in medieval (Animal keeping during Allauddin Khilji, Mughal period, Maharana Pratap, Ranjit Singh, Tipu Sultan, etc.) and modern India (Veterinary medicine during East India Company, British Raj, post independence, veterinary education, white revolution, history of RVC, electron microscopy in biomedical research and

ICAR-IVRI profile) were developed at IVRI, Bareilly. E-inventory document of museum was prepared and published. Webpage of museum was prepared and can be accessed through IVRI website (http://ivri.nic.in)

Support for Infrastructural Development

The additional grant for new amenities to be created in various AUs was released during the year. The support under the component 'Development and Strengthening' continued during the year for renovation and refurbishing of existing structures, with emphasis on improving the condition of student hostels across Agricultural Universities (AUs), purchase of new equipment for upgrading of student and Common Instrumentation laboratories, support for smart classrooms, conduct of practicals, both UG and PG, personality development, holistic growth, etc. leading to overall strengthening of infrastructure in AUs. An amount of ₹ 294.35 crore was provided to support these activities during the year.

Laying of Foundation Stone for Auditorium at DUVASU, Mathura

Smart Classroom Facility

Across the country, AUs are being supported to ensure that the quality of higher agricultural education and learning is improved. Smart classrooms, supported by the Council have enabled effective delivery of course curriculum, ensuring enriched learning experience.

The support for strengthening of PG and UG laboratories led to improvement in conducting practical classes. For increasing awareness in latest techniques and research in cutting edge areas, support was provided for student and faculty amenities/tours/capacity building and participation in seminars, symposia, workshops etc. With the support from Council, the AUs initiated short courses/workshops/lectures on overall personality development, leadership programmes as well as spoken English as per need.

The support also helped improve amenities in the hostels and other services in the campus, including facilities for disabled. Placement cells helped students obtain placement or advice on career development. Education Technology Cells were strengthened by publication of booklets, pamphlets and exhibition of model products. Substantial support from Council was provided and the universities were encouraged to develop overall personality of students by teaching them self-defence, yoga, career development talks by guest faculty, conducting workshops, counselling for exams, etc.

Implementation of Budget Announcements: Establishment of New Universities

- Financial support has been extended for the

Library Strengthening

The Library Strengthening grants to the tune of ₹ 12.05 crore were utilized to strengthen and modernize the university and colleges libraries services by enriching the resources and infrastructure. University libraries and colleges were automated through Koha and other softwares. The Web-OPAC through e-KIOSK has helped students and faculties to locate the books and journals etc. Self check in/ checkout Kiosks were made available to library users. University Library provided Web-OPAC to all component colleges, KVKs and research stations and IDEAL facility made available. Many agricultural university libraries implemented the RFID technology in the library for library security and library in house operations such as self check in and check out and stock verification. Several text/ reference/e books/ encyclopedias etc. were added for scientists/ students/ faculties to keep them updated with recent advancement in subjects. Several new services like access to library resource from their desk, SMS alerting service, and Wi-Fi facility in library premises were provided under this. Electronic resources like INDIASTAT, CMIE, CAB Abstracts, Britannica Encyclopedia, Animal Simulator were procured for library users free of cost. Reprographic services were strengthened and newsroom facility developed for the students. Highend scanner and other hardware were procured to carry out digitization of thesis for Krishikosh. New books, e–journals, general education books have immensely helped students to improve research, formulate projects, improvement in publication quality and compete 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, which could be attributed to the rich collection of books and information material available in the libraries.

establishment of Agricultural University in Andhra Pradesh and Horticultural University in Telangana. So far, an amount of ₹ 135.00 crore has been released to each university. With the establishment of these new universities, the agriculture development in these states shall be further strengthened.

- Financial support has been extended for the establishment of Horticultural University in Haryana. An amount of ₹ 5.0 crore has been released during financial year 2016-17.

Support under Tribal Sub-Plan

Tribal welfare programmes were supported in 21 agricultural universities with financial support of ₹ 38.00 crore. This has contributed in up-liftment of the livelihood and socio-economic conditions of the rural and tribal communities. Various programmes were executed through more than 1,500 training programmes, workshops and demonstrations, etc. leading to capacity building and creating awareness among more than 50,000 tribal farmers.

The interventions have led to adoption and spread of improved varieties of crops in tribal areas and increase in farm income from livestock rearing. Farmers were made aware about benefits of scientific housing of animals, adoption and spread of improved breed of animal and poultry birds, and health care of pig and poultry. Capacity building programmes and inputs on managing the agro-forestry models, crop intensification through cultivation of short duration summer crops like moong, increased land use efficiency due to cultivation of short duration rice varieties, made it possible the early sowing of wheat. Additional income generation opportunities through backyard poultry and bee keeping have been provided through training programmes. Awareness regarding latest agricultural production technologies, distribution of quality seeds, planting materials, animal breeds, fish and improved agricultural tools and implements led to enhanced production. To generate additional income, farmers of NEH region were also provided with low-cost poly houses, mushroom production and vermicompost pits. Tribal farmers were encouraged to establish silage-making units to preserve surplus green fodder to make the quality fodder available for feeding during lean periods.

Farmer-scientist inter face meeting on Elephant footyam

Trainings were imparted on preparation of milk products and poultry products viz., Chicken soup, chicken essence, nuggets, kababs, hot-dogs, frankfurters, giblets etc, and also value addition of fruits, cereals and pulses. In Lahaul Spiti district trainings on orchard management were imparted and improved planting material and implements were distributed. Tikhur is the minor tuber/ rhizomatous crop available in the forest area of Bastar and establishment of mechanized starch extraction technique has helped in extraction of good quality of tikhur with less time and energy.

Farmers have been trained in use of modern farm equipments, proper nutrition, soil sampling etc. The region shrink and vacuum packaging machines for vegetable and apricot packing were introducd for the first time in Leh region.

Training of tribal farmers

Capacity Building of Farmers: With a vision of bringing transformational change in rural development processes and to build skilled human resources at village level relevant to National needs towards organic farming/sustainable agriculture and cow based economy and also to provide professional support in these areas, Agricultural Education Division initiated **PDDUUKSY** for farmers with 100 training centres across the country in different zones, viz. North (32), West (20), South (20), East (18) and NE (10) on the basis of knowledge, skill, ability and past experiences related to organic farming, natural farming and cow based economy. Each training centre has been entrusted to conduct 5 training

programmes during the current financial year. To monitor the activities of training centres, 4 Field Coordinators were appointed during 2016-17. Two days' orientation programme for Centre Incharges was organized at ICAR, Headquarters, New Delhi during 19-20 January, 2017 wherein a detailed discussion was held on the modalities of conducting training programmes, financial guidelines, administrative procedures and syllabus for training program and all the Centre In-charges were informed accordingly.

A one-day review workshop was also conducted under the chairmanship of Hon'ble Minister of Agriculture and Farmers Welfare during 18-19 April, 2017 at NRC on Integrated Farming, Motihari (Bihar) for the Centre Incharges of PDDUUKSY of different zones to know the status of training programmes organized by respective centres and to get feedback from the participants, to plan future programmes and to prepare roadmap of new strategies to be implemented during 2017-18. During the year under report, 174 trainings were conducted at different Farmers' Training Centres under the supervision of different SAUs/CAUs/DUs/ICAR-Institutes, wherein 5,268 farmers were trained and benefited by these training programmes.

Reforms initiated by Agricultural Education Division

- Agricultural Education Division declared Agriculture and its allied disciplines as Professional Degrees
- Developed minimum standards for Establishment of New Colleges
- Enhanced National Talent Scholarship (NTS) for UG from ₹ 1,000 to Rs 2,000/month
- Introduction of NTS for PG Students @ ₹ 3,000/month
- Development of Agricultural Education Portal (EKTA) by integrating Student Portal, Grants, Accreditation and Online Examination Management System
- Online Counselling System initiated
- Online Project Proposal Submission and Grant Management through http://education.icar.gov.in started
- ICAR Data Centre established at IASRI, New Delhi
- Implemented Academic Management System for Deemed Universities of ICAR.

ICAR-NATIONAL ACADEMY OF AGRICULTURAL RESEARCH MANAGEMENT

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 academic programmes in agricultural and technology management to develop a new generation of young leaders and managers who can contribute to sustainable agricultural development at the national level.

The Academy organized:

- 64 need-based and mandated capacity building programmes.
- 1,003 participants registered for online certificate course, viz. 'Massive Open Online Course (MOOC) on Competency Enhancement for

Education Portal and National Information System on Agricultural Education Network (NISAGENET)

Agricultural Education Division, ICAR helped revamp the existing structure of NISAGENET and as a new initiative, Education Portal was designed, developed and launched which included student portal and fund management to generate all the student related information. The system is available at http://education.icar.gov.in. It has the desired functionality of fund demands for various components by all universities under the various heads. Necessary support was provided to the universities to submit demand under different components. Various reports can also be uploaded and creation of user profile and role management of different users along with customization of filling format is also fesasible.

In the financial year 2017-18, the fund demand and allocation module, various functionalities such as Unique Student ID (USID) generation for student portal and new initiatives under EKTA (*Ekikrit KrishishikshaTakniki Aayam*), were initiated.

The existing NISAGENET system was further strengthened. Faculty profile module was enhanced and now the faculty can publish their own information on the web. A webpage address also has been provided to each faculty which they can use to publicize. Their profile including basic data of faculty members along with their publication list, awards, courses taught, and their research areas. Regular contact and technical support has been maintained with the Nodal Officers of each university for data uploading and validation in NISAGENET.

Digital collection of resources: Digital repository, a collection in the form of old and valuable books, journals, thesis, research articles, popular articles, monographs, catalogues, conference proceedings, success stories, case studies, annual reports, newsletters, pamphlets, brochures, bulletins and other grey literatures from various ICAR institutions and State Agricultural Universities (SAUs) was supported. The repository achieved a milestone of having more than 100,000 (one lakh) documents which include 49,000 thesis (Ph.D. and M.Sc.) and 51,000 other institutional publications, viz. books, research articles, reports, annual reports, etc. during 2016-17. At present, repository has more than 20 million digitized pages in 100,000 digital items (volumes) like old books, old journals, reports, proceedings, reprint, research highlights, training manuals, etc.

Effective Teaching' aimed at improving the quality of teaching.

- Policy workshops on digital learning in agriculture; agri-innovation; role of ICAR-NAARM in shaping agricultural research, education and extension system for 2030.
- Several programmes for administrative and technical staff for enhancing competency and efficiency in discharging their functions.
- A special Interactive Session on "Doubling farmers income by 2022: Concerns and Strategies", to sensitize the agricultural scientists, researchers, development planners and students on the need to realign their R and D activities towards meeting the Government of India's stated objectives.
- Two brainstorming sessions– on 'Restructuring of FOCARS' and the other on 'Agricultural research and education management strategies for 2030' (same have been internalized in the ongoing programmes of the Academy).

The Academy continued its efforts in imparting postgraduate education in the niche areas of Agribusiness Management (PGDMA) and Technology Management in Agriculture (PGDTMA) to develop a new generation of young leaders and managers who can contribute to sustainable agricultural development at the national level. NAARM achieved 100% placement of final year PGDMA students of the seventh batch of PGDMA.

The Centre for Agri-Innovation of the Academy, as part of start-up India campaign initiative, conducted several entrepreneurship development programmes. These included sensitization workshops at universities across the country including north-eastern region. "Startup Samvaad" were organized and 16 startups were extended incubation support under the aegis of Centre for Agri-Innovation at the Academy. Out of these 16 startups incubated, six were given the certificate of recognition by the Department of Industrial Promotion and Policy, GoI. The Centre also supported 4 startups with seed funding support.

In addition, the Academy in partnership with CIIE, IIM-A, supported by DST has launched Food and Agribusiness Accelerator Programme, 2.0 called "Agri Udaan" to encourage startups to scale up.

Under *Mera Gaon Mera Gaurav*, *Pradhan Mantri Aadarsh Gram* Yojana, the Academy adopted Vemulanurva and Banjarala Thanda village and activities were carried out as motivational activities, while, the baseline survey is under process. Soil health based advisory services were provided to the farmers, highlighting the importance of soil as a critical component of the natural system.

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12. Social Science

Economics

Enhancing farmers' income: Who to target and how? The Government of India in its annual budget of 2016-17, for the first time, has indicated a change in policy stance from excessive emphasis on food production towards improving farmers' income, and has set a target of doubling it by 2022. Identification of farmers and their locations are important to target the efforts and investments accordingly. Three-fourths of the farmers lie at the bottom of land as well as income distribution, and a majority of them are located in the eastern, central and western regions that are generally deficit in infrastructure, institutions and human capital. There are prospects of income growth in farming sector through reduction in inefficiency in input use production, raising cropping intensity and diversification of portfolio in favour of high-value, high-growth enterprises, viz. horticulture and animal husbandry. Harnessing their potential would require improving farmers' access to information on modern technologies and agricultural practices, and to institutional credit and remunerative markets. It is essential to improve complementarities of infrastructure and institutions as the lack of any one of these, may deprive farmers of the benefits of investments in others. Nonetheless, in the long-run sustainable improvements in farmers' welfare will critically be determined by the pace of transfer of labour from agriculture to non-agricultural sectors. The implication is that if the constraints due to ubiquitous small-holdings were to be mitigated, strategies for broad-based growth of rural nonfarm sector would be required.

Key characteristics of marginal farm households in different income classes, 2012-13

Variables	Per capita income (₹/annum)			
	<₹15,000	₹15,000-30,000	>₹30,000	All
% of total marginal farm households	77.30	16.10	6.60	100.0
Landholding size (ha)	0.41	0.44	0.45	0.42
% cropped area irrigated	65.47	61.36	57.45	64.17
Gross returns (₹/ha)	46230.00	70047.00	105149.00	54686.00
Net returns (₹/ha)	25655.00	45683.00	79420.00	33084.00
% area under high-value crops	6.30	8.91	14.59	7.41
% households engaged in livestock production	47.14	58.33	59.32	50.08
% households engaged in non-farm business	7.77	16.48	20.72	10.33
% households receiving wages and salaries	52.08	69.44	73.59	56.84
% households having outstanding loans	45.22	55.37	51.06	47.48
% households having access to information	39.44	44.71	50.50	41.24

Farmers' income estimation: Attempts made in India to estimate the farm income are largely based on the point information. In some cases, the approach could not cover the sector as a whole owing to paucity of data and aggregation issues. The doubling of farmers' income requires initial or benchmark set of estimates regarding the income which are to be doubled in a given time-frame. A Committee was constituted to provide the approach for estimation of farmers' income in the country. The methodological approach for estimating the total household income are discussed here.

The net farm income may be estimated from agriculture by deducting the paid-out labour cost, imputed value of family labour and rental value of land: This is equivalent to returns to family labour and fixed factors of production i.e. land. The net value added is computed by deducting the value of inputs such as seeds, organic manure, chemical fertilizers, current repairs and maintenance of fixed assets and other operational cost, feed of livestock, irrigation charges, market charges, electricity, pesticides and insecticides, diesel oil, financial intermediation services indirectly measured and consumption of fixed capital. It does not deduct the cost of paid-out human labour which is one of the important cost items. Thus the labour cost may be computed using the labour share in disaggregated studies. The farm income, thus derived needs to be adjusted for the non-farm income component.

Computing the total household income: Situational assessment survey of NSSO provided the details of farmers' income from farm as well as non-farm sources. Using this, the ratio between total household income and income from farm sector may be computed. This ratio signifies the gains from non-farm sector. A ratio of 1.67 was derived between total household income and income from farm sector. This signifies that a

Existing development programme

household is able to earn 67% more from non-farm sources over a base of 100% income from farm sector. As the SAS provides single point information, the growth in GDP agriculture and GDP non-agriculture may be used to project it further. The income derived earlier by deducting the paid-out cost may be multiplied by this ratio to arrive at the total household's income. The nominal income needs to be converted to real income by using a suitable deflator. The gross real income may be divided by the number of cultivators, holdings and net sown area to examine the changes happening at individual level.

Enhancing resilience of Indian agriculture: Climate change ultimately creates disturbance to agro-ecosystems, thereby impacting farmers and farming community. Mainstreaming climate change adaptation (CCA) in India is still at its preliminary stage. Major advantage under this approach is that no new policies, programmes and institutions need to be formed separately, owing to strong interconnection between adaptation and development. In order to mainstream the adaptation strategies in an integrated manner, various developmental programmes of different ministries were studied and converged for enhancing its effectiveness and targeting. The study suggested six broad thematic groups for various existing development programmes and interventions, namely, Rural Livelihood Security; Natural Resource Management; Production Augmentation and Productivity Enhancement; Risk Financing; Food Grain Management' and Research and Extension. Pertinent to these broad thematic groups, the study identified 24 ministries and 161 developmental programmes being operationalised during the year 2015-16. Further, these broad thematic groups were segregated into 24 sub-groups and 54 categories. The broad thematic groups were divided into sub-groups and categories, such an extended categorization is in consonance with the stated objectives and mandates

of the programmes/ schemes and ability to mitigate the vulnerability to climatic changes.

This approach envisages to sensitize the policy makers towards the program replication issue and ensures effective utilization of the available financial resources thereby bringing prudency, effective targeting and outcome oriented towards enhancing the resilience of Indian agriculture/vulnerable section or region. Making local adaptation plans as an integral part of local development planning by ensuring the engagement of local government bodies and multiple stakeholders from the respective community, can be considered as an alternate strategy to reduce the climate change adaptation costs. Incorporation of local knowledge and strategies being adopted by the inhabitants in dealing with the climatic aberrations forms a significant supplement to the decision making process both in the district and state level plans since adaptation integration process requires synergy between all the decision making levels.

Network Project on Market Intelligence: High price volatility in agricultural commodities and increased risk faced by the farming community necessitate the study of agricultural commodity prices and their behaviour to understand the causes and providing the real time information to the stakeholders. The Network Project on Market Intelligence was carried out to provide reliable and timely price forecasts to farmers for more than 40 major agricultural commodities through a network of 14 institutions throughout the country. More than 180 pre-sowing and 263 pre-harvest price forecasts were disseminated through personal contacts, SMS, television, radio, university websites, pamphlets, Facebook, WhatsApp, YouTube etc., to the farmers before sowing and during harvests to facilitate informed and intelligent decisions by the farmers.

To provide information to the farmers, it is essential that forecast prices turn out to be close to the actual market prices. Forecast accuracy, estimated as the mean absolute percentage error indicates the degree of closeness of the forecasts to the actual market prices

Spatial Span of Market Intelligence Centres across the country

and reflects the quality of forecasts. Through innovations in methodological approaches followed, there was greater precision in forecasts overtime; however, horticulture and pulses remained volatile. Potato and onion are extremely sensitive crops in terms of the impact of all external influences to the prices. The pre-harvest forecasts, due to obvious reasons, were more precise than pre-sowing harvests.

The impact of price forecasts on the stakeholders was also examined. The forecasts by BHU (Varanasi) Centre revealed that the prices for potato crop were expected to be low during March and high during May 2016 in Uttar Pradesh. This information was efficiently utilized by a few farmers; they stored the crop during March-April and sold it in May, which led to realization of 30-40% higher price by them. The average increase in income for farmer was

Forecast accuracy (MAPE values)

Subsectors/Commodities	2013/14	2014/15	2015/16	2016/17	Overall
Pre-harvest	9.35	11.02	11.90	11.83	11.54
Cereals	2.00	9.70	6.30	15.63	9.71
Dry fruits	-	16.78	8.91	9.30	11.50
Fibre	-	2.45	10.69	11.15	7.58
Fruits	-	7.81	15.66	12.45	13.94
Oilseeds	3.90	4.50	5.13	2.84	4.38
Plantation crops	-	11.86	9.94	4.22	9.72
Pulses	8.43	6.00	8.31	5.75	7.01
Spices	17.76	8.24	8.70	4.29	7.79
Vegetables	11.90	16.79	12.38	18.79	14.82
Pre-sowing	19.52	17.89	15.15	18.80	17.30
Cereals	11.76	7.47	7.42	26.51	14.12
Fibre	-	18.69	9.12	10.90	14.08
Oilseeds	5.36	19.01	10.99	11.19	14.02
Pulses	11.85	19.29	24.75	22.25	19.94
Spices	17.00	6.52	9.98	6.76	9.06
Vegetables	43.22	25.40	17.79	15.74	21.39

estimated to be ₹ 100-150/quintal. Bengal gram farmers reported similar results, but the changes in marketing pattern on the basis of price forecast were observed only in less perishable commodities. The income of farmers was increased by storing the produce for a few months in case of potato, mustard and bengal gram. The storage cost was covered by increase in prices. In Gujarat, the cotton farmers benefitted from the price forecast information. The average price realized by the Gujarat cotton farmers was ₹ 4,594, which increased later on to ₹ 5,040 as per the price forecast provided to farmers by JAU (Junagadh) centre. The farmers followed the price advisory and the incremental gain realized per farmer was ₹ 36,000.

The regional studies helped in understanding the price movements, linkages between marketing infrastructure and price behaviour, impact on farmers' decision making etc. Market intelligence efforts are extremely important and need to be institutionalized over time. There is a need to develop a sound market intelligence system in the country with wide coverage in terms of regionally important commodities. Timely, adequately and reliable forecast disseminated to farmers will be more effective if supported by market infrastructure and other logistics.

Farm-size efficiency relationship in Punjab agriculture: The study analyzes the resource use efficiency and identifies the determinants of technical efficiency of paddy, wheat and cotton crops in Punjab. Large farmers were technically more efficient than the farmers with smaller land holdings in all selected crops. This implies the presence of economy of scale in the Punjab state. Large farmers made relatively higher use of machines and fertilizers per hectare and used less labour. On the other hand, marginal and small farmers applied more irrigation hours per hectare as compared to medium and large farmers leading to inefficient and injudicious use of groundwater resources. The study suggested that—efforts should be extended to increase operational land holding through tenancy reform consolidation of fragmented land-holdings and to improve crop yield; if farmers reallocate inputs, they would be able to save a reasonable amount of money without reducing output; farm size and number of schooling years of head had a positive and significant relationship with efficiency; number of fragments, age of family head, diversification index and bio-abiotic stress negatively influenced technical efficiency. The average potential for improvement in technical efficiency i.e. the yield gap in production is estimated as 26.95, 24.02 and 7.26 % in cotton, paddy and wheat, respectively, without increasing the input use.

Optimum crop plan in Asom for increasing farm income: The productivity level of agriculture sector in Asom is yet to reach an acceptable level despite several efforts in the past years. Optimum cropping plan was developed using linear programming approach to maximize the net returns under availability of land constraint. Attempts were made to obtain crop combination under rainfed and irrigated area separately in both *kharif* and *rabi*. The result from the linear programming indicated higher returns than the existing plan (₹ 39.30 hundred crore in optimum plan over ₹ 34.16 hundred crore in existing plan at market price based on 2010-11 data under cost of cultivation scheme). The model also indicated that if the net irrigated area is increased from present 6 to 12 % of the net sown area then return at market price increased to ₹ 41.8 hundred crore. There is a need for efforts in improving the irrigation structure in the state.

Improving ICT for agricultural education in India: A study conducted in State Agricultural Universities in northern states, revealed that more than 50% faculty reported 60-100% improvement in various academic and professional indicators.There is ample scope of improving the faculty productivity by increasing the availability and use of ICT initiatives in NARS. Faculty opined that age is not a major factor for adoption of ICT in comparison to lack of infrastructure and training facilities. Eighteen percent faculty requested training for developing the skills needed for ICT use, 9% emphasized on infrastructure development and allocation of funds for strengthening access to ICT resources at the university; 7% were for promotion of ICT through incentives; while 4% wanted continuous connectivity to internet with appropriate speed.

Intensity and impact of public investment in agricultural R&D: India followed a policy of committed public resources for agricultural development, including that for development and dissemination of farm technologies. Initially, there was comparatively slow growth in the total public funding in real terms, but it accelerated later during 1960s when the SAUs were being established. After a moderate growth in 1970s, the national funding grew more than 6% per annum during 1980s, which was sustained during the 1990s and thereafter. Thus, the growth was nearly 6% since 1980s, almost doubling the real investment in each decade. The annual real funding for research and education at 2011 prices during the triennium ending (TE) 2014 was ₹ 86.68 billion and nearly half of this funding was from the states. If we take research funding net of education, the national funding was ₹ 53.38 billion. Much of the growth in the funding was since late 1990s, mainly because of higher funding from the central government. For international comparison, funding or expenditure is expressed in purchasing power parity (PPP) or international dollar rather than in US dollar (or any reference currency) using the nominal exchange rate, and PPP conversion rate takes into consideration prices of a bundle of goods and services in both the countries, India and US in this case with a reference year 2011. In 2011 PPP dollars, research funding stands at 3,533 million during 2011-14, as against 1,905 million during 2001-03 and 1,034 million in 1991-93. The highest investment was about 4,000 PPP dollars in 2011, indicating that there is near doubling of public funding in real terms in each decade. This trend however, could

not be sustained during the last few years.

In terms of research intensity, funding or expenditure as percentage of AgGDP, India spent only 0.40% of AgGDP on research during 2012-14 and it has been at this level since 2001, except in 2011 where it reached to 0.52% because of higher plan allocations of the Union Government. The expenditure intensity was 1.8% in Brazil, 0.5% in China and 3.01% in the high income or developed countries. This gap in the expenditure intensity in India and other countries of comparable size was much higher during the 1980s and early 1990s, which narrowed down subsequently due to higher funding coming after the mid-1990s. The present trend is likely to continue as the government intends to reach the research intensity of 1% of AgGDP, which shall bring India close to the funding level of China and Latin America. But the trend in last couple of years indicated slow down in the public expenditure, which must be reversed. Higher allocation of public fund and well qualified scientific manpower will strengthen India's position as a major provider of agricultural R&D services globally.

Level and intensity of agricultural research funding in India, triennium averages

	1981-83	1991-93	2001-03	2012-14
Research and education funding, 2011 million ₹	14,003	24,697	44,669	86,682
Research funding, 2011 million PPP dollars	594	1,034	1,905	3,533
Research intensity (funding as percentage of AgGDP)	0.25	0.31	0.39	0.40

Research impact in the rice-wheat system: Impact of recent technological interventions in the rice wheat system was assessed using the economic surplus method. The aggregate gross economic benefits from all the technologies were compared with the research cost for computation of the net benefits. All the technological interventions likely to generate economic benefits (net present value) worth ₹ 190.8 billion over 20 years at 2014 prices. More than three-fourths of the aggregate benefits were generated by wheat and common rice varieties due to their larger adoption, and most of the aggregate benefits likely shared by the consumers. The estimated internal rate of return is 38.80% and the ratio of net benefits to the cost is 17.31.

These estimates of economic benefits are slightly lower than the median rate of return (IRR 53%) reported for India in the past for the green revolution technologies, but quite comparable to the rate of returns (IRR about 40%) from technological interventions under the National Agricultural Innovation Project. Our estimates are comparable to those obtained for CGIAR research; estimated B-C ratio for system-wide research was 4.76 for the period 1960-2001, which improved to 17.26 when the benefits were extrapolated through 2011. The estimated internal rate of return was 34 %.

Statistics and Computer Application

ICAR Data Centre

Shri Radha Mohan Singh, Union Minister for Agriculture and Farmers Welfare, inaugurated the ICAR Data Centre and launched the KVK Mobile App at ICAR-Indian Agricultural Statistics Research Institute, New Delhi.

ICAR Data Centre provides the ICT infrastructure for hosting the web applications developed by ICAR Institutes; the unified messaging solution which is based on Microsoft Exchange Server, which helps ICAR personnel to stay connected with each other via instant messaging, email, audio/video calls, persistent chat rooms, online meeting and

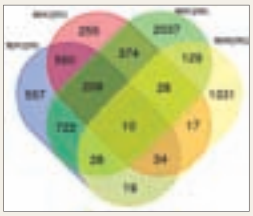
presentations for scientific/research/technological/ educational/ extension information exchange; uniform email IDs (https://mail.icar.gov.in) of all ICAR personnel under single ICAR domain for effective communication. ICAR Data Center is ISO-27001:2013 certified for Information Security and ISO 20000-1:2011 for IT Service Management System.

Management system for post graduate education: The Management System for Post Graduate Education, initially designed by IASRI and implemented for IARI, was enhanced to meet the additional requirements of outreach program of IARI, CIFE, NDRI and CAU. System enables automation and streamlining of all the academic activities of a university and builds a repository of the academic records and e-learning resources. The system was implemented at IARI, New Delhi along with its outreach programs, and CIFE, Mumbai. System was made operational for IVRI, Izatnagar (http://amsivri.icar.gov.in/) and NDRI, Karnal (http://amsndri.icar.gov.in/). System implementation was initiated for CAU, Imphal.

ICAR-Personal management information system (PMIS): PMIS, a workflow based system is developed for managing the various scientific cadres, transfer process with real time tracking of transfer applications, posting of newly appointed scientists in a transparent

Herbicide resistance genes for better chickpea variety development

A mega team of ICAR scientists from ICAR-IIPR, Kanpur and ICAR-IASRI, New Delhi successfully reported candidate genes and pathways of herbicide tolerance in chickpea for the first time in the world (http://journal.frontiersin.org/article/10.3389/fpls.2017.00958/full). Present finding reports 6,310 differentially expressed genes (DEGs), of which 3,037 were regulated by 980 miRNAs, 1,528 transcription factors associated with 897 DEGs, 47 Hub proteins, 3,540 putative simple sequence repeat-functional domain marker (SSR-FDM), 13,778 genic single nucleotide polymorphism (SNP) putative markers and 1,174 Indels. Reported markers can be used for future association studies to develop marker assisted selection (MAS) for refinement. In endeavour of chickpea variety development programme, these findings can be of immense use in improving productivity of chickpea germplasm with better ecological and food safety.



and efficient manner at ICAR. PMIS System was successfully implemented for posting of new recruited scientists and online transfer process in ICAR.

Genetic code of groundnut stem rot disease causing fungus *Atheliarol fsii:* A team of scientists from JAU, Gujarat and ICAR-IASRI, New Delhi has successfully sequenced this fungal genome (~73Mb) and identified 16,830 genes. This study also revealed insight of evolution of pathogenicity and virulence. This fungal genome was sequenced for the first time in the world (https://www.nature.com/articles/s41598-017-05478-8). This finding will pave the way of genome based solution in stem rot disease management leading to better productivity of groundnut crop in tropical region of world.

Estimating crop area, yield and production under mixed, repeated and continuous cropping: Sampling methodology for estimating crop area, yield and production under mixed and continuous cropping was developed. This methodology was tested and validated in Indonesia, Rwanda and Jamaica. The developed sampling methodology is likely to be adopted globally specially in developing countries in future by Food and Agriculture Organization of the United Nations. One technical report in the form of Technical Report Series: GO-21-2017, March 2017, Global Strategy, FAO, Rome, was published by the FAO and is available at FAO's Global Strategy web site.

Private food grains stock estimation: A suitable sampling methodology aligned with existing Input Survey for estimation of private food grain stock and post harvest losses at farm level was developed. The estimates of food grain stock, pre-harvest opening stock, production obtained, quantity sold, quantity stored, quantity disposed, percentage stock and percentage post-harvest loss at farm level were obtained along with its percentage Standard error (%SE), and were reasonably good. Therefore, it is expected that for overall holding size classes, the proposed methodology will provide farm level reliable estimates of food grain stock including post-harvest losses at district level. The project report was accepted by the FAO-India. The study established the feasibility of inclusion of developed questionnaire in the future Input Survey of Agriculture Census in India to estimate the food grains stock including post-harvest loss at farm operations and will bridge the gap on post-harvest information and private food grains stock in on-farm and off-farm domains of the supply chain.

Estimation of area and production of horticultural crops: The ICAR-IASRI is the National Level Agency (NLA) under Mission for Integrated Development of Horticulture (MIDH). Testing and validation of the methodology for estimation of area and production of horticultural crops developed by ICAR-IASRI is being carried out in Andhra Pradesh, Tamil Nadu, Maharashtra and Himachal Pradesh. Primary data collection work was completed and data entry and scrutiny of data are in progress. The methodology being tested and validated under Coordinated Programme on Horticulture Assessment and Management using Geoinformatics (CHAMAN) may be implemented in all the states of the country from 2018-2019.

Estimation of state level crop area and production using reduces sample size: Under the pilot study Developing State Level estimates of Crop Area and Production on the Basis of sample Sizes Recommended by Professor Vaidyanathan Committee Report, a suitable sampling methodology was developed. Primary data collection work was completed in Asom, Odisha, Uttar Pradesh, Karnataka and Gujarat. The data entry work

Agricultural Research Data Book

The Agricultural Research Data Book (ARDB) 2017 was published. The ARDB 2017, which is twentieth in the series, is an attempt to put together main components/ indicators of such information and comprises 170 tables organized into 10 sections namely, Natural Resources, Agricultural Inputs, Animal Husbandry, Dairying and Fisheries, Horticulture, Production and Productivity, Agricultural Engineering and Produce Management, Export and Import, India's Position in World Agriculture, Investment in Agricultural Research and Education and Human Resources under National Agricultural Research System (NARS). Apart from updation of tables, 22 new tables added, which consist of state-wise data on area and production of 7 food grains rice, wheat, jowar, bajra, maize, pulses, oilseeds, and 5 fruit crops mango, banana, sweet orange, apple and papaya; 3 vegetable crops potato, tomato and onion; production and per capita availability of livestock products like milk, egg, and production of meat and wool. For depicting state-wise data, thematic maps were prepared using Geographical Information System (GIS).

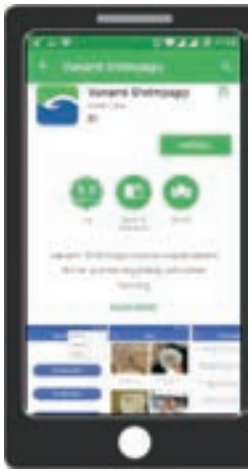
for 4 states except Gujarat has also been completed and data were received from the states. Data collection work in the State of Gujarat was completed for the Agricultural Year 2016-17 and the data entry work is in progress. Analysis of the data was done for few states and the estimates of crop area and yield was found with acceptable level of precision from a sample size of less than 2% of the whole population considered under this study. Development of online data analysis software to analyze the survey data collected under the project has been initiated.

Web based software for small area estimation: Under a study, Development of Innovative Approaches for Small Area Estimation of Crop Yield, Socio-economic and Food Insecurity Parameter, a web based software for small area estimation under an area level model was developed (http://sample.iasri.res.in/ssrs/index_sae.jsp). This software provides small area estimates for both sampled as well as non-sampled areas along with standard error and percentage coefficient of variation. The software also provides the user manual to describe the step by step procedure for using this software.

Response surface designs for resource optimization: Plackett-Burman designs were explored to obtain minimum level changes for some of the factors, keeping the total number of changes fixed as the least. A general expression for the total number of changes in the run sequences of Plackett-Burman designs was obtained and using a SAS macro Plackett-Burman designs were generated. Minimally changed run sequences for fitting response models incorporating indirect effects were investigated, and it was found that minimally changed run sequences of 2^k factorial is ensuring the constancy of variance of the predicted response. Developed an R-software package, termed as *minimalRSD*, for the generation of minimally changed run sequence for Response Surface Designs (RSDs) and hosted at https://cran.r-project.org/web/packages/minimalRSD/ index.html.

This package consists of three series of designs, viz. central composite designs (CCD) with full as well as fractional factorial points (half replicate) and Box Behnken designs (BBD) with minimally changed run sequences.

Vanami Shrimpapp: An android based mobile application 'Vanami Shrimpapp' was developed for the dissemination of technical information related to shrimp industry to the stakeholders. The App provides information on better management practices of Pacific white shrimp (*Penaeus vannamei*) farming in the format of Frequently Asked Questions (FAQs), targeting shrimp farmers and field level extension workers of coastal states. The App is available at Google Play Store free of cost, and it works off-line enabling users to access information at their preferred timings. App contents are organised in six major heads namely, shrimp pond preparation, seed selection and stocking, feeding and feed management, soil and water quality management, health management, regulation, food safety and record keeping. The App works as a two-way interactive tool containing both static and dynamic modules. In the active module, the users can post their queries through 'post a query' option, and the questions are answered within two working days after consultation with a subject matter specialist.



Empowering women in agriculture

ICAR-Central Institute for Women in Agriculture (ICAR-CIWA), a prime research institute, has the mandate of carrying out research exclusively on gender issues in agriculture. The outputs in the form of gender related information, knowledge and model have the potential of benefiting different stakeholders including farm women.

Gender sensitization for empowering women in agriculture: The outreach project on "Development and Testing of Institutional Innovations for Empowering Women in Agriculture" primarily focused on gender sensitization of the stakeholders engaged in research, extension and developmental works related to women in agriculture. Workshops covering NGOs, media and institute personnel; and training programs for farm women in jute handicrafts, garden tools, oyster mushroom cultivation and other crops were conducted. Radio programs, voice message services, success stories documentation, development of training modules and checklists etc were used as potential outreach strategies for including gender in institutional programmes and disseminating institutional innovations to the end users. For integrating gender perspectives in agricultural research and extension, Empowerment in Crop Production Index (ECPI) was developed, tested and verified. The factors influencing agri-entrepreneurship developments by rural women were identified by a checklist. Suitable agri-educational modules were developed and workshops conducted involving R&D stakeholders and selected women in the project "Promoting Agricultural Education among Rural Women for Entrepreneurship Development".

Gender Knowledge System Portal: Gender Knowledge System Portal was developed in which data on gender friendly technologies, information and statistics, publications and schemes are being uploaded. It is a single window knowledge system on gender related information, databases, research, technologies, etc. in agriculture for the benefit of policy makers, researchers, development and extension workers, teachers and students. The portal would host different data bases and information capsules generated through studies under the project and compiled from other sources. The portal would provide a platform to the R&D stakeholders working on gender issues and women

empowerment to share their information and facilitate cross learning among professionals. Information and data bases on the portal may serve as sources of inputs for researchers in formulation of projects.

Nutrition and livelihood enhancement of tribal families: The project Multi-sectoral Package of Practices for Nutrition and Livelihood Enhancement of Tribal Families, documented researchable issues in the tribal eco-system and facilitated capacity building and skill upgradation through need based and sustainable interventions for improving livelihood. Capacity building and skill up-gradation programmes were conducted in Mayurbhanj and Gajapati districts of Odisha in which 340 tribal farm families benefited through 19 field level demonstrations and technological interventions in improved methods of vegetable cultivation, nutrition gardening, intercropping for additional income generation, hygienic storage and drudgery reduction. This project could improve the farming and nutritional situations of these tribals.

Nutritional and economic security of tribal farmers and farmwomen were addressed through the project "Engendering Millet based Value Chains for Promoting Livelihood Opportunities of Farmwomen in Selected States". Opportunities for women of Koraput district in processing and value addition in fingermillet value chain were identified. For creating an enabling environment for meaningful participation of women in ragi processing, two millet processing units were established in Koraput district. In the collaborative project on "Livelihood and Nutritional Improvement of Tribal Farmwomen through Horticulture", improved nursery raising methods, improved vegetable cultivation practices, backyard nutritional garden, conservation of water, organic manuring, vermin composting and proper cultivation practices for high value vegetables and fruits, replacement of existing local varieties with high yielding varieties of horticultural crops were introduced. These interventions increased income of farm families by about 34%.

Improvement of nutrition and livelihood: For improvement of nutrition and livelihood of farm women emphasis was on development of sustainable production systems like, integrated farming system for farm women under different agro-ecosystems for rural households. In three village eight agriculture and animal husbandry based integrated farming system models were implemented, which consisted of different components, viz. crop (high yielding short duration varieties replacing the traditional once), poultry (Vanaraja breed), fiber (jute), and fisheries (catla, rohu and mrigal). A model of 1.5 acre (0.9 acre–cropping system, 0.45 acre–horticulture, 0.07 acre–honeybee, 0.06 acre–cow shed, 0.02 acre–bio-compost) was suitable for increasing income of a five member family over traditional cropping system by 33%. A resource efficient horticulture model was developed with drip irrigation, crop diversification, high density plantation, protected cultivation, coconut based multi-storey cropping, intercropping options with banana, drumstick, staking method of vegetable cultivation, mulching in pineapple etc to maximize farm income in minimum land under the project Development of resource efficient horticulture model for livelihood improvement of rural women. Farm-women were sensitized in Integrated pest management through interventions in seed treatment, machan planting system, resistant varieties, pheromone trap, yellow sticky trap, neem oil and trichocard in their own field. For further improvement of livelihood of women, a project on Promoting gender equity through family poultry production was carried out with an alternate non competitive feed ingredient in poultry feed (incorporating azolla up to 10% in the diet of Vanaraja laying hens without any adverse affect on egg production and egg quality). Socio economic profile of 100 households from 3 selected villages was collected for possible interventions for their livelihood improvement.

Achievements of AICRP on Home Science: Under the component of Home Science Extension and Communication Management, work was done under projects entitled Dynamics and performance of women groups in agriculture and allied sectors and Techno socio-economic dimensions of women empowerment. In the first project, secondary data were collected from 2,832 SHGs out of 3,749 on the profile of the group members, group dynamics, group activities and income generation/ entrepreneurship and empowerment status by using a developed interview schedule. Under the project Women empowerment, a campaign was organized for creating awareness regarding popularization of kitchen/ herbal gardens and vermicomposting units were established. Considering

Drudgery reduction of farm women

Different projects were taken up for reducing operational drudgery and increasing efficiency of farm-women. Under the project "Ergonomic evaluation of selected manually operated farm equipments in mango and cashew nut", selected manually operated farm equipment and the energy expensive activities were identified and evaluated ergonomically. Minor orchard tools, fruit harvesters with adjustable handles were introduced and found to be useful. Under project Technological interventions for drudgery reduction with increased work efficiency through women friendly farm tools/ equipment/ technologies in Odisha, woman-friendly farm tools namely seed treatment drum and cotton stalk puller were scaled up. Introduced eight tools, viz. DRWA hand operated maize dehusker-cum-sheller, Cono weeder, Paddy drum seeder, CRRI hand winnower, Sitting type groundnut decorticator, hanging type grain cleaner, tubular maize sheller and improved sickle to SHGs through KVKs of OUAT for field assessment. Further, tools and implements repository, database on gender friendly tool packages for paddy, vegetables and maize, checklists and test protocol for hand ridger were developed under the project "Ergonomic Studies for Increasing Work Efficiency and Productivity of Farm Women".

the changing faces of rural livelihoods in India, the AICRP on Home Science carried out the family and group entrepreneurship development with market linkage looking for sustainability in their livelihood security.

Under the project Characterization of drudgery of women in the production environment and assessment of technology packages in mitigating drudgery, drudgery of women was characterized for three crops and five production systems in the operational villages. The results indicated how location and factors impacted drudgery in production system. Seed-cum fertilizer dibbler, rice picker, sapling transplanter and flower harvest bag were ergonomically evaluated after field interventions. Twenty-six technologies were up-scaled and disseminated among SHG groups for mitigating drudgeny of farm women.

A standardized questionnaire was prepared to combat nutritional problem among farm families in which information on socio-economic status, assessment of haemoglobin status, anthropometric assessment, clinical signs and symptoms, assessment of knowledge, awareness and practice (KAP) among adolescent girls, nutrient intake by the adolescent girls was collected. Out of 5,069 school going adolescent girls 2,932 were screened out with haemoglobin level less than 12g / dl. Diet survey of subjects was done before intervention programme. Among all the 10 centres the mean energy intake for both control and experimental group was lowest for Rajasthan centre i.e. and highest in Karnataka centre. Protein rich recipes, viz. mix pulse shev, proteimix powder, peas stick and millet and moringa powder based value added products were developed and transferred into rural entrepreneurship

For combating occupational health hazards functional clothing kit, viz. head gear with mask, protective shirt and pant, gloves, apron, protective kurta without hood, protective kurta with hood, triangular mask and knitted fabric face cover were designed and developed for the workers engaged in different activities in agriculture, agriculture allied sectors and assessed for its suitability and acceptability among workers through trials. Refinement in apron, pleated mask and knitted gloves was done according to suggestions of respondents. Non conventional fibres from underutilized plant sources (bhindi fiber) and non woven fabric were used for making different products, viz. shopping bag, pen stand, purse, tea cozy, pot mat, coaster, file cover, seed pot etc.

A sample of academically backward children (1,167) from 10 centres, was selected for developing competency of rural youth in agriculture. Students from Jorhat, Hisar, Palampur, Pantnagar, Udaipur and Ludhiana showed high external resilience in school, home, community and peer assets which covers caring relationship, high expectation and meaningful participation. Assessment of socio-economic status of 349 school dropout youth, showed that majority of the respondents belonged to lower middle income category. A Counseling centre was established at Hatichungi, Komar Gaon, AAU, Jorhat.

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13. Information, Communication and Publicity Service

The Directorate of Knowledge Management in Agriculture is committed to promote ICT driven technology and information dissemination system for quick, effectual and cost-effective delivery of messages to all the stakeholders in agriculture. Keeping pace with the current knowledge diffusion trends, Directorate is delivering and showcasing ICAR technologies, policies and other activities through print, electronic and web mode. Directorate is the nodal center for design, maintenance and updating of ICAR website along with facilitation of network connectivity across ICAR institutes and KVKs. Besides, the Directorate provides public relation and publicity support to the council and its constituents across the country. DKMA is part of the Farmers FIRST project; its main aim is to showcase the impact of the project through print as well as social media.Under this project five trainings were conducted by the DKMA team.

Knowledge and information products

The monthly research journals, *Indian Journal of Agricultural Sciences* and *Indian Journal of Animal Sciences* made available in open-access mode besides availability of in-house journals like *ICAR Reporter* and *ICAR News* on ICAR website. The *India-ASEAN News on Agriculture and Forestry* has been again started. Besides it has also brought out special issues of the *Indian Farming* on 'World Food Day 2017' (October 2017) and 'Doubling Farmers Income' (January 2018), besides *Indian Horticulture, Kheti* and *Phal Phool*. ICAR popular magazines were reoriented to make them demand-driven and competitive. To share the agricultural knowledge and information through value added information products in print the DKMA has brought out 25 books in English and 10 books in Hindi. The DKMA has more than 120 textbooks in process under UG/PG Level textbooks programme for the Agricultural Universities, as these are written according to the revised syllabus of the Fifth Deans' Committee Report. Capacity building for agricultural knowledge management and communication was also strengthened, as its personnel conducted workshops and traingings. Publication of authoritative and benchmark publications under Handbook series- *Handbook of Agriculture, Handbook of Horticulture, Handbook of Agricultural Education* and *Handbook of Agricultural Extension* are in process at different stages.

The e-books were also brought out and copies of the electronic CDs were distributed among farmers in meetings and rallies of the Union Minister for Agriculture and Farmers Welfare. The ICAR website was 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://epubs.icar.org.in/ejournal. The ICAR website was revamped to make it more user- friendly with links to related organizations and issuing weather based agro -advisories. Now ICAR journals are read in more than 202 countries. The DKMA is also collaborating with IASRI in imparting trainings under Farmer's FIRST project. During 2017 Business Unit has achieved the target of Rs 62.00 lakh through sales of ICAR publication. Business Unit has participated in all the major events for distribution of ICAR publications and for making ICAR publications more visible to agricultural community. Capacity building of ICAR scientists for agricultural communication and knowledge management was strengthened through imparting training courses at several Institutes. The DKMA organized a two- day National Workshop on Developing a Roadmap for Agricultural Knowledge Management in India, at NASC Complex, Pusa, New Delhi from 27 to 28 September 2017. The technical sessions were on: Present status and future prospects of knowledge management; Managing data, information and knowledge banks for higher agricultural gains; Role of media and industry in knowledge management; and Restructuring the infrastructure for knowledge management. The strategic policies to be developed for content development, infrastructure and manpower for Knowledge management in agriculture at ICAR-DKMA were discussed at length. ICAR-DKMA has developed an ICAR-Public Interface, *e- Krishi Manch*, as a public-connect platform for stakeholders in an efficient, quick and simple manner by direct approach. The portal was launched on 17 May 2017. *e-krishi Manch* has 1,812 registered users and received 110 queries from various stakeholders.

Social media

The Council shares the knowledge resources of ICAR with scientific community, students and public on social media platforms. The facebook page has attracted > 152,000 likes and twitter handle has 18,300 followers. The YouTube Channel of ICAR includes 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 each. Contents for Social Media are conceptualized and developed to lay emphasis and spread awareness on Government schemes and programmes along with

new varieties and technologies. ICAR /DARE websites: During the reported period more than 1,355 new pages were created and more than 1,451 pages were updated with latest inputs. Specific weather based agro-advisories and contingency plans for agricultural activities were updated on the websites regularly to benefit farmers and extension functionaries. Crucial advisories were developed and posted from time to time in view of natural calamities. Currently, DKMA is revisiting its strategies in the light of open access policy, quality policy and e-governance modules. The gestation period of knowledge and information products is being reduced by adopting innovative management practices and latest IT tools. Linkages are being developed with international organizations to project the Indian agricultural research on global fora. DKMA, with all its efforts, is sensitizing and catalyzing ICAR system towards a new information and communication regime ensuring outreach of agricultural research to its stakeholders. The ICAR website (www.icar.org.in) presents knowledge and information in bilingual mode (English and Hindi) for a wide range of stakeholders that include researchers, students, policy planners, farmers and civil society. The website is updated regularly with news, success stories, announcements, circulars, tenders and other relevant content. Currently, on an average more than three lakh hits per month from visitors across the globe are recorded with a significant percentage of new visitors. The ICAR website was updated on regular basis, 1,355 new pages were created, and visitors from 221 countries visited the website from across the globe; the top five countries include India, United States of America, Union Arab Emirates, United Kingdom and Phillipines. Under outreach programme, video films depicting successful technologies were produced and telecast over National and Lok Sabha channel. Dedicated radio (AIR) and television (Doordarshan) programmes on ICAR launched Facilitated Media Meets at ICAR institutes.

E-publication platform

The ICAR website also hosts e-publishing portal for textbooks (http://epubs.icar.org.in/ebooks) of the Council. The portal provides online manuscript submission, review and e-book hosting platform for authors, students, academicians. The portal also has catalogue of textbooks, etc. The on-line availability of research journals online in Open Access has enhanced visibility and improved the global reach. The top ten countries those read ICAR literature are Iran, Turkey, China, Algeria, Egypt, Indonesia, USA, South Korea, Mexico and Malaysia. Research journals have 55405 registered readers and total registered users on the e-publishing platform of research journals are more than 75,000. In all the e-pubs platform Indian Agricultural research journals (http://epubs.icar.org.in/ejournal) hosts 39 research journals published by the Council or professional societies in agriculture. Viewership analysis revealed that on this portal—total sessions were 253,376

by 139,865 users, and they viewed 1,459,581 pages in 188 countries. Open access archives pertaining to the *Indian Journal of Agricultural Sciences*, *Indian Journal of Animal Sciences*, *Indian Farming* and *Indian Horticulture* have 511 issues with more than 13,000 articles. Write-Workshops were also organized to motivate and train young authors in scientific writing. Trainings on 'Online article processing' and editorial assistance, were provided to various stakeholders for printing and publishing of scientific on-line journals.

Showcasing of new technologies

The Council organized and participated in **15** exhibitions for showcasing the new technologies on the occasion of national and international events, and sale of ICAR publications and e-products (January-December 2017). Notable exhibitions in which ICAR participated are 15.

Consortium for e-Resources in Agriculture

Consortium for e-Resources in Agriculture (popularly known as CeRA) is the first of its kind for facilitating 24×7 online access of select journals in agricultural and allied sciences to all researchers, teachers and students, policy planners, administrators and extension specialists in National Agricultural Research and Education System (NARES) through IP authentication. Currently CeRA is subscribing to over 3,900 journals and 1,174 e-books to 152 member institutions of NARES. To create awareness among scientists/faculty/students of member initiations of CeRA, a detailed programme was envisaged region wise. More than 100 participants from all the 152 member institutions of CeRA participated for the workshop. The workshop helped in dissemination of information among the member institutions. During 2017, CeRA introduced the provision of e-books and procured 1,174 e-book related with agriculture and allied filled. These e-books are accessible to all the member institutions of CeRA from January onwards. Apart from this, CeRA has also provided access of new e-Resource i.e. ISO standards, 84 Wiley e-journals and Indiaagristat.com to member institutions. During this period over 23 lakhs of full text journals were downloaded by member institutions of CeRA and over 5 thousand Document Delivery Requests were successfully fulfilled.

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14. Technology Assessment, Demonstration and Capacity Development

The frontline extension system as part of National Agricultural Research System of the country has taken up a number of activities through Krishi Vigyan Kendras (KVKs) and other programmes for application of farm technology in farmers' field. Besides taking up technology assessment, refinement, demonstration and capacity development programmes during the year, the other initiatives such as Farmers FIRST, Attracting and Retaining Youth in Agriculture (ARYA), Climate Resilient Integrated Farming System (IFS), Cluster Frontline Demonstration of pulses and oilseeds, Cereal Systems Initiatives for South Asia (CSISA), National Innovations on Climate Resilient Agriculture (NICRA), documentation and registration of farmers' varieties under Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA), 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 and refinement

Assessment: During the reported year, 3,446 technology interventions across 3,340 locations by laying out 26,029 trials on the farmers field on various crops under different thematic areas, namely cropping systems,drudgery reduction, farm machineries, integrated crop management, integrated disease management, integrated nutrient management, integrated pest management, integrated weed management, processing and value addition, resource conservation technologies, seed and planting material production, storage techniques besides varietal evaluation for cereals, pulses, oilseeds, fruits, vegetable crops and commercial crops.

In livestock, 580 technology interventions across 584 locations covering 6,160 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 livestock species covered were cows, buffaloes, sheep, goats, poultry, pigs, and fisheries.

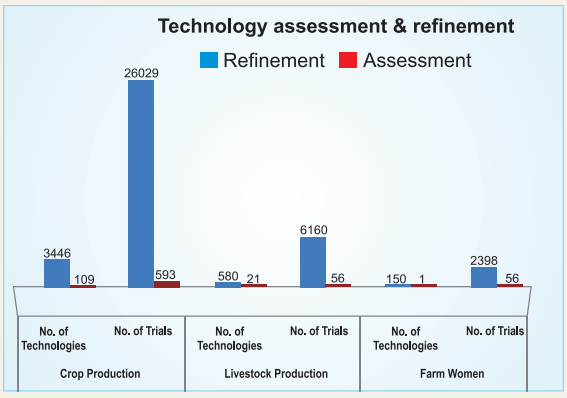
As many as 159 technologies related to rural women were assessed at 483 locations through 2,398 trials under the thematic areas of drudgery reduction, health and nutrition, processing and value addition, energy conservation, small-scale income generation, storage techniques, household food security, organic farming, agroforestry management, mechanization, resource conservation technology. The major enterprises included were mushroom cultivation, vermi-compost production, nutritional gardens, processing of fruits and vegetables, etc.

Refinement: Total 109 technological interventions were refined across 123 locations by laying out 593

Off-season vegetable production to improve the livelihood of Kullu farmers

Kullu district of Himachal Pradesh, owing to its diverse agro-ecological situations, is endowed with comparative advantage for growing various off-season vegetables. As the apple cultivation/production shifted further to higher altitudes, off-season vegetables emerged as a suitable remunerative alternative for farmers. KVK, Kullu, initiated its programmes towards the diversification of agriculture through off-season vegetable cultivation. The total area under off-season vegetables in the district has increased from 301 ha in 1995-96 to 6,537 ha in 2016-17. The productivity (average) of the vegetables as a whole also increased to 188.5 q/ha in 2016-17; about 18-20 times more than 1995 - 96. Various vegetable cultivation technologies popularized by KVK, Kullu, have also spread to the adjoining district, Mandi, where large numbers of farmers have now started vegetable cultivation as a vocation for their income improvement. With the adoption of vegetable cultivation technologies (65-85 %), the net annual income of the farmers in the district now ranges from ₹ 1.5 lakh to ₹ 2.0 lakh from one acre of land.

As there is a huge demand of fresh vegetables in the nearby big city markets, the farmers supply their vegetable produce directly to the number of market yards established by Agricultural Produce Marketing Committee (APMC). The produce is transported to other cities and towns, where the demand is further high.



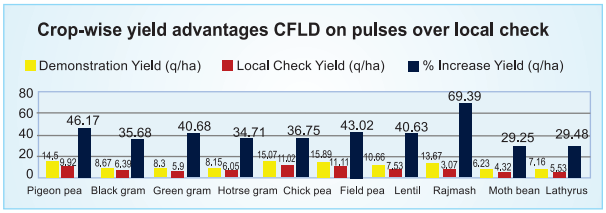
trials in the farmers' fields under various thematic areas, viz. integrated crop management, integrated disease management, integrated nutrient management, integrated pest management, integrated weed management, resource conservation technologies and varietal evaluation. The major crops included are cereals, pulses, oilseeds, fruits and vegetables.

Besides, 21 technological interventions in 28 locations were also refined through 56 trials on livestock, poultry and fisheries enterprises under the thematic areas, viz. disease management, evaluation of breeds, feed and fodder management and nutrition management. In addition, one women specific technology was also refined by conducting 10 trials in 3 locations under the thematic areas, viz. health and nutrition.

Frontline demonstrations

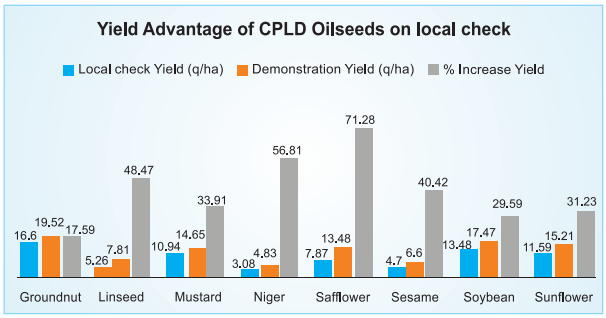
During the year, a total of 182,696 demonstrations covering an area of 66,203 ha were organized. Of these 71,910 (39%) demonstrations covering an area of 28,764 ha were on pulses; 39,514 (22%) demonstrations covering an area of 16,928 ha were on oilseeds and 50,579 (27%) demonstrations covering an area of 15,214 ha were on other crops (cereals, millets, commercial crops, fiber crops, spices, medicinal crops, plantation crops, fodder crops and horticultural crops, etc.). Demonstrations (8,140) were organized to promote the hybrids cultivation in millets, oilseeds, pulses, fodder crops etc., covering an area of 3,483 ha. Demonstrations were conducted on tools and farm implements (5,040) covering an area of 1,814 ha; on livestock enterprises (5,566); and on other enterprises including gender-specific technologies for women empowerment (1,974).

Pulses: A total of 71,910 cluster frontline demonstrations were conducted covering an area of 28,764 ha in various pulses— in *kharif* 24,522 demonstrations (9,809 ha area), in *rabi* 35,672 demonstrations (14,269.85 ha), and in summer 11,710 demonstrations (4,684.75 ha). Out of total area of 28,764 ha in the country the major pulses FLDs were on *kharif* pulses i.e. pigeon pea (4,741.8 ha), blackgram (2,734.6 ha), greengram (1,973.8 ha), horsegram (228 ha), rajmash (19.12ha), mothbean (112 ha) followed by *rabi* pulses, i.e. chickpea (6,014.46 ha), lentil (3,689.7ha), fieldpea (1,819.09ha), greengram (1,375.4ha), blackgram (1020.2ha), pigeon pea (83ha), rajmash (180ha), lathyrus



(88ha); and summer pulses, greengram (3962.9ha), blackgram (717.4ha), rajmash (4.45 ha).

Oilseeds: A total of 39,514 cluster frontline



demonstrations were conducted covering an area of 16,928 ha in various oilseeds—highest in *rabi* (area, 10,264 ha, number-23,866) followed by *kharif* (area, 5,788 ha; number-13,539) and summer season (area-875 ha; number-2,109). During *kharif* season more area (18.66 ha) was covered under soybean demonstrations (4,145) followed by sesame (1,732.7 ha) through 4,141 demonstrations. Other crops included were groundnut (5,110.66 ha), niger (505 ha) and sunflower (173.6 ha). During *rabi* rapeseed and mustard occupied highest area of 5,826.69 ha with 13,750 demonstrations followed by 1,278.5 ha area under groundnut (2,745 demonstrations), 1,091.28 ha area under linseeds (2,626 demonstrations) and 885.6 ha area under sesame (2,151 demonstrations). Other *rabi* crops demonstrated were sunflower (395 ha area) and safflower (209.0 ha). Similarly, in summer season highest area (287.0 ha) was covered under groundnut (726 number of demonstrations) followed by 285.6 ha area under sesame through 659 numbers of demonstrations. Other summer oilseed crops demonstrated were rapeseed and mustard (31.01 ha) and sunflower (190 ha).

Cereals: In rice, wheat, maize, and barley 25,157 demonstrations were conducted, covering an area of 9,100 ha. The highest increase in yield was recorded in oats (51.6% increase over farmers' practices), followed by 27.2 % in maize and 25.9 % in rice. Wheat demonstrations recorded an increased yield of 22.7% over farmers' practices.

Millets: Demonstrations were also conducted on foxtail millet, finger millet, pearl millet and kodo millet in 2,168 farmers' fields covering an area of 900.1 ha during the year, achieving the highest average increase of 37.4% in finger millet over local checks/farmers' practices.

Commercial crops: In the country 1,843 demonstrations were conducted in sugarcane (447), cotton (1,095) in an area of 655 ha through KVKs. The yield increase in FLDs was 17.7% in cotton, 15% in sugarcane, and 32.4 % in tobacco as compared to local checks in respective crops.

Fodder crops: Demonstrations on crops such as barseem, cowpea, lucerne, maize, napier, pearl millet, guinea grass, horse gram, sorghum and sudan grass were conducted in 2,120 farmers' fields covering an area of 448 ha. The fodder yield increase under demonstrations ranged from 21.4% in berseem to 38.2%

in napier grass as compared to their local checks.

Horticultural crops: Altogether, 18,760 demonstrations on horticultural crops comprising vegetables (12,192), fruits (2,315), flowers (567), spices and condiments (2,417), tuber crops (664) and plantation crops (605) were conducted in 3,907 ha area in the country. The increase in yield recorded under FLDs as compared to farmers' practice was 35.0% in fruits, 47.1% in vegetables, 29.4% in flowers, 38.7 % in spices and condiments, and 29.9% in plantation crops over the farmers' practices.

Hybrids: To achieve higher harvest index in crops, KVKs conducted 8,140 demonstrations on hybrids covering an area of 3,483 ha in cereals, millets, oilseeds, pulses, fodder crops, cotton and horticultural crops. In rice, sorghum, pearl millet and maize, 4,813 demonstrations were conducted in 1,955.3 ha to demonstrate the potential of various hybrids. Demonstrations on hybrids of oilseeds were conducted across the country covering 833.3 ha and achieving 44.35% increase in yield in NRCH-B101 mustard compared to local checks while 726 demonstrations were conducted on fodder cultivars achieving enhanced yield up to 291.5 % in napier grass as compared to local checks. Similarly, 1,395 demonstrations were conducted on vegetable and fruit crops hybrids covering an area of 278.4 ha and has achieved yield increase as high as 179.1% in coriander (Arka isha) and 154.6% in Pumpkin (Arjuna F_1 hybrid).

Farm mechanization: Demonstrations (5,040) were conducted on improved tools and farm implements including drudgery reduction technologies covering an area of 1,814 ha.

Livestock and fisheries: Demonstrations (7,513) were conducted covering dairy animals, sheep and goat, poultry birds, ducks and rabbits, 262 units of fisheries and 8,193 units of prawn cultivation.

Other enterprises: Demonstrations were carried out on bee keeping (28 units), mushroom production (15,724 units), vermi-compost production (243 units), sericulture (178 units) and value-addition (944 units) activities covering a total of 45,280 units in the country.

Promoting home scale women-entrepreneurship with Yenjuk - a wild edible fruit in Longleng district, Nagaland

Smt. Wanmei Phom, a housewife from Tangha village established a home scale processing unit with highly perishable Yenjuk, a wild edible fruit available in plenty during the season and not preferred for direct consumption due to high acidic taste and therefore go waste every year. She started processing Yenjuk fruit with sugar and jaggery in right proportion and final product is packed in LDPE/HDPE pouch which can be stored for eight months. Ten packets (100 g) of preserved yenjuk fruit product can be prepared from 1 kg of fruits. KVK, Longleng, took initiatives and provided packaging materials as well as encouraged her in Food Safety and Standards Authority of India (FSSAI) for registration so that she could expand her business. She has processed 1,500 packets of preserved yenjuk and earned a net profit of ₹ 16,746. Now her product is sold not only in the District but also in the local markets of Kohima and Dimapur round the year.

Capacity development

As many as 49,768 training programmes were organized wherein 14.21 lakh farmers/farm women, rural youths and extension personnel participated and benefited.

Farmers and farm women: Training courses (38,941) were organized on various technologies for the benefit of 11.31 lakh farmers and farm women. These courses were on productivity enhancement of field crops (22.55 %), horticultural crops (15.57%); plant protection (14.68%); empowerment of rural women (12.05%); livestock production and management (11.09%); soil health and fertility management (8.56%); farm machinery tools and implements (2.4%); capacity building and group dynamics (5.39%); production of input at site (2%); fisheries (2.4%); and agro-forestry (1.4%). Out of these courses, 51% were conducted on campus (19,522) and 49% were organized off-campus (19,419). Among the crop production technologies, about 36 % of the training courses were on integrated crop production technologies followed by weed management (7.36%) and seed production (11.35%). Out of 6,064 training courses on horticulture, 3,308 were on vegetable crops, 1,606 on fruit crops, 405 on spices, 241 on ornamental crops, and 136 courses on medicinal and aromatic crops.

Rural youth: Skill-oriented training courses (6,788) were organized for 1.75 lakh rural youth, including 55,742 young women (32%) during the year. These courses were on integrated farming (6%), mushroom production (9%), value-addition (8%), dairy farming (6%), seed production (6%), vermin-culture (3%), nursery management of horticulture crops (4%), bee-keeping (4%), protected cultivation of vegetables (3%), repair and maintenance of farm machinery implements (2%), sheep and goat rearing (4%), poultry production (3%), production of organic inputs (6%), and small-scale processing (2%).

Extension personnel: Capacity development programmes (4,039 courses) were also conducted for 1.14 lakh extension personnel, out of which 28,614 (25%) were women personnel. These courses were organized for extension functionaries working in government and non-government organizations who were directly or indirectly related with the development of agriculture sector. Training was imparted in frontier areas of agricultural technologies related to productivity enhancement in field crops, integrated pest management, integrated nutrient management, group dynamics and famers' organization, management of farm animals, rejuvenation of old orchards, women and child care, livestock feed and fodder production, protected cultivation technology and

Sugarcane variety Co-0238 doubling farmer's income in Saharanpur

District Saharanpur cultivated sugarcane in an area of about 79,634.00 ha. The popular sugarcane varieties CoSa 767, CoSa 8436, Coj 64 etc. being cultivated by farmers are susceptible to diseases and give low yield. Co 0238 variety of sugarcane (released in 2014) was demonstrated in farmers' field. The average yield recorded at farmers field was 1,375 q/ha over the local yield of 710 q/ha with cost of cultivation of ₹ 151,960/ha, gross income of ₹ 412,500/ha and a net profit of ₹ 260,540/ha. KVK has taken up steps for popularization of this variety in the district. As a result, within the span of three years the variety Co 0238 is being cultivated in about 43,000 ha out of 79,634 ha area under sugarcane cultivation in the district. The farmers of adjoining districts are also impressed by the performance of Co-0238 variety and are now demanding the seed of this variety.

Information and Communication Technology (ICT) applications.

Sponsored training: A total of 5,109 sponsored training courses were conducted benefiting 2.08 lakh farmers and farmwomen, rural youth and in-service extension personnel. Most of the sponsored courses were related to on-site input production, economic empowerment of women, processing and value-addition, methods of protective cultivation, farm machinery tools and implements, fisheries management, household nutritional security, animal nutrition management, animal disease management, drudgery reduction of women and fisheries.

Spread of vegetable nursery raising through poly tunnel in Dehradun district

Poly tunnel technology was established in 12 villages of Raipur block and 20 villages of Kalsi and Chakrata blocks of Dehradun district in Uttarakhand. Further, this technology was also established in three more villages of Vikasnagar block under the financial support of NABARD, Dehradun where farmers are raising vegetable nursery and supply to the farmers on reasonable rates. Consequently, poly tunnel technology was spread across 50,000 sq. m. area in which farmers are raising more than 2 crore seedlings of different vegetables every year. As a matter of fact, vegetable's nursery raised under poly tunnel condition and their timely and early transplantation in the field significantly improved the productivity and production of vegetables. Mortality of seedling in the field during and after plantation is almost nil if seedlings are raised under poly tunnel. Introduction of poly tunnel technology increased the productivity of tomato, brinjal, chilli, capsicum, cabbage, cauliflower up to 30 % owing to healthy, disease free planting material and their cent per cent survival in the field. The productivity of bottlegourd, bittergourd, cucumber, smoothgourd, ridgegourd also increased up to 20 % due to early nursery raising and their plantation in the field before peak period. Hence, farmers harvested early production, which fetched premium price in the markets that enabled the farmers to earn up to ₹ 2.50 to 3.00 lakh from 1 ha of land in a year.

Extension programmes

For creating awareness among farmers about improved technologies and to provide timely advisory to farmers, KVKs organized different extension programmes. Extension programmes/activities (6.07 lakh) in the form of advisory services, diagnostic and clinic services, celebration of important days, exhibitions, exposure visits, ex-trainees *sammelan*, farm science club conveners' meet, farmers' seminar, farmers' visits to KVK, field days, film shows, group meetings,

Modified manual groundnut decorticator became boon for Etah farmers

Farmers of Etah (Uttar Pradesh) were facing problems in decorticating of groundnut because they had no other option for preparing seeds except to break the groundnut pod by pressing it by hand fingers, which is really very tedious, time taking and requires whole family engagement in this work. The grain damage was more with existing groundnut decorticator, therefore farmers did not adopt it. The KVK, Etah modified the ICAR- CIAE Manual Groundnut Decorticator with inclined concave opening instead of horizontal concave opening wherein only 2% grain damage was observed as against 7-10% with existing decorticator and also the decorticating capacity has been increased up to 548% over farmers' practice. As a result, a group of five farmers started custom hiring services of modified manual groundnut decorticator under the guidance of KVK, Etah and started earning ₹ 15,000 to ₹ 25,000/ year from single groundnut decorticator mainly in sowing time of groundnut during February, March and July. Besides, one manufacturer at Awagarh has also started fabricating the modified manual groundnut decorticator and selling at the cost of ₹ 3,250/ machine.

kisan ghosthi, kisan melas, lectures delivered as resource persons, *mahila mandal* conveners' meetings, method demonstrations, plant/animal health camps, scientists' visit to farmers' field, self-help group meetings, soil-health camps, soil-test campaigns, workshops and others, were organized which were attended by 147.50 lakh participants of which 144.15 lakh were farmers and 3.34 lakh extension personnel. The KVKs also organized 2.98 lakh other extension programmes through electronic and print media to have wider coverage in the district. These included electronic media 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.

Production of technological products

KVKs produced large quantity of technological products like seeds and planting materials of improved varieties and hybrids, bio-products and elite species of livestock, poultry and fish which benefited 58.81 lakh farmers in the country.

Seeds: During the year, 9.67 lakh quintal seeds of improved varieties and hybrids of cereals, oilseeds, pulses, commercial crops, vegetables, flowers, fruits, spices, fodder, forest species, medicinal plants and fiber crops, were produced and provided to 44.40 lakh farmers.

Planting materials: Quality planting materials (459.49 lakh) 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 7.53 lakh farmers.

Bio-products: Bio-products, namely, bio-agents (94.46 q), bio-pesticides (1,771.67 q), bio-fertilizers (2,935.23 q), vermi-compost, mineral mixture etc. were produced and supplied to the extent of 10,868.17 q and benefiting 6.62 lakh farmers.

Livestock, poultry and fish fingerlings: Improved breeds of cow, sheep, goat, buffalo and breeding bull were produced and supplied to 25,462 farmers. Different strains/breeds/eggs of poultry birds (chickens, quails, ducks and turkey) were provided to 20,397 farmers. Improved breeds of pigs were provided to 417 farmers. KVKs also enabled 45 farmers to establish small rabbit rearing units by providing 129 rabbits. Fish fingerlings (41.18 lakh) were produced and supplied to 2,217 farmers.

Technology week

Technology week, under public-public and public-private partnership mode, was organized by KVKs benefiting 14.59 lakh farmers, farm-women, extension personnel, rural youth and members of self-help groups. The events included 29,033 extension activities such as seminars, skill demonstrations, film shows, field visits, live demonstrations, exhibitions and scientist-extension personnel-farmer interactive sessions.

Soil, water and plant analysis

A total of 7.54 lakh samples (comprising 6.99 lakh samples of soil, 0.50 lakh of water, 0.04 lakh of plant, and 0.003 lakh of manure) were analyzed covering

Adding value to millets

Tribal Women of West Godavari showed the way. West Godavari district has six mandals dominated by tribal population ranging from 7 to 64 %. These people are mostly dependent on agriculture for livelihood. Two Self Help Groups were formed, which established their own millet processing units with the financial assistance of Integrated Tribal Development Agency (ITDA) and technical guidance from KVK, Venkataramannagudem under tribal sub-plan (TSP). Each group has a membership of 15 tribal women. Both the groups branded their product by the name 'SRI FOODS' under FSSAI, Andhra Pradesh registration, Vijayawada. The processed products like *ragi, jowar*, multigrain biscuits, malt powder etc., and approximately 800 kg (40 kg each) of millet products were supplied to 28 schools every week and thereby each group is earning ₹ 200,000/ month. After deducting the expenses, net profit is shared among the members of the group. The millet products are also supplied to nearby supermarkets in Eluru, Koyyalagudem, Rajahmundry and local shandies in the villages. ITDA is encouraging the farmers by giving orders as per their requirement for official meetings and functions. Recently an outlet in Eluru Rythu Bazar was also started and the sales are encouraging with a turnover of about ₹ 30,000 to 50,000/ month.

Experiences of farmer-led seed production in Nandurbar, Maharashtra

The KVK, Nandurbar facilitated seed production of paddy, onion, redgram and chickpea through tribal Self Help Groups (SHGs) of Nandurbar district in convergence with DOGR, Rajgurjnagar since the year 2004-05. Seed production was managed by Cluster Development Committee (CDC) and SHGs in 14 villages. The various stages of seed collection, processing, storage and distribution are managed by CDC. Jai Bajarang SHG was first tribal farmers group which hired 0.20 ha of land and received net profit ₹ 43,000 from onion seed production. Over the past 13 years 25 tribal farmer groups comprising 100 producers from 15 villages have got involved in this seed production programme in Nandurbar district. Tribal SHGs produced 16.69q of onion seed worth ₹ 8.35 lakh with a net profit of ₹ 7.45 lakh during 2016-17. Seeing the success of the intervention, many farmers are willing to become members of CDC.

Kharif potato in (Surguja) district, Chhatisgarh opened new vistas of farm economy

The Mainpat block is known as 'Shimla' of Chhattisgarh which is situated 65 km away from Surguja district headquarter. The farmers of Mainpat block grow *kharif* potato for many years but due to lack of awareness on production technologies its productivity has declined over a couple of years. Shri Matthias lives in Aamgaon village of Mainpat block has cultivated *Kharif* potato under the technical guidance of KVK, Ambikapur (Surguja) by following information on use of healthy seed material, seed treatment, sowing in ridge and furrow, timely use of balance fertilizer dose etc., and reaped huge potato production (2,179/ha) with less cost of cultivation as against 100-130 q/ha by other farmers and thus earned ₹ 205,500 as net profit/ha. The farmers of nearby villages are also impressed towards adopting production technologies of *kharif* potato for obtaining higher production and income.

12.68 lakh farmers belonging to 0.66 lakh villages and the revenue generated was ₹ 522.15 lakhs.

Rainwater harvesting

Rain Water Harvesting Units with micro irrigation system were established in 91 KVKs across the country. Utilizing this facility, KVKs have organized 248 training courses and 264 demonstrations and produced 386,421planting materials of different crops. Further, 22,386 farmers and 1,540 officials visited these units and got acquainted with the rainwater harvesting techniques.

Mobile advisory services

Mobile advisory was provided for timely and need based information to the farming community. During the reported year, 632 KVKs were involved in this service through various service providers. Information on weather, market, various farm operations, outbreak of pest and disease incidence and their control measures were given to farmers through Short Message Service (SMS). As many as 90,532 SMSs were sent to benefit 627.23 lakh farmers on various aspects of agriculture, horticulture and animal husbandry, weather forecast, and pest and disease.

National Innovations on climate resilient agriculture (NICRA)

Under the sub theme-Technology Demonstrations and Dissemination for Climate Resilient Agriculture, 1.18 lakh farmers were covered in 151 villages of 121 districts. Integrated packages of proven technologies were demonstrated in one village of every selected district for adaptation and mitigation of the crop and livestock production system to climate vulnerability. During the year, 121 KVKs carried out 14,213 demonstrations on natural resource management

Business model of Gujarat farmer for growing vegetable under protected conditions

Shri HareshbhaiViradiya, an innovative farmer of Motamahika village, taluka-Gondal, district Rajkot of Gujarat, established greenhouse of one acre area under the technical guidance of KVK, Rajkot-II, Gujarat. Initially, he faced some problems in vegetable cultivation like heavy pest and disease occurrence and improper pollination under the protected environment. To overcome these, he adopted hand pollination at flower opening time by identifying male and female flowers. All family members were involved in doing this operation until mid-night, and by proper pollination they got maximum production and also standardized the use of IPM practices to protect their crops from heavy occurrence of pest and diseases. As compared to earlier situation, in the third year the ridgegourd yield was 15,000 kg and he earned ₹ 720,000 from one acre area in *rabi* season. He got production of other vegetables like cucumber 15,000 kg, ridgegourd 16,000 kg from the same green house and earned ₹ 1,070,000 during 2015-16 from one acre of green house and in 2016-17 he had further increased his production of vegetables (cucumber and ridgegourd) up to 39,000 kg/acre and earnings ₹ 16.0 lakh with a net profit of ₹ 12.95 lakh/acre. Shri Hareshbhai set an example of doing green house farming and his adventurous efforts encouraged 15 fellow farmers to adopt the protected cultivation of vegetables.

Shri Beniram, Morena (Madhya Pradesh) made bee-keeping a profitable venture

Shri Beniram Kushwah from village Mirghan, Morena established Bee Keeping Unit under the technical guidance of KVK, Morena, with two bee colonies in 2007-08. He has gradually increased bee colonies every year and at present he has 400 colonies. As a result his honey production and income increased substantially up to 160q and ₹ 17.40 lakh annually in the year 2016-17 respectively. He has registered his own firm. The productivity of rapeseed- mustard and pigeon pea in his area increased 15 to 25 % because of pollination by honey bees.

covering 5,785 ha; 18,337 demonstrations on crop production technologies covering 5,887 ha;1,819 demonstrations on fodder and feed production covering 727 ha area; and 14,594 demonstrations related to livestock and fisheries. Capacity-building interventions and the extension activities like exposure visits benefited 43,969 farmers.

Technological backstopping

The Directorates of Extension (DEs) of SAUs/CAUs organized 311 capacity development programmes for updating the technical knowhow of 13,995 staff of KVKs. Likewise, the ICAR-Agricultural Technology

Mass campaign to mitigate crop residue burning in Punjab and Haryana

A massive campaign was organized by 35 KVKs in Rice-Wheat Cropping System belt of Punjab and Haryana for creating awareness among farmers and other stakeholders against ill effects of crop residue burning on soil fertility and environment. The campaign was coordinated by ATARI, Ludhiana and organized at KVKs with the active participation of farmers and technical support of ICAR Institutes, Agricultural Universities and state line departments by bringing all the stakeholders at one platform.

Farmers were motivated by organizing *Kisan melas, Sammelans, Gosthis*, Travel Seminars, Group Meetings with Village *Panchayats*; releasing of five lakh residue management advisories; distributing extension literature; and delivering 22 Radio and TV talks. Besides, special Vad-Samvad programmes were also organized on DD Kisan Channel to highlight the issue for wider publicity. To demonstrate the benefits of crop residue management at multi-location strategic sites, as many as 1,200 live demonstrations were conducted in 4,708 ha to popularize the use of happy seeder, zero till machine, baler cum knotter and other residue management practices.

Six Climate Resilient Villages (four in Punjab and two in Haryana) were made residue-burning free**.** It has also created impact in nearby 42 villages, where burning was very less. The farmers who are fully convinced for not burning crop residues for the last three years have also been taken in loop to motivate other fellow farmers to adopt various interventions of crop residue management. The KVKs of Punjab and Haryana are continuing their efforts and generating data from demonstrations for impact analysis and also preparing inventory of farmers who have managed crop residue successfully without burning so that good practices of composting of straw and use of crop residue management implements like happy seeder, zero till drill, baler cum knot maker etc. could be promoted among farming community on large scale.

Cultivation of organic betelvine in Sagar Island

Betelvine is an important cash crop in Sagar Island. Especially the *Meetha Pata* variety grown here is very famous countrywide. The betelvine leaves of Sagar Island are losing its characteristics like aroma, flavour and other distinct features owing to the use of excessive and injudicious use of chemical fertilizers. Shri Swapan Bhuia, a progressive farmer of remote Sagar Island in extreme south of South 24 Parganas has established Hi-tech Shade Net Boroz with the financial help of National Horticulture Mission and technical guidance of KVK, Nimpith. After training, Bhuia started preparing bio-fungicide *Trichoderma* and bioinsecticide *Metarhizium* with the help of domestic pressure cooker and a specially designed wooden box at his farm, and started applying these organic inputs to the betelvine orchard. Now, Shri Swapan Bhuia does not use any chemical pesticides for treatment of betelvine saplings, the soil of his boroz, and for spraying over the vines. The use of *Trichoderma* (bio-fungicide) eradicated the pathogens of *Phytophthora* rot (*Phopsa/Togra*), *Sclerotium* collar rot (*Gendi*) and *Colletotrichum* leaf spot (*Kath chitla*). The *Metarhizium* (bio-insecticide) took care of sucking pests, like Thrips. He also used *Pseudomonas fluorescens*, neem oil, Beauveria as other biopesticides. He depends upon vermicompost, oilcakes, and biofertilizer like *Azotobacter*, PSB, VAM, etc. Earlier, by conventional means, he used to sell betel leaves worth ₹ 6.30 lakh after investing ₹ 1.5 lakh in a year. Now he is earning ₹ 8.00 lakh per year after investing only ₹ 0.80 lakh. Shri Swapan Bhuia is now recognized as the lead farmer of betelvine in the district.

Research Application Research Institutes (ATARIs) upgraded the knowledge and skills of 5,362 staff of KVKs by arranging 100 capacity development programmes at various SAUs and ICAR Institutes. Besides, DEEs of AUs also organized 767 workshops and meetings for effective implementation of programmes of KVKs. The officials of these Directorates made 2,856 visits to the KVKs during scientific advisory committee meetings, field days, technology weeks, workshop/seminar, training programmes, etc. to review and monitor the activities of KVKs in the operational areas of respective Universities. They also made 2,679 field visits to review and monitor activities at farmers' fields like on-farm trials, frontline demonstrations, farmer-scientist interaction, exhibitions, etc. These directorates also arranged and provided technological products like seed to 455 KVKs, planting materials to 168 KVKs, bio-products to 151 KVKs, livestock breeds to 73 KVKs, livestock products to 64 KVKs, and poultry breeds to 82 KVKs. The DEEs published 337 technology inventories for the benefit of farmers.

Agricultural Technology Information Centre: Forty-seven Agricultural Technology Information Centres (ATICs) in the country served as single window delivery system by providing technology information, advisory services and technology inputs to the farmers.

In all, 7.03 lakh farmers visited the ATICs for technological solutions during the year. Technological information was provided to 2.36 lakh farmers, both through print and electronic media. Farmers (4.52 lakh) got quality technological inputs namely 17,827.59 q seeds, 12.44 lakh planting material, 899 livestock, 0.09 lakh poultry birds and 228.7 q bio-products through ATICs. Besides, 1.86 lakh farmers were benefited by diagnostic and advisory services like, soil and water testing, plant diagnostics, veterinary advisory services, soil health cards etc.

SPECIALIZED PROGRAMMES

New India Manthan-Sankalp Se Siddhi

The major thrust of *Sankalp Se Siddhi* was to create mass awareness about government of India's commitment for doubling farmer's income by the year 2022. The country level awareness programme was organized from 19 August to 11 September 2017. KVKs (565) across the country organized the events with the participation of 4.5 lakh farmers. The programme was attended by 74 Union Ministers, 286 MPs of Lok Sabha and Rajya Sabha, 111 Ministers of various States, 350 MLAs, and 391 Chairmen of Zila Panchayat. Besides, 178 district magistrate and 2,176 bank officials also participated in this programme. Out of 565 programme, 315 programmes were directly covered by doordarshan and the event was telecast by 825 other channels including private and local channels.

Pre-kharif and pre-rabi Campaigns

As per the guidelines of ICAR and Ministry of Agriculture and Farmers Welfare, Government of India, pre-*kharif* and pre-*rabi* campaigns were organized by 438 KVKs with the participation of 1.69 lakh farmers across the country for better planning and Farmers' participation ensuring timely dissemination of knowledge and information, flow of technological inputs and effective crop management strategy.

New India *Manthan-Sankalp Se Siddhi*

Pulses seed-hubs

Under the project, Creation of Pulses Seed-hubs, seed hubs have been set-up at 97 KVKs for production of quality seeds of major pulse crops. During the year, 20,479.30 q seeds of pigeon pea, blackgram, greengram, lentil, chickpea, field pea and lathayrus were produced and made available to farmers.

Pradhan Mantri Fasal Bima Yojana (PMFBY)

The KVKs created awareness about *Pradhan Mantri Fasal Beema Yojana* (PMFBY) across the country for protecting farmers from production risks that happens through crop loss/damage due to unforeseen natural vagaries and to stabilize the income of farmers by adopting innovative and modern agricultural practices. Under this scheme, farmers need to pay a very low premium for insuring their crops, which is 2% for *kharif* crops, 1.5% for *rabi* crops, and 5% for commercial and horticultural crops. During the reporting year, 523 KVKs across the country organized this event with the participation of 40 Union Ministers; 17 Ministers of respective State Governments; 155 Members of Parliament; 293 Members of Legislative Assembly and many Government and Non-government officials benefiting 2.91 lakh farmers and farm women.

Attracting and Rataining Youth in Agriculture (ARYA)

The ARYA project aims at attracting and empowering youth in rural areas to take up agriculture and allied sector enterprises for sustainable income and employment. Under ARYA 930 different enterprise units related to mushroom production, processing and value-addition of Non Timber Forest Produce, processing and value-addition of lac, backyard poultry management, vermi-compost production, bee keeping, piggery, large cardamom production, fisheries, off-season vegetable production under walk-in tunnel, cardamom cultivation under protected condition, pine-apple production, Integrated farming systems, production of vegetable and fruit nursery, herbal jaggery making unit, commercial goat farming etc.were established during the year benefiting 2,467 rural youth in the selected districts. Skill training was given to 3,879 rural youth through 92 various training programmes pertaining to the enterprise units allotted to each ARYA centre. Eight exposure visits were arranged to 327 youth to different enterprise units being managed successfully as training and confidence building measure.

Large cardamom production Senapati

Skill training on mushroom cultivation- Nellore

Farmer FIRST programme

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

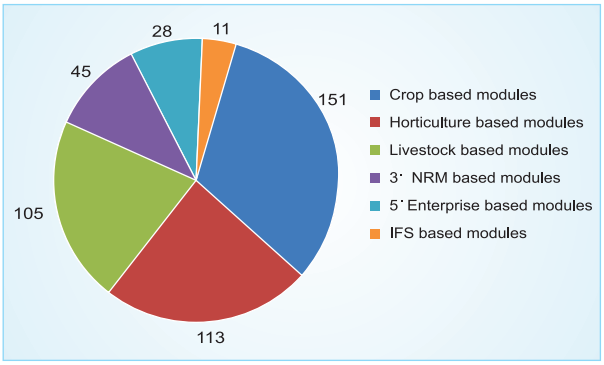
Mushroom - a lucrative enterprise for Smt B. Sahu

After the sudden demise of her husband, Smt B. Sahu, from Angul (Odisha) could establish herself with consistent support by KVK, Angul (Odisha). As a result she established Mushroom Unit in 2011. Initially she experienced scares of hindering factors but succeeded to emerge as mushroom entrepreneur. At present she grows mushrooms round the year by maintaining 7,800 beds and earning a net profit of ₹ 3.06 lakh/ annum. She is involved in mushroom cultivation and from this income she manages her family and her children's education. She is also able to provide employment to two farm women of the same village. She also encourages and motivates Women Self Help Groups to take up mushroom cultivation and to include mushroom as part of their daily diet.

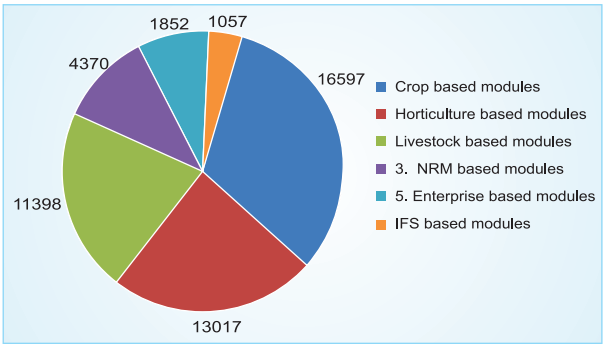
through enhancing farmers-scientists interface. In this approach, the farmer will be in a centric role for research problem identification, prioritization, conduct of experiments and its management in farmers' field conditions. It emphasizes on resource management, climate resilient agriculture, production 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, the 51 centres have made several interventions at the field level in crop, horticulture, livestock, NRM, enterprise and Integrated Farming Family System (IFS) modules. Under crop module, about 151 number of technologies were demonstrated in which 16,597 of number of farm households were benefited. Likewise, under horticulture, livestock, NRM, enterprise and IFS modules, 113, 105, 45, 28 and 11 number of technologies were demonstrated and 13,017, 11,398, 4,370, 1,852 and 1,057 number of farm households respectively were benefited.

The salient technologies demonstrated through Participatory Technology Development (PTD) mode under crop and horticultural modules are nursey management, varietal demonstrations, quality seed production, zero tillage, Integrated Pest Management (IPM) and Integrated Nutrient Management (INM). Under animal science based module, backyard poultry, selection and demonstration of improved breeds, mineral mixture, clean milk production and vaccinations were



Number of Technologies



No. of Farmers participated

the major technologies demonstrated. Technologies such as laser levelling, soil testing, improved irrigation structures, agroforestry and water harvesting structures were demonstrated under NRM module. Under the enterprise module, the landless stakeholders were

Refined-indigenous technology of brined jackfruit processing

Traditionally jackfruit brining was done using hand measure and the shelf life of the product was more than a year. However, this technique remained familiar only to a few of the elderly women, though demand gradually restricted to limited farm families who managed to process it for their household use. Considering its demand and the low cost technique, it was felt that the fruit can be used effectively by revival of this technique through standardization of the same with a community approach. In this direction KVK, Kasaragod, Kerala worked on the revival of traditional jackfruit brining technique through different activities and standardized the technique. On determining the brining percentage the technology was demonstrated in a few schools with school lunch programmes involving teachers and students and women SHG's. For the past three years, 7,700 kg of raw jackfruit has been processed by different organizations in Kasaragod district. The brined jackfruit, which was earlier stored in large pots or plastic containers is also made available in small standing pouches with attractive packaging and labeling and sold @ ₹ 150/kg. Value added products from brined jackfruit like *Nippattu* and *Undalakalu* (supplemented with sprouted fingermillet flour) was also standardized and promoted through above mentioned two women entrepreneurs and other SHGs in the district.

empowered with technologies related to agro processing such as production of mango based products, milk products, handicraft items, etc. Further, each FFP centres designed and demonstrated (IFS) module suitable to their agro climatic region. Innovative technologies were developed under FFP through PTD mode such as mango harvester, which was improved over the existing metallic one with light weight plastic with replaceable blades, rearing poultry birds in mango orchards to reduce pest population, and cultivation of shade loving fodder crops in old mango orchards to generate additional income to the farmers.

Integrated Farming System enable farmer to earn ₹ 60,000/month from 2.4 ha land

Shri Govindraj, S/o Hanumiah, hails from Dandenahalli village of Magadi Talluk in Ramanagara district, Karnataka has now become role model for other farmers. He has adopted integrated farming system at his farm with the technical support from KVK, Magadi, Ramanagara on his 6 acres farm. Earlier, he cultivated finger millet, sunflower and used to earn around ₹ 1.5 lakh/ year. Under the guidance of KVK, Ramanagara he began cultivating integrated improved varieties of different crops. He has introduced new improved varieties of finger millet (MR-1and MR-6) red gram (BRG-1 and BRG-2) field bean (HA-4) and soybean (KBS-23). He also strengthened his livestock component by planting fodder cuttings such as Co-3, Co-4 and Chaya. Besides, he adopted labour and input saving practices like use of herbicides, seed drill for *ragi* sowing, IPM practices in vegetables and azolla production. Effective utilization of all these resources helped him to earn ₹ 3.50 lakh from poultry followed by banana (₹ 1.50 lakh), dairy (₹ 0.82 lakh), tomato (₹ 0.60 lakh), and finger millet (₹ 0.50 lakh) during the year. With the diversification of crops and integration of livetock his earnings have now reached more than ₹ 7 lakh/year from the same piece of land.

Hi tech tuberose cultivation enhanced farmer's income

Shri Thangarasu, a 62 year-old progressive farmer, of village Kuvagam, Ariyalur, Tamil Nadu has 10 acres of land. He started cultivating tuberose under the technical guidance of the KVK, Ariyalur, Tamil Nadu. He cultivated an improved tuberose variety Prajwal released in one acre. The selected field was ploughed thoroughly by chisel plough (once), disk plough (once) and cultivator (four times) and then 10 tonnes of FYM, 500 kg single super phosphate, 800g of Azospirillum, 800g of phosphobacteria, 1 kg of *Trichoderma viridi* along with FYM 50 kg and neem cake 100 kg were applied before ploughing. Tuberose corns (300 kg) treated with Azospirillum, Phosphobacteria, *Pseudomonas*, Nematicide and *Trichoderma viridi* were sown 45 cm × 25 cm apart with polythene mulching techniques to control weeds and facilitate soil moisture conservation. The expenditure incurred for polythene mulching, fertilizer, pesticide, flower harvesting, irrigation, labour etc. was ₹ 60,000. An average of 30-35 kg of flower yield was harvested every day and sold in the nearby flower market at Kumbakonam with average price of ₹ 50/kg. However, the demand for tuberose was as high as ₹ 400/kg during marriage seasons. He harvested 6,000 kg tuberose flowers/acre and gained a net income of ₹ 4.2 lakh/acre within a year through the sale of flowers.

Avadh Mango Grower Society

This programme has made its mark in implementation areas through creation of SHG, Farmer Inetrest Group (FIG), Society and Farmer Producer Organization (FPO). For instance, Avadh Mango Grower Society, Lucknow was formed to promote production and marketing of organic Malihabadi Dusseri Mango and they have obtained Geographic Indicator (GI-125) with the help of Farmer First Project Centre at CISH, Lucknow, which helped the farmers to sell their mango at the premium rate of ₹ 60/kg.

Mera Gaon Mera Gaurav (MGMG)

Mera Gaon Mera Gaurav (MGMG), an innovative flagship programme of ICAR is operational and being monitored by 11 zones in the country. Total institutions (126) including ICAR institutes and SAU's is working under MGMG programme which is monitored by ATARI, of each zones. During 2016-17, total 1,226 groups were formed by involving 4,774 scientists under ICAR institutes and SAUs. Through training, demonstration, literature distribution, general awareness and linkages developed with other departments/ organizations a total of 976,033 farmers from 5,346 villages were benefited under this programme.

KVK Portal

KVK portal (kvk.icar.gov.in) was launched to collect and monitor all information related to mandated activities of KVKs at one platform. During the year, information such as events (33,460 number), CFLD

Successful introduction of kiwi fruit in Wokha District, Nagaland

The Wokha hill district of Nagaland has vast potential for the cultivation of high value kiwi fruit. Realizing its importance, kiwi cultivation was introduced at New Wokha Village in 2 ha of area. Grafted kiwi namely Allison (female) and Tomuri (male) brought from NBPGR, Regional Station, Bhowali, Nainital (Uttarakhand) were planted by each of the selected farmer. The farmers were provided training on production technologies of kiwi followed by supporting interventions. Around 70 % of the saplings survived with good vegetative growth. During the year 2016, the first harvest was obtained with 5 - 8 kg Kiwi fruits per vine. Being a new crop, therefore, most of the harvested fruits were gifted by the farmers. Only little quantity was sold @ ₹ 150/ kg. As kiwi fruit has high value in the market and cost around ₹ 200-250/ kg, farmers may reap the benefit in forthcoming years.

Harvesting more crop from every drop of water in Kutch

The KVK-Kutch-I, Gujarat has taken up various interventions like small check dams, well recharging, check dams renovation, desilting of ponds, drip irrigation etc., under the project Rain Water Harvesting and Micro Irrigation. As a result, added 42 open wells, were added which raised groundwater level by 3 to 6 meters with over flowing of water in 5 open wells during monsoon. This helped to grow *kharif* and *rabi* crops, also area under Castor and Bt. Cotton increased and growing fodder crop even in summer and cultivation of pomegranate started in the region. Thus, 247 ha area under irrigation has been increased mainly due to rain water harvesting and thus value of crop produced was estimated with worth of about ₹ 148 lakh in these villages. Before the project implementation, irrigation facility in the field crops is only limited during good rainfall year and farmers of Bhalot village was not in a position to grow even single season crop properly. Further, farmers were promoted and linked with subsidy of Gujarat State Government. As a result, 85 farmers adopted drip irrigation in 105 ha area. Presently, more than 250 open wells are fully functional for irrigation. Farmers are now able to grow more than one season crops with same water. Average increase in cotton yield in the village due to drip irrigation is 26%. Area covered under irrigation is just double than the previous year irrigated area. Looking to the success and impact of Rain Water Harvesting and Micro Irrigation System, farmers of surrounding villages have now started to use this the technologies. More than 300 ha area under Micro Irrigation is covered in nearly surrounding villages (Lifra, Bagada, Waghura, Fachariya).

on pulses (336 number), CFLD on oilseeds (284 number), facilities added (2,575 number), filling of packages of practices (crop-361 number; livestock-133 number; fisheries-53 number; horticulture-241 number), filling of KVK profile report (employees-530 number; posts-468 number; finance-187 number; soil health cards-334 number; appliances-173 number; crops-282 number; resources-256 number; fish-126 number) were uploaded on the portal by all the KVKs across the country.

Skill development training in agriculture

Agricultural Skill Council of India (ASCI) has affiliated 100 Krishi Vigyan Kendras (KVKs) for conducting skill development training in different qualifications packs (QPs)/job roles of 200 hr or more duration. KVKs organized skill development training in 30 jobs roles in which 3,778 rural youths participated. Maximum number of trainings organized in the job role of "Mushroom Grower-Small Entrepreneur" by 28 KVKs followed by "Quality Seed Grower" by 23 KVKs. In 19 KVKs, skill development training was conducted for gardener, 17 KVKs for dairy farmer -entrepreneur, 14 KVKs for small poultry farmer and in 13 KVKs on beekeeper.

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15. Research for Tribal and Hill Regions

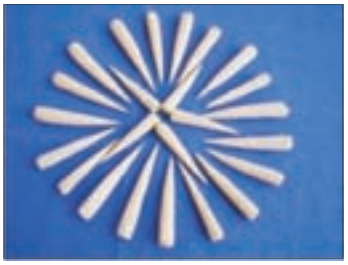
Specific technologies are required for the tribal and hill farmers of unique ecosystems of the Himalayas, Coastal region of Goa and Islands of Andaman and Nicobar. The research institutes located in north-west Himalayas (Vivekanand Parvatiya Krishi Anusandhan Sansthan, Almora), the north-east Himalayas (ICAR Research Complex for NEH Region, Umiam), and Andaman and Nicobar Islands and Goa (Central Island Agricultural Research Institute, Port Blair and ICAR Research Complex for Goa) are engaged in area-specific research.

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 and Kashmir. The salient accomplishments during the period under report are presented here under:

Varieties released and notified

Central maize VL Baby Corn 2: The maize hybrid was released for the states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Punjab, Haryana, Delhi, Uttar Pradesh, Maharashtra, Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh. It produced an average cob yield of 1,725, 2,492, 2,163 and 2,216 kg/ha for Zone I, II, IV and V respectively. The average yield is 18-20 q/ha. The grains are yellow and flat semi-dent, plant height is 200 to 205 cm in the hills with a maturity (baby corn) of 48-50 days. It is responsive to nitrogen fertilizer and high planting density. It exhibited moderate resistance against turcicum leaf blight, maydis leaf blight, common rust and PFSR. The seed parent also exhibited resistance against turcicum and maydis leaf blight and possess high yield potential.



Central maize VL 55: The single cross hybrid was released for the states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, North East Hills, Andhra Pradesh, Telangana, Maharashtra, Karnataka and Tamil Nadu. The grain yield was 7,071 kg/ha in Zone I and 8,024 kg/ha for Zone IV. It exhibited moderate resistance against maydis leaf blight, common rust and PFSR. The grains are yellow and flat semi-dent, plant height is 185 to 195 cm in the hills with a maturity duration of 95-100 days in the mid hills. The seed parent of FH 3605, V 407 exhibited resistance against turcicum and maydis leaf blight. The male parent V 405 also exhibited a fair degree of tolerance against turcicum leaf blight. They also possess high yield potential and flowering in male and female parents nick well. The hybrid is responsive to nitrogen fertilizer.

Central rice VL Dhan 158 (VL 8657, IET 22982): VL Dhan 158 was released by the CVRC in 2017 for the rainfed upland (June sown) ecosystem of Uttarakhand and Himachal Pradesh. It is highly resistant to blast. It has an average grain yield of 2,728 kg/ ha in the lower hills and 1,757 kg/ha under the mid-hill conditions. It has a maturity duration of 110 to 120 days.

Mera Gaon Mera Gaurav (MGMG): Under the MGMG programme, 31 villages in 6 clusters in the Almora district were taken up. The activities carried under MGMG during the period were demonstrations of improved varieties of soybean (VL Soya 63 and VL Soya 65), rice (VL Dhan 65), ragi (VL Mandua 324 and VL Mandua 352) and barnyard millet (VL Madira 172). Four *goshthis*/ meetings were conducted. Eight crop based advisories were also sent to farmers through mKisan portal and need based SMS service. Linkages between farmers and NABARD were strengthened.

Millet Demonstrations in *Tunakot* Village

Soybean Demonstrations in *Raun-Dal* Villages

EASTERN HIMALAYAS

Diversification of rainfed upland rice system in the Eastern Plateau and Hill Region: Under rainfed upland conditions of Eastern Plateau and Hill Region, the experiment on diversification of direct sown upland rice was conducted during *kharif* 2016. The treatments were, sole crop of rice, finger millet, blackgram, horsegram, pigeonpea, vegetable cowpea, rice + blackgram in area ratio of 1:1, rice + horsegram in area ratio of 1:1, finger millet + blackgram in area ratio of 1:1 and finger millet + horsegram in area ratio of 1:1. The sole crop of vegetable cowpea recorded the maximum rice equivalent yield of 16.4 t/ha followed by that of pigeonpea (15.0 t/ha), horsegram (9.9 t/ha), blackgram (9.7 t/ha) and finger millet (6.2 t/ha). The study highlighted that the diversification of rainfed upland rice system with vegetables, pulses and millets would be more profitable in Eastern Plateau and Hill Region.

Crop diversification in rainfed upland rice system

Strong anti-inflammatory activity revealed in indigenous crops of Manipur: Indigenous plants (24) were screened for their inhibitory activity against Cyclooxygenase-I (COX-I) and -II (COX-II) enzyme. COX-I is constitutively expressed in cells involved in normal physiological functions, whereas COX-II is induced by various cytokines, growth factors and carcinogens. Among the plant extracts evaluated, maximum inhibition of COX-I enzyme was observed with *Cuscuta reflexa* (92.50%), followed by *Cephalotexas* (90.30%). Maximum inhibition (71.98%) was found in *Rhus semialata*; followed by *Arisaema tortusum* (61.35%) and RCM-MP-SSR-1 (51.69%). All these three plants showed the potential for development of non-steroidal anti-inflammatory drugs (NSAIDs).

Radical scavenging and anti-cancer activity of *Rhus semialata*: For searching potential agent against reactive oxygen species, water extracts of 15 diverse indigenous crops were screened for DPPH radical scavenging activity. Among the extracts, *Phylantus uranium* has shown maximum activity (0.24 mg IC_{50} value), followed by *Rhus semialata* (0.40 mg IC_{50} value) and *Paris polyphylla* (0.73 mg IC_{50} value). The *Rhus semialata* was further investigated for bioactive compounds present in stem bark extract and three compounds were isolated and identified. The Compound 1 and 2 were identified as gallic acid and methyl gallate. Another isolated compound was observed to be having close resemblance with gallotannin. These compounds were tested for their anti-cancer activity against U937 breast cancer cell line using MTT assay. Compound 1 (gallic acid) significantly reduced the cell viability in a dose-dependent manner.

ISLANDS AND COASTAL REGION

Coastal region

Varieties released

Goa Dhan 1 (KS 12): A high yielding salinity tolerant rice variety released for cultivation in coastal saline soils of Goa which accounts for 25-30% (12,000-15,000 ha) of the total cultivated area of rice crop in the state. It is a white kernelled semi-tall variety having short-bold type of grains. The yield potential of the variety is 23-26 q/ha with yield advantage 33-35% over the national check variety CST 7-1.

Goa Dhan 2 (KS 17): A high yielding salinity tolerant rice variety released for cultivation in coastal saline soils of Goa which accounts for 25-30% (12,000-15,000 ha) of the total cultivated area of rice crop in the state. It is a red kernelled tall variety having long bold type grains. The yield potential of the variety is 26-28 q/ha with yield advantage of 45-50% over the national check variety CST 7-1.

Goa Cashew 2 (Tiswadi 3): This is an early season variety of cashew (mid-February- April). The variety has a high shelling percentage (28.82-29.55 %) with kernel weight of 2.42 g with W180- W210. The cashew apple is cylindrical and yellowish orange.

Goa Cashew 3 (Ganje 2): This is a mid-season (March-May) high yielding variety. This bears in bunches. The variety has got a high shelling percentage (29.50%).

Goa Cashew 4 (KN 2/98): This is a long season high yielding variety. This variety has bunch bearing characteristic. Maturity of fruits starts from mid-February and continues till the end of May.

Islands

Varieties released

CARI Brinjal 2 developed: CARI Brinjal 2 is a high yielding bacterial wilt resistant brinjal variety and gives 20-25 t/ha fruit yield. The plants are medium tall, semi spreading type with profuse branching; greenish medium leaves; fruits oblong, purple and medium compact. It is suitable for growing in island conditions during the dry season, i.e. October to May.

Cage culture of silver pompano: Demonstration of grow-out farming of silver pompano, *Trachinotus blochii* in marine sea cage was carried out to popularise cage culture technology of marine fin fishes among the fishers and fish farmers. The cage was successfully launched at Minnie Bay, South Andaman. Low cost GI open sea cage in Andaman waters so far proved to be sturdy, which also endured the catastrophic 'Vardah' cyclone that hit the Islands during the first quarter of December 2016. Successful transportation of silver pompano seeds was achieved with 100 % survival and the same were stocked in cages; and a stocking density of 30 numbers/m^3 was maintained. For the culture period of 11 months fishes achieved maximum length of 22.5 cm.

New records of freshwater and marine fishes: Freshwater fishes *Mugilogobius tigrinus*, *Redigobius oyensii*, *Brachydanio rerio* and marine fish *Tomiamichthys russus* were reported for the first time from the Andaman Islands.

TRIBAL SUB PLAN

Uttarakhand

Farmers' participatory hybrid maize seed production in Jaunsar tribal area: As part of the institute's work plan to establish a farmer-participatory maize hybrid seed production system at local level, seed production of Vivek Maize Hybrid 45 was organized with a local tribal farmer in the village, Yamuna Khadar in block Vikasnagar of district Dehradun during *kharif* 2016. A total of 300 kg hybrid seed was harvested.

Maize Production at Farmers field

Farmers Participatory Hybrid Seed Production at Vikasnagar Technology Transfer

Technology transfer: Varietal demonstrations of VL Dhan 85, VL Mandua 352 and VL Arhar 1 were organized at Jaunsar area. Enhancement in yield resulted in an increase in the availability of maize for household consumption leading to improvement in overall food and nutritional security for the households.

Varietal demonstrations of wheat and lentil varieties were also undertaken in Niti, Quanu, Jaunsar, Munsyari and Dhaniyad cluster in an area of about 15 ha in which 200 farmers benefitted.

Participation of tribal farmers in Institute Foundation Day: Farmers from Jaunsar and Jhankat tribal area were invited to participate in the Institute Foundation Day programme. On this occasion, tribal farm women Mrs Meena Devi Tomar of village Dhanpauation was felicitated for her active role in promoting institute's technological interventions in Jaunsar tribal areas.

Participatory inter-watershed water transfer: Laying of gravity fed HDPE pipe lines was carried out at Hattal and Sainj villages (Dehradun, Uttarakhand) in participatory mode. In Hattal, pipe line (6.0 km + 2.0 km) is connected to two tanks of 300 and 180 m^3 capacities and in Sainj separate pipe line (5.6 km) is connected to a low cost dug out pond of 200 m^3 capacities for water storage. Most of the material cost was borne by the Institute under TSP and 100 % cost of the labour component was contributed through cash and kind by the members of the association. At present, a total of 670 m^3 water is available to the farmers for 24 hr/day in these two villages where off-season vegetables are being successfully cultivated in about 30 ha area. The average annual family income of farm families from agriculture was ₹ 32,700 and ₹ 10,600 during 2013, which is now ₹ 82,820 and ₹ 83,400 in Hattal and Sainj, respectively. This increase in income is 2.53 times in Hattal and 7.87 times in Sainj village.

Water resources created

Rajasthan

Integrated watershed development: Under the Tribal Sub Plan, a watershed was developed at Bernia, a tribal village of Dungarpur, Rajasthan. A detailed benchmark survey was carried out to assess problems and potentials of the watershed. Scarcity of water and low productivity of both crops and livestock were the major problems in the area. To improve the availability of water in the village, capacity of the existing village

Rainwater harvesting structures in watershed area

pound or nadi was increased from 4,000 m^3 to about 12,500 m^3 by excavation. A conveyance channel of 400 m length connecting the pond to farmers' field was constructed, which benefitted 12 farm families. For drinking water in the watershed area, three rainwater harvesting tankas of 21,000 litres capacity each were constructed.

Data on *kharif* crop yield showed increase in yield from 5-7 q/ha for paddy and 1.5-2.5 q/ha for urd-bean over the traditional cropping practices of the farmer. For *rabi* crops, yield increase for wheat was 12-15 q/ha and gram 3-4 q/ha. Under horticulture development, 450 seedling of pomegranate (Bhagwa), 350 seedling of lemon (Kagzi), 500 seedlings of mango (Mallika), and 300 saplings of (Jackfruit) were distributed. The survival of various fruit trees varied from 60-80 %.

Andaman and Nicobar Islands

Farming system studies in tribal areas: The Nicobari tribal communities mainly rely on coconut, tuber crops, pigs and marine fisheries for their livelihood. The employment generation in their traditional system was only 41 man days/year. Considering the successful intervention of tuber crop based farming system, 15 farmers adopted the tuber crop based farming system at Harminder Bay. The model comprises 300 m^2 of fenced area in the vicinity of the tribal settlement integrated with piggery unit. Farmers were distributed with planting materials of tuber crops (elephant foot yam, colocasia, sweet potato), ginger and piglets. The employment generation increased to 101 days/year, while net income has increased to ₹ 43,128/annum (average of 15 farm families) as compared to their traditional system. With the success of this system, more tribal youths have come forward to adopt the tuber crops based farming system as their livelihood options.

❑

Plant Genome Saviour Community Award

Khola/Canacona Chilli Cultivators Group, South Goa was awarded with the prestigious Plant Genome Savior Community Award by PPV&FRA, New Delhi. The awards were conferred by Sri Radha Mohan Singh, Union Minister for Agriculture and Farmers Welfare, Government of India on 21 December 2016, for conservation and preservation of Khola/ Canacona Chilli, a medium pungent land race with bright red colour.

In the same function Sri Radha Mohan Singh, Union Minister for Agriculture and Farmers Welfare, awarded Rev. Saw Saytha, President of Karen Welfare Association, Mayabunder, North and Middle Andaman. The community was honoured for its contribution to conservation and preservation of traditional and unique rice varieties, viz. Khushbuyya, Black Burma, White Burma, Red Burma, Mushley and Nyaw-in etc., since 1925 in the islands.

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 the 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 AgrInnovate India Limited, Delhi under its administrative control.

The AgrInnovate 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 AgrInnovate 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 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 eight 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 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 ICAR also recruits scientists and other posts, and services through an independent recruitment body, Agricultural Scientists' Recruitment Board (ASRB), which is accountable to the ICAR Society. ASRB receives funding from the Government of India. The Senior Officers at the ICAR (headquarters) are listed in Appendix 3. The research set up of the ICAR includes **112** Institutes: **69** Research Institutes (Appendix 4), **6** National Bureaux (Appendix 5), **23** Project Directorates and Agricultural Technology Application Research Institutes (Appendix 6), **14** National Research Centres (Appendix 7), and **81** 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, and

Information, AKMU, Public Relations Unit, Media and CeRA. The ICAR promotes research, education and frontline extension activities in **74** Agricultural Universities: **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 vacant posts

During the year, the following posts were filled up under the promotion quota: two Deputy-Secretaries, three Under-Secretaries, two Section Officers, six Assistants, four UDCs, and two skilled supporting Staff at ICAR (Hq), one Chief Administrative Officer, nine Senior Administrative Officers, fourteen Administrative Officers under Combined Cadre of AO and three Deputy Director (Finance)/Chief Finance & Account Officer, seven Senior Finance & Account Officer and six Finance & Accounts Officers from Combined Cadre of FAO, Besides, Direct recruitment of 216 assistants for appointment at ICAR (HQ)/ Institutes were also finalized.

Financial upgradation granted under MACP Scheme

During the year, Thirteen (13) eligible officers and staff of ICAR (Hq) 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 Personnel and Trainings) instruction in this regard.

E –governance in ICAR

DARE/ICAR has strengthened the E-governance activities to encourage transparency, people's participation, and promotion of democratic society, managing voluminous data and information effectively, simplicity, efficiency and accountability with as per yardsticks of the Government of India. For this purpose, a separate E- Governance cell has been established in ICAR to monitor the following activities:

- *e-Office:* e-Office module developed by NIC towards smart, paperless, transparent and file management system. The system has been implemented in DARE/ICAR headquarters and is being extended to ICAR Institutes also.
- *CPGRAMS:* For prompt and effective redressal of public grievances lodged on the online Public Grievances Portal (CPGRAMS). Monthly reports are generated for overdue grievances pending for more than 30 days and forwarded to nodal officer concerned for resolving on priority.
- *Aadhaar Enabled Biometric Attendance System*: This system has been implemented in DARE/ ICAR. Records of attendance marked on BAS in respect of the ICAR employees are generated at regular intervals and forwarded to nodal officers/ concerned Divisional Heads for monitoring and taking action as per DoPT guidelines.
- *ICAR-ERP:* Enterprise Resource Planning (ERP) solution was implemented and monitored in ICAR (Hq) and Institutes. The system has been modified to accommodate 7th Pay Commission recommendations, new plan and GST requirements.
- *ICAR Institute Information Management System* (IIMS): IIMS has been developed to monitor the activities to improve institutional resource utilization and research output. The system is under testing and refinement at present.
- *Vigilance Online Integrated Complaints and Enquiry* (VOICE): An application exclusively for Vigilance Section for monitoring vigilance cases.
- *Court Case Monitoring System*: A web-based application has been developed for monitoring court cases i.e. starting with the entry of a new court case to recording down all proceedings and maintaining the history of each and every case.
- *e-Procurement:* e-Procurement has been made mandatory for procurement of goods/services. This system enables the tenderers to download/ submit their bids online on government portal.
- *Online RTI:* This is a portal to file RTI applications/first appeals online alongwith payment gateway. Through this portal, RTI applications/first appeals can be filed by Indian citizens for ICAR and its institutes. These are viewed by delegated officers of ICAR for prompt redressal.

ICAR website/ portals

- ICAR web site**:** URL is icar.org.in and all activities of ICAR taking place in ICAR (Hq) and its institutes are uploaded on regular basis. The circulars, guidelines, important instructions related to all divisions can be downloaded from ICAR website.
- *e-Krishi Manch:* An ICAR-Public Interface, e-Krishi Manch developed as a public-connect platform for stakeholders. Through this system, users can send their queries through web interface or SMS directly to Subject Matter Divisions of ICAR or Research Institutes and receive response quickly.
- *Education portal:* All the existing portals developed by ICAR-IASRI, New Delhi for education are merged into a single portal. This portal includes the Fund Demand and Release Management System, Student Portal, Academic Management System etc.
- *Krishi Portal:* This knowledge based Resources Information Systems Hub for Innovations in Agriculture and consisting of six repositories namely Technology Repository, Publications Repository, Experimental Data Repository, Observational Data Repository, Survey Data Repository and Geo-portal developed at IASRI, has been updated and further strengthened

- *KVK Portal:* It provides basic information and facilities of KVK, District Agricultural Contingency Plan, upcoming, ongoing and past events organized by KVKs, Package of Practices related to crop, horticulture and other enterprises to farming community. The portal facilitates KVKs to update and upload all types of information so that the related information and knowledge can reach the farming community in time. A KVK Mobile App for farmers has also been developed for Android users, and is available in Google Play Store. Farmers need to register and select concerned KVK in the App for accessing information. Farmers can ask any farm related query to the experts of KVKs for solution.
- *Facebook page of ICAR:* The ICAR has maintained its Facebook page and URL: www.facebook.com/InAgrisearch. Through this page ICAR's stories, photographs, activities, technologies, organize contests etc. are showcased.
- *ICAR Twitter account:* The ICAR also maintains its twitter account, ICAR@icarindia, to tweet comments and receive suggestions on it.

ICAR personnel management system

- *Personnel Information Management System:* ICAR Personnel Management Information System has been developed and implemented across ICAR. It has been used to add, modify, retire and transfer scientific personnel belonging to various cadres such as scientist, senior scientist, principal scientist and RMP positions. It provides real time information of scientific personnel posted at ICAR.
- *Implementation of on-line transfer system for scientists:* An on-line transfer system with revised guidelines has been developed by ICAR to decide the transfer of scientific personnel in a transparent way. The system takes into account various parameters involved in effecting the transfer by bringing objectivity, removing ambiguity, bring transparency and facilitate faster decision making in alignment with the Government of India guidelines for the transfer of personnel. The revised policy guidelines to regulate the inter-institutional transfer contain specific parameters on categorization of areas and the location of the institutes and the tenure of posting of scientists to avail the provision of inter-institutional transfer by assigning due weightage to various parameters. For effective implantation by on-line mode, the operating procedure for institutes located in difficult areas and other locations are also specifically defined with a focus on user friendly access and implement ability. The revised guidelines were issued vide circular dated 20 February 2017. The transfer system considers currently active transfer-cycle during which scientist (s) posted in an institute can avail the option for transfer. Live monitoring system has been incorporated to monitor the real-time status during active transfer-cycle.
- *Uniformity in nomenclature of Heads of Regional Stations/Regional Centres:* All scientific positions having nomenclatures viz. Joint Director, Scientist/Officer-In-Charge of Regional Stations of an institute but are similar to Head of Regional Stations/Regional Centres and incumbents are selected by ASRB on the basis of model qualification prescribed for the position of Head of Division have been re-designated as Head of Regional Station/Centre as the case may be. The Office Order to this effect was issued on 12 April 2017.
- *Rationalization of score card system***:** A committee was constituted on the recommendation of the Governing Body and with approval of the competent authority to suggest modifications in the existing score card and make recommendations on other issues concerning selection to senior scientific positions in ICAR through ASRB. This committee has submitted its report giving specific recommendations which were placed before the 241 Governing body meeting and subsequently posted on ICAR website inviting specific comments. Based on the inputs received, the Score Card was further refined by a committee of senior officers under the Chairmanship of Director General, ICAR and has been finally approved by the President, ICAR Society for approval. The revised scorecard will bring more transparency and objectivity in selecting various senior level positions in ICAR.
- *Amendment in ARS Study Leave Regulations:* In alignment with UGC Regulations, the ARS Study Leave Regulations, 1991 were notified vide Council's letter No. 3-21/81-Per-IV dated 17.02.1992. Now on the recommendations of Committee on ARS, amendment in ARS Study Leave Regulations to incorporate relevant changes with respect to duration of study leave in alignment with extant UGC Regulations has been considered and approved by the Governing Body in its 239th meeting. Accordingly, ARS Study Leave Regulations, 1991 have been amended vide ICAR notification dated 26th May'2017 and posted on ICAR website.
- *Revision of guidelines for redeployment/transfer/diversion/adjustment/up-gradation/re-designation of various positions in ICAR:* The issue of redeployment/ transfer/ diversion/adjustment/up-gradation/re-designation of various positions in ICAR was deliberated upon by the Governing Body in its 239th meeting with reference to the relevant guidelines of the Ministry of Finance (MoF), and observed that the cases of redeployment/ transfer/ diversion/ adjustment/ up-gradation/re-designation of posts would amount to creation of new post with simultaneous abolition of adjusting post. Prior approval of MoF is required for the same as per prescribed

procedure. After due deliberation Governing Body has recommended and the Competent Authority approved that ICAR should follow the procedure laid down by Ministry of Finance, Government of India. Accordingly, in supersession of all earlier orders on the subject revised order to regulate all such cases have been implemented vide O.O dated 26 May 2017, and posted on ICAR website.

- *Review of Cadre Strength of ICAR institutes by Cadre Review Committee:* After developing the Personnel Management Information System (PMIS) database on scientific personnel in consultation with all institutes, it emerged that distortion exist in sanctioned vis-à-vis scientific strength at some ICAR institutes. A committee was constituted with the approval of President of ICAR Registered Society and Union Minister of Agriculture and Farmers Welfare to identify these distortions. After a comprehensive and rigorous exercise conducted by the committee in consultation with concerned SMD and the institutes, these distortions were identified and optimized based on the recommendations of the committee. This exercise was followed by initiating their view of Cadre Strength of ICAR institutes, in view of the current mandate and activities of the institutes, by a committee constituted with the approval of President of ICAR Registered Society. This exercise is being carried out in an interactive mode and in consultation with SMD and the concerned institutes.
- *ARS disciplines re-defined:* With the approval of 239th Governing Body recommendations and the approval of President of ICAR Registered Society, the discipline 'Agricultural Statistics and Informatics' was divided into three disciplines: (*i*) Agricultural Statistics, (*ii*) Computer Applications and (*iii*) IT and Bioinformatics with the vacancy ratio of 40:30:30 respectively and a provision have also been made to review the same after completion of two recruitment cycles. Further, two disciplines namely 'Agricultural Structures and Environmental Management' and 'Agricultural Process Engineering' were merged and named as 'Agricultural Structure and Process Engineering'. This decision has been implemented/notified wef. 17 April 2017.
- *Review of Agricultural Scientists' Recruitment Board:* A committee has been constituted with the approval of the competent authority to review the functioning of Agricultural Scientists' Recruitment Board (ASRB) and suggest measures for revamping and restructuring of ASRB in a holistic manner to increase transparency, efficiency and accountability in the functioning of ASRB and to strengthen its structure focusing on all relevant aspects. The Committee commenced the deliberation on the issues in which the procedure being followed in other similar scientific organizations are also being looked into and comments have been sought form stakeholders. Further, the committee is holding wide ranging discussions/consultations with former Chairman, Members of ASRB, DDGs and Directors in ICAR system and Vice Chancellors of some SAUs during these meetings. The report is likely to be submitted shortly.
- *Revised APAR introduced for all scientific positions:* Revision of APAR format for various scientific positions was initiated with reference to extant DoPT guidelines and formats were developed by NAARM in consultation with all SMDs and ASRB. The revised APAR formats were further examined by a committee in consultation with all SMDs and thereafter have been adopted for implementation *vide* circular dated 20 June 2017.

INTELLECTUAL PROPERTY AND TECHNOLOGY MANAGEMENT

IP protection and grant of titles

Patents: Patent applications (101) from 31 ICAR institutes were processed at Indian Patent Office. These

Patent applications filed

Agricultural implements: Side view image capturing device; and double roller banana pseudo-stem fibre extractor.

Animal health/ vaccines/ diagnostics: A process for the preparation of CARI poultry semen diluent.

Cotton and jute textile processes: Integrated grading system for natural fibers including jute fiber and; and digital color and luster meter for lingo-cellulose fiber.

Dairy products and processes: Caseino phosphopeptides-divalent metal (iron/zinc) nan complexes and method of preparation; construction of mutant strain of *kluyvero-mycesmarxianus* for enhanced galactose utilization; and preparation of buffalo milk casein hydrolysates with enriched ant oxidative peptides and the process.

Fish/marine products and processes: Spring- less apparatus for holding bivalves during a pearl production surgical operation; and process to prepare anti-dyslipidaemia concentrate from seaweed.

Food products and processes: Process for preparing Nutmeg taffy, cashew apple crunch and resultant food product; and process for making uniform, smooth and succulent *seekh kebabs* without hardening of outer layer.

Plant-protection methods and processes: Process of obtaining swertiamarin powder concentrate from *Enicostemma* species and an encapsulated formulation based on the same; semi-synthetic diet for mass rearing of five species of genus *Bactrocera* of agricultural and quarantine significance; apparatus for *in vivo* mass production of entomo-pathogenic nematode; process and kit for insect facilitated controlled pollination in oil palm; and liquid culture process for mass multiplication of chlamydospores.

included application filed (20), application published (50) and patent granted (31). Thus, taking the cumulative figure to 1,045 patent applications filed, and 212 granted from 75 ICAR institutes. The application filed during the period of report were classified based on their subject areas as mentioned below:

C*opyrights:* Six copyright applications were filed by three ICAR institutes for their research outcomes including, data entry software for crop area and yield estimation survey; design of micro-irrigation system (DOMS); mobile assisted personal interview version 1(MAPI ver. 1); statistical analysis of agricultural experiments part 1: single factor experiments 'Swarna Tripti'; and 'Swarna Vasundhara' (Soybean). A total of 110 filed copyrights have been thus recorded from 24 ICAR institutes.

Designs: Three applications were filed by NRC on Meat, Hyderabad, and CIFRI, Barrackpore. These included: (i) Burger patty mould; (ii) Cage culture structure; and (iii) tissue embedding machine. A total of 23 filed design applications have been recorded from 5 ICAR institutes.

Trademarks: Twenty trademark applications under different classes were filed by four ICAR institutes for different products and processes, viz; Fish Maid, Avikaminmix, Avikesil-S, Memnaprash, CAGE GROW (Fish Feed) and institutes word and logos (viz. ICAR-NCB). Till date a total of 102 trademark applications were filed by 25 ICAR institutes out of these 30 applications were registered.

Plant varieties: Plant varieties of genera and species, including rice, *durum* wheat, barley, maize, groundnut, soybean, Indian mustard and onion were submitted for registration from ICAR during the reported period. Nineteen applications for plant varieties (15 extant; and 4 new varieties) were filed at the Registry. From the applications filed earlier, 44 varieties (37 extant and 7 new) were granted registration certificates; raising the cumulative figure of registered varieties to 800. The cumulative total for plant variety protection applications submitted rose to 1,205.

Capacity building and outreach activities: Capacity building in the new domain area of intellectual property rights and technology management was emphasized by organizing different programmes at institute/ zonal/ national levels. During reported period 93 ICAR institutes organized 39 Awareness generation programmes/ Interface/ Product-specific Meets/ Workshops/ Seminars, wherein 8,042 scientists/ researchers/ business professionals/ and other stakeholders were benefited.

These *inter-alia* included:

Training: organized for Agri-start-ups; business proposal development for PCs and start-ups; meat product processing for north-eastern hills region youth; patent filing procedure; create a successful tissue culture enterprise; and pre- and post-harvest management techniques for seed quality.

Workshop: Biodiversity and IP for innovation; recent trends in bioinformatics; agri-innovation; IPR and commercialization of technology; revitalizing fisheries and aquaculture; patent filing procedure; and sensitization on agri-incubation for start-up. Besides, ICAR (Hq) organized an advanced workshop on IP Management, jointly with DRDO-TIFAC, and workshop on Identification of Techno-Commercial Projects for Upscaling jointly organized with TDB, TIFAC and IICA for Agricultural Innovators and Entrepreneurs,

Patent applications granted

Agricultural implements: Coconut testa removing machine (IN278013); urea molasses mineral block machine (IN283378); coconut chips slicer (IN285418); and Pusa chickpea thresher (IN282047).

Animal health/ vaccines/ diagnostics: Bio-enrichment of cattle feed for better digestibility (IN 276257); methods for preparation of antigen from field strain of *Mycobacterium avium* sub sp. *paratuberculosis* and determination of antibody (IN277425); multiple antigenic peptide assay for detection of *Peste des Petitis Ruminants* (PPR) virus specific antibodies (IN278622& IN278622); and recombinant antigen based rapid sero-diagnosis of infectious bursal disease (IBD) (IN277404).

Cotton and jute textile processes: Method for the production of cellulose powder from crop residues (IN276255).

Crop production processes: Improved process for detoxification of *Jatropha curcas* cake (IN280965). *Dairy products and processes:* Process for the preparation of ready to constitute (IN284267) and reconstitute *makhana kheer* mix (IN287541); and chitosan based bio-preservative mix for buffalo meat (IN278630).

Fish/marine products and processes: Competitive ELISA for diagnosis and sero-monitoring of microbial infections in cultured freshwater fishes (IN277740); process for differential sero-diagnosis of gram-negative bacterial infections and detection of their toxins in human food in reference to fish and fish products (IN277749); and method and an apparatus for developing gonadal maturity in carp (IN275820).

Food products and processes: Device for stripping curry leaf (IN285640); preparation and method of processing of aloe candy from aloe species (IN285360); Jaisalmeri preserve and candy from fruit of toosh (*Citrullus colocynthis*) (IN282751); process technology for preparation of blended guava leather (IN286775); and method of preparing aloin (IN277501).

Plant-protection methods and processes: Samfungin: a novel fungicide and the process for making (IN277235); process for the preparation of 5 substituted 1-3,4 oxiadiazole – 2 thiols (IN279536); improved neem larvicidal compositions (IN282129); slow or controlled release mosquito larvicidal composition and a process for preparation (IN282133); bio-pesticidal formulation with improved shelf-life (IN284264); super absorbents and the method(s) of obtaining the same (IN274643); improvement in/or relating to synthesis of o-alkyl derivatives of oxime ethers of piperonal as potential fungicides (IN281543); non-sticky insect trap (IN278215) and insect rearing and collection apparatus (IN280435).

during the reported period.

Agri-business Meet: Policy makers and farmer's interaction meet; industry stakeholder consultation on blue economy meet; farmers/ traders/ processors/ entrepreneurs-scientist interaction meeting for preservation of fresh litchi fruits; and value addition in coconut and palmyrah.

Awareness Camp: These camps were arranged for fish products and women entrepreneurship; potential of using Geographical Indication for traditional fish products; integrated development of honeybee keeping; Geographical Indication (GI) of Dashehari and registration of varieties; Intellectual Property Rights, Clean meat production; Biodiversity Act, rules and regulations; and registration of farmer's variety and importance of GI. Besides, some special programmes were organized including creative session for school kids- a happy innovation hour for kids; Entrepreneurship Development programme for attracting youth to agriculture and soil fertility evaluation and nutrient management.

Further to expose the scientific and technical staff to specific nuances of intellectual property and technology management issues 78 persons from different ICAR institutes were deputed to attend 52 capacity building programmes organized by 36 different national/ international organizations.

Technology Transfer/Commercialization

Twenty-four ICAR institutes finalized 259 partnership agreements with 154 organizations and 44 individual entrepreneurs. These agreements were signed for 120 technologies of agriculture and its allied fields viz. animal production and processes (3); biofertilizers (15); dairy products and processes (10); crop varieties (31); farm machines and tools (2); fish-based products and processes (11); food processing and value addition (29); plant-protection measures (6); soil management (3) and textile jute products and processes (10). Some important technologies transferred during the period are mentioned below:

Crop varieties	*Vegetables/Spices:* Chilli: Kashi Surkh, Pusa Jwala, Arka Kyathi; Cowpea: Kashi Kanchan; Okra: IIHR-385-5-1, IIHR-386-7-2, OKMHS-3, Kashi Bhairo, Kashi; Satdhari, and Kashi Vibhuti; Onion: Pusa Red; Pepper: Arka Coorg Excel; Tomato: Kashi Adarsh and Kashi Aman; and Turmeric: IISR Pragati. *Fruit/Flowers:* Guava: Arka Kiran and Arka Rashmi; Marigold: Arka Agni and Arka Bangara-2. *Food Crops:* Rice: PB 1637; Wheat: HDCSW 18 and HD 3086.
Animal production and processes	Slaughter house for pigs and value added pork products processing unit; indigenous progesterone impregnated vaginal sponges for oestrus synchronization in sheep; and area specific mineral-mixture pellets for augmenting reproduction and production in sheep.
Biofertilizers	Production of *Pseudomonas fluorescens*, *Trichoderma viride*, *Pseudomonas fluorescens*, *Verticillium chlamydosporia*, *Pseudomonas fluorescens*, *Trichoderma harzianum*, and VAM biofertilizer.
Dairy products and processes	*Detections Kits:* DNA-based method for differentiation of cow, buffalo, sheep, goat and camel milk; strip based test for detection of maltodextrin in milk; spore-based kit for detection of antibiotic residues in milk at dairy farm; paper strip assay for rapid detection of pesticide residues, and mastitis detection card test kit. *Dairy Products:* Arjuna herbal ghee; milk protein enriched iron fortified bajra biscuit; bajra lassi; and fast acidifying yoghurt culture for greek style yoghurt.
Fish-based products and processes	Dot Elisa Kit; Spot Agglutination Kit; Indian white shrimp (*Penaeus indicus*); Antihypercholesterolemic extract (Cadalmin™ Ace) from seaweeds; Design and construction of commercial fishing vessels.
Food processing and value addition	*Fruit/Milk/Vegetable Products:* Anthocyanin extraction from black carrot; coconut chips; guava squash; fresh and hygienic kalparasa and natural coconut sugar; jaljeera drink; RTS beverage from amla, guava and kokum; and whey mango, onion paste making; and dried onion flakes and powder. *Animal/ Fish:* Production of fish kure - extruded snack product from fish; low fat meat emulsion and process; production of chitin and chitosan.
Plant-protection measures	Entomopathogenic nematode-based galleria cadaver technology for insect-pest management; nano-matrix for delivery of pheromone for the management of red palm weevil and rhinoceros beetle; para-pheromone trap; and VL- white grub beetle trap-1.
Textile and jute products and processes	Design and manufacturing of pre-cleaner, double roller gin, baling presses and feeding systems; design and machinery for automatic cotton ginning plant; chipping of cotton stalks for value addition; automatic electronic fibre bundle strength tester for multiple fibre; digital fineness meter for multiple fibres; digital colour range indicator, and thermal insulation value tester.

SUCCESS STORY

Established-a-manufacturing unit for production of fish based organic fertilizer

A manufacturing unit for fish-based liquid and solid organic fertilizer was established at Cochin, Kerala as part of the technical consultancy with the Company M/s San Isidro. The products are marketed under the brand name **MeMe** *Natural*, which are purely organic products from fish developed with the technical guidance from the Central Institute of Fisheries Technology (CIFT). The products are found to contain amino acids, macro-and micro-nutrients for boosting the growth and productivity of plants.

The liquid fertilizer is used for foliar feeding is an effective method for correcting soil deficiencies and overcoming the soils inability to transfer nutrients to the plant. Tests showed that foliar feeding can be 8 to 10 times more effective than Soil feeding and provide up to 90% of foliar-fed nutrients. The application of foliar spray was advocated in spices like cardamom, black pepper, tea etc.; and encouraging results were reported. The quick absorption of nutrients and precise dosage of foliar sprays has resulted in the success of precision farming of costly vegetables and flowering plants. The optimized supply of required micro- and macro Wndia Pvt Ltd. nutrients results in the maximum productivity of the available space that minimizes the wastage of costly inputs.

Successful joint venture by the NRCB, APEDA and Fair exports (India) Pvt Ltd.

A successful joint venture by the NRC for Banana, Tiruchirappalli, APEDA, New Delhi and Fair Exports (India) Pvt. Ltd., Kochi under the Public Private Partnership (PPP) mode set an Indian export to find a new voyage to the Dubai Sea Port with its 'Made in India' Farm Fresh ***Nendran Bananas***, in a first of its kind attempt. The NRCB, Trichy under funding at APEDA, Ministry of Commerce and Industry, Government of India, transferred a technology to M/s. Fair Exports, Kocchi based private firm which exported two consignments of 10-ton capacity each to Dubai. This has opened a new gate to banana marketing in gulf countries. Comparatively, banana shipment through sea is cost effective; promotes to get end product with superior quality; and fetches a higher price.

Agri-business incubation

This initiative addresses the much-needed requirements of business incubation for converting agriculture technologies into an attractive commercial proposition. Accordingly, 25 Agri-Business Incubation (ABI) centers have been supported/ established in various institutes. These ABIs undertook different activities to facilitate the business environment in the ICAR institutes, which include, Agri-entrepreneurs/ Incubators admitted for incubation (173); Agri-entrepreneurs/Incubators graduated (56); New products/ technologies incubated (54); Entrepreneur Development Programme organized (60); and Agri-business Development/Awareness Programmes Organized (63).

PROGRESSIVE USE OF HINDI

DARE

DARE ensures compliance of the provisions of the Official Language Act 1963, Official Language Rules, resolution, general orders, notification, administrative or other reports, or press communiqués, issued or made by the Central Government or by a ministry, Department or office thereof or company, company owned or controlled by the Central Government or by any office of such corporation and various orders/instructions issued by Department of Official Language from time to time on progressive use of Hindi for official purposes in the Department and Autonomous bodies coming under its purview. Besides these, Administrative and other reports and official papers laid before a House or the House of Parliament and also the contract and agreements executed etc. Efforts to make Hindi as official language in accordance with official language policy are being made on continuous and on-going basis.

Targets and achievements, in brief, accomplished by Hindi Section of DARE with regard to progress of *Rajbhasha* and implementation of Official Language Policy are detailed below:

Policy implementation: The Official Language Division of the Department, manned by an officer of the level of Assistant Director (OL), has made continuous efforts towards implementation of the instructions issued by the Department of Official Language in this Department and Autonomous Bodies under its purview. In this regard, effective check points have been prepared for compliance of the implementation of the Official Language Policy and circulated to all officers to ensure more and more use of Hindi while disposing of their official work. Emphasis is also given to achieve the targets of correspondence in Hindi with offices located in 'A', 'B' and 'C' Regions.

Notification of institutions/offices under rule 10(4) of the Official Language Rules 1976: Institutes/Offices

of ICAR where 80% of staff have acquired working knowledge of Hindi, are notified under Rule 10(4) of the Official Language Rules 1976. Overall 129 offices and attached stations with regional offices of ICAR have also been notified upto 27 September 2017.

Official language policy related meetings: Quarterly Joint Meetings of Official Language Implementation Committee of DARE and ICAR are held regularly under the Chairmanship of Additional Secretary (DARE) and Secretary, ICAR, who is the nodal officer for implementation of the official language policy in DARE. Deputy-Secretary/Under-Secretary/Section Officer, representing various divisions of the Ministry/ Departments, are to be nominated as members of these committees while Hindi Officer, Assistant Director/ Deputy Director (OL) concerned would function as Member-Secretary of the same. Four meetings were organized and follow up action were taken in compliance with the decisions taken in these meetings.

Official language policy related reports: Annual Assessment Report and Quarterly Progress Reports regarding use of *Rajbhasha* in the Department are sent to the Department of Official Language regularly.

Official language policy related inspection: During the year, two Institutes of ICAR were inspected and suggestions were given to solve practical problems being faced by the employees of these offices while working in Hindi.

Bilingual printing of manuals/ rules: In pursuance of Section 3(3) of the Official Language Act 1963, all Resolutions, Notifications, Communiqués, Press release, Rules, Regulations, Administrative Reports and all Official Reports meant for laying in the Parliament are issued bilingually. Other than above, Stationary items, name plates, notice boards, forms, procedural literature, rubber stamps, invitation cards etc. of all the Ministry/ Department should be got prepared both in English and Hindi.

Training: Apart from monitoring and implementation of the Official Language Policy and Programmes of the Government, Hindi Section arranges training of the personnel for effective use of Hindi, Hindi Typing and Hindi Stenography and translation. Officers have been issued instructions to make use of the services of stenographers, PAs, PSs trained in Hindi Stenography for doing work in Hindi. The stenographers not knowing Hindi Stenography are being nominated for such training.

Translation work: Hindi Section of the Department carries out translation work under section 3 (3) of Official Language Act. Accordingly, documents like Cabinet Notes, Resolutions, Notifications, MoU/ MoA/ Work-Plans in Agriculture with other Institutes were translated in Hindi within the stipulated time-frame based on their priority.

Hindi pakhawada: This was observed from 14 to 29 September 2017 in the Department in association with ICAR. On the occasion, the Message of Union Minister for Agriculture and Farmers Welfare, and Secretary, DARE and DG, ICAR regarding progressive use of Hindi was circulated. Besides, various competitions were also organized on this occasion.

Use of mechanical/electronic equipment: All equipments like Electronic typewriters, Tele-printer/ Telex / Computers etc. should be bilingual. Ministries /Departments are especially invited to ensure strict compliance of the orders issued from time to time by the Department of Official Language. DARE is also trying its best for compliance of orders issued by the Department of Official Language.

Incentives scheme: This scheme may be operated on financial year basis. The Officers who participate in this scheme will maintain a record of their work done in Hindi. For this year, this scheme has been circulated among all officers on 8 August 2017

ICAR

One hundred and thirty ICAR Institutes/Centres have been notified in the Gazette under Official Language Rule 10(4). Besides, some sections of ICAR (Hq) have been specified under rule 8(4) to do their cent per cent administrative work in Hindi. The total number of thus specified sections is 16.

- As per the Annual Programme four meetings of the Joint Official Language Implementation Committee of DARE and ICAR were held under the chairmanship of Additional Secretary, DARE and Secretary, ICAR. During the reported period four Workshops were organized for various categories of staff to make them aware of the O.L. Policy of Government of India and to impart training on Unicode.
- Official Language Implementation Committees are functioning in most of the ICAR Institutes. Proceedings of these Committees are received at the Headquarters and appropriate suggestions and guidelines are given to the concerned institutes.
- 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 made to them for effective implementation. ICAR Headquarters regularly participated in TOLIC's meeting.
- The employees are being nominated regularly for Hindi type training in every session. At Headquarters, training in Unicode typing was also reported period imparted by the *Hindi Anubhag*.
- During *Hindi Pakhwara* was organized between 14 and 29 September 2017 at ICAR Headquarters. On this occasion Union Minister of Agriculture and Farmers Welfare sent a message that was conveyed to all ICAR institutes. The Director General of ICAR also issued an appeal to make progressive use of Hindi at every level.
- During the reported period under the cash award scheme of Official Language Department, Cash Awards were given to 10 officials at ICAR

Headquarters for doing their maximum official work in Hindi.

- *Under the Rajarshri Tondon Rajbhasha Purskar Yojana,* during 2015-16, following Institutes were awarded for doing their maximum work in Hindi.

	Big Institutes	Award
1.	IARI, Pusa, New Delhi	First
	CAZRI, Jodhpur	Second
2.	Institutes/Centres of 'A' and 'B' Region	
	NBPGR, New Delhi	First
	NSSLU&PB, Nagpur	Second
3.	Institutes/Centres of 'C' Region	
	NAARM, Hyderabad	First
	IIOR, Hyderabad	Second

- Under the *Ganesh Shankar Vidyarthi Hindi Patrika-Purskar-Yojana* for 2015-16, different Institutes were awarded for the following magazines published by them:

Name of Magazine	Name of the Institute	Award
'Ikshu'	ISRI, Luknow	First
'Himjyoti'	DCFR, Bheemtal	Second
'Maru Krishi Chayanika'and 'Amber'	CAZRI, Jodhpur and CTRI, Mumbai Institutes/Centres of 'C' Region	Third (Joint Price)
'Kadanna Saurabh'	IIMR, Hyderabad	First
'Dhan'	CRRI, Cuttack	Second
'Jal Tarang'	CIBA, Chennai	Third

- In accordance with the Instructions/Orders of Department of Official Language, 21 Institutes were inspected during the period and suggestions were made for effective implementation of Official Language. Parliamentary Committee on Official Language inspected progressive use of Hindi in 12 ICAR Institutes during the reported period. Participated as representative of ICAR (Hq) in all the inspection meetings. Action was ensured to be taken on the assurances given by the respective institutes.
- House magazine of ICAR (Hq) *'Rajbhasha Alok, '2016'* depicting the Hindi activities of different Institutes was published and released on 16 July 2017 by Union Minister of Agriculture & Farmers Welfare.
- The Council and its institutes are organizing *Kisan Melas* and other *Gosthies* in Hindi and other Indian languages. Training is being imparted to the farmers of different regions in their regional languages and Hindi as well.
- Cabinet Notes, Audit Accounts, Annual Plan, SDG, Governing Body, Parliamentary Standing Committee on Agriculture, AGM of ICAR Society and proceedings of many other meetings were prepared bilingually and translation of material received from various sections was also done. The draft speeches of Union Minister of Agriculture & Farmers Welfare, State Ministers for Agriculture and other higher officers of ICAR were prepared in Hindi.

FINANCE

The Revised Estimates in respect of DARE/ICAR for 2016-17 was ₹ 6238.00 crore. An internal resource of ₹ 275.15 crore (including interest on loans and advances, income from Revolving Fund Schemes and interest on Short-term Deposits) was generated during 2016-17. The total allocation Budget Estimates for 2017-18 is ₹ 6800.00 crore.

TECHNICAL COORDINATION

Doubling Farmers Income by 2022

In pursuance of the policy initiative taken by the Government of India towards doubling the farmer income by March 2022 a presentation was made by Prof. (Dr) Ramesh Chand, Member (*NITI Aayog*) on 14 February 2017 during the Annual Conference of the Vice Chancellors of the Agricultural Universities and the Directors of ICAR Institutes. As this is a very challenging task, it would involve coordinated effort from all the concerned departments and agencies with a mission-mode approach. Towards this objective, State-wise Coordination Committees (SCCs) for doubling farmers' incomes have been constituted at the level of ICAR with the Vice Chancellor of one of the Agricultural Universities in the state as the Chairman and one of the Directors of ICAR Institute/ ATARI as the convener of the committee. All the other Vice Chancellors and the ICAR Directors of the concerned region, one nominee of DAC&FW, DAHDF, Ministry of Food Processing Industries and Ministry of Water Resources as well as the senior representatives of the concerned State Departments as the members of the committee. The committees have already developed the comprehensive strategy documents on doubling farmers' income by 2022 for their respective states which are being further revised. The plans have taken into consideration, the, agro-ecologies in the State, land use and cropping pattern, natural resource endowments, important development indicators, infrastructure for agriculture and Government programmes, productivity gaps and major constraints. They also consider the potential for development of Horticulture, Livestock, Fisheries, Agro-forestry and Post-harvest processing etc. in the states. Besides, the plans have given special focus on the role of technology and developing the strategy and action plan for enhancing production, cost reduction, quality improvement and generating additional income. Potential contribution to farmers' income and strategy for scaling out these technologies (Technology information/packages validated/successfully demonstrated) have also been included as examples

to be replicated in different agro-ecologies. Focus is also given on Value Chain Development, Market Linkages and Trade Potential, Policy and Investment Requirements and Role of the Government besides giving implementation plan along with the institutional responsibilities. *NITI Aayog* and DAC & FW Documents, Policy Papers developed by NIAP and other relevant documents were also consulted by the SCCs to develop the state specific strategy documents. The detailed presentations of various state coordination committees were held before the renowned Agricultural Scientist, Prof. (Dr) M.S. Swaminathan and Member *NITI Aayog*, Dr. Ramesh Chand on 3 November to suggest further refinements in these documents. The revised documents have been received from all SCCs and will be given to state governments for implementation

Regional Committee Meetings

The meeting of ICAR Regional Committees No. III was held during 29-31 May, 2017 at Imphal, Manipur. DG, ICAR stated that while food production scenario of the region has improved substantially over last one decade, the region is still deficit in pulses, oilseeds, fish, meat, milk and egg production. He emphasized that concerted effort are being taken by ICAR to forge better coordination and convergence among Central and State Departments, Agencies, NGOs and other stakeholders for developing a strong Agricultural Research, Development and Extension Programme in the region to achieve self-sufficiency in various sectors of agriculture and also to double the income of the farmers by 2022 in line of the Vision of Government of India. Actionable points were identified and assigned to the respective institutes/ universities/ KVKs to be resolved in a targeted time frame. The action taken on the issues raised in the previous Regional Committee Meetings were also reviewed.

ICAR Directors Conference

ICAR Director's Conferences were held between 14 and 15 February 2017 and again on 16 July 2017. The event, inaugurated by Shri Radha Mohan Singh, Union Minister of Agriculture and Farmers Welfare, deliberated on aligning the research, teaching and technology dissemination strategies with the national priorities and programmes.

Support to societies and other activities

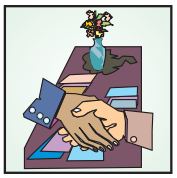
During the period, the Council provided financial support to 78 societies for the publication of Scientific Journals. Besides, Societies/associations/universities were supported for holding National Seminars/ Symposia/Conferences (85) and International Seminars/ Symposia/Conferences (31 Nos.).

Swachh Bharat Mission

Department of Agricultural Research and Education/ Indian Council of Agricultural Research along with all ICAR Institutes and establishments implemented their respective *Swachhta* Action Plans. During the last 1 year, two Swachhta Pakhwadas were organised during 16-31 October 2016 and May 16-31, 2017 besides one special campaign '*Swachhta Hi Seva*' between 15 September and 2 October 2017. Vermicomposting, whey utilisation, straw enrichment, wastewater recycling, cotton waste and fisheries waste management among others were promoted through various field and farm activities undertaken during the Pakhwada. Vermicomposting/ Composting of biodegradable waste management & other technologies on generation of wealth for waste was demonstrated at 756 locations, 204 events were organized to demonstrate the application of waste water for agricultural use. 38 special *swachhta* workshops were organized for the benefit of staff, farmers and general public. Different activities related to *Swachh Baharat* Mission were taken up in 3,527 villages involving 13,987 officers and staff members from various ICAR Institutes and KVKs. Poster competitions/ essay competitions/debates were organized at 123 places. Based on the performance of the Institutions, awards (first, second and third) have been given to the outstanding performers in the competitions held for the three categories i.e., the offices in ICAR (Hq), ICAR Research Institutes and KVKs.

ICAR Awards 2016

On 16 July 2017, the 89th Foundation Day of ICAR, the ICAR Awards for 2016 were presented to the winners in a major function organized at NASC, Complex, Pusa, New Delhi. The awards were given in 19 different categories to 122 awardees, comprising 3 Institutes, two AICRPs, 12 KVKs, 80 scientists, which included 13 women scientists and 19 farmers. ❑



17. Partnership and Linkages

DARE

The Department of Agricultural Research and Education (DARE) was established in the Ministry of Agriculture in December 1973. The DARE coordinates and promotes agricultural research and education in the country. DARE provides the necessary government linkages for the Indian Council of Agricultural Research (ICAR), the premier research organisation for co-ordinating, guiding and managing research and education in agriculture including horticultural, fisheries and animal sciences in the entire country. Apart from ICAR the Department of Agricultural Research and Education has more autonomous body, viz. the Central Agricultural Universities in Imphal (Manipur), Jhansi (Uttar Pradesh) and Pusa (Bihar) under its administrative control; and is wholly financed by the Government of India. DARE is the nodal agency for International Cooperation in the area of agricultural research and education in India. The Department liaises with foreign governments, United Nations, CGIAR and other multilateral agencies for cooperation in various areas of agricultural research. DARE also coordinates admissions of foreign students in various Indian agriculture universities/ ICAR Institutes.

Memoranda of understandings/agreements/work plans

- A Declaration of Intent was signed between the Ministry of Agriculture and Rural Development of the State of Israel and the Ministry of Agriculture and Farmers Welfare of the Republic of India for Cooperation in the field of agriculture on 11 November 2016.
- A Memoradum of Understanding between ICAR and Belarusian State Agricultural Academy, Belarus was signed on 11 September 2017.
- A Work Plan (2017-18) was signed between ICAR and University of Queensland, Australia on 4 August 2017.
- A Work Plan (2017-21) was signed between ICAR and the College of Agriculture and Life Sciences, Cornell University, USA on 13 September 2017 through exchange of letter.
- Number of approvals (8) granted by DARE to State Agricultural Universities to sign MoUs/ MoAs with foreign universities/institutions

Following Work Plans were signed with various ICAR Research Institutes in collaboration with six CG Centers:

- Work Plan was signed between ICAR and International Rice Research Institute for 2017-2022 on 7 February 2017.
- Work Plan was signed between ICAR and International Crop Research Institute for the Semi-Arid Tropics for 2016-18 on 15 March 2017.
- Work Plan was signed between ICAR and International Food Policy Research Institute for 2016-19 on 11 May 2017.
- Work Plan was signed between ICAR and International Centre for Agricultural Research in the Dry Areas for 2017-22 on 24 May 2017.
- Work Plan was signed between ICAR-Bioversity International for 2017-21 on 7 June 2017.
- Work Plan was signed between ICAR and International Centre for Tropical Agriculture for 2017-20 on 11September 2017.

Major Events

During the reported period DARE did following major events:

BRICS (Brazil, Russia, India, China, and South Africa): The MoU was signed for Establishment of BRICS Agricultural Research Platform on 16 October 2016 with *ex-post facto* cabinet approval on 2 August 2017. The Coordinating Centre of the BRICS Agricultural Research Platform was inaugurated by Dr T. Mohapatra (Secretary (DARE) & Director General, ICAR) at NASC Complex, New Delhi on 11 April 2017.

Annual Membership of CABI/ISTA: Annual Membership contribution to Centre for Agriculture Bioscience International (CABI), United Kingdom, and International Seed Testing Association (ISTA), Switzerland for the current year were released.

Cooperation with International Organizations: The ICAR- CABI Memorandum of Agreement was signed on 22 September 2017 for concerning scientific and technical co-operation.

Collaborative Research Projects

Following Collaborative Research Projects were approved:

- ACIAR Collaborative Research Project, 'Mitigating the effects of stripe rust on wheat production in South Asia and Eastern Africa' and Memorandum of Subsidiary Arrangement for research project.
- UNEP/GEF Full Size Project 'Mainstreaming agro-bioversity conservation and utilization in agricultural sector to ensure ecosystem services and reduce vulnerability'.
- Collaborative research project, 'Establishing the International Mungbean Improvement Network' between Indian Institute of Pulses Research, Kanpur and World Vegetable Centre and to

authorize Director, IIPR, Kanpur to sign the project Agreement.

- Collaborative research project on 'Improvement of banana for small holder farmers in the Great Lake Region of Africa' (Indian Component-Breeding for improved bananas with *Fusarium* wilt *(Fusarium oxysorum* f. sp. *cubense)* resistance) was approved in collaboration with National Research Centre on Banana, Trichy and Bioversity International, Rome.
- Collaborative research project on 'Genetics of insecticide and *Bacillus thuringiensis* toxin (Bt toxin) resistance in *He!icoverpa armigera*'.
- Collaborative research project on 'Enabling smallholders to improve the livelihoods, food, nutrition and environmental security through agro-forestry systems' with Central Agro-forestry Research Institute, Jhansi, Central Arid Zone Research Institute, Jodhpur, and World Agroforestry Centre, Kenya and Oil and Natural Gas Corporation Ltd., New Delhi.
- Collaborative research project on 'Strengthening and Integrating Agricultural Science and Technology Indicators (ASTI)' in Indian NARES in collaboration with National Academy of Agricultural Research Management (NAARM), Hyderabad funded by International Food Policy Research.
- Collaborative research project proposal on 'Bio-fortification of Rice' submitted by Indian Institute of Rice Research, Hyderabad for funding under Harvest Plus Programme of CGIAR coordinated by Centre for Tropical Agriculture and International Food Policy Research Institute.

Foreign collaborated Project of ICAR

South Asian Association for Regional Cooperation

- Several training/consultation proposals were received from South Asian Association for Regional Co-operation (SAARC) Secretariat/SAARC Agriculture Centre.
- A Regional Training Programme on 'Field Epidemiology Training Programme for the Veterinarians' at NIVEDI Bengaluru was held for 18-20 participants from SAARC member countries (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka) at NIVEDI Bengaluru from 15 to 24 May 2017.
- Regional Expert Consultation Workshop on 'Facilitating the use of microbial pesticides in South Asia', held at National Bureau of Agricultural Insect Resources, Bengaluru from 11 to 13 August 2017.
- The Regional Expert Consultation Meeting on 'Technology Sharing of Spice Crops in SAARC Countries' was held at Indian Institute of Spice Research, Kerala from 11 to 13 September 2017.

Afghan National Agricultural Sciences and Technology University

- A course was conducted on 'Agronomy of Food and Oilseed Crops' from 7 January to 4 February 2017; and two courses on 'Soil Science 1 and 2' from 6 February 2017 to 18 March 2017 at IARI, New Delhi. On completion of various courses, valedictory function was organized on 20 March 2017 for transcript distribution. ORWs fortheses research have been developed with the help of faculty at IARI, New Delhi.
- On the request of ANASTU, syllabus for the M.Sc. courses on Agricultural Economics, Plant-Protection and Horticulture were developed with the help of Professors at IARI, New Delhi, and syllabus for a course on Animal Husbandry was developed with the help of Professors at IVRI, Izatnagar. All the syllabi have been sent to ANASTU.

ASEAN-INDIA Cooperation

- The approval for project entitled 'Genetic improvement of hybrid rice parental lines for enhancing yield heterosis' was received from the Indian Mission ASEAN/MEA. The project is being implemented in the NRRI, Cuttack.
- Plan of Action 2016-2020: The Medium Term Programme of Action, ASEAN-India Cooperation in Agriculture and Forestry (2016-2020) was endorsed by SOM AMAF on 30 May 2017. With the endorsement by both ASEAN and India, the document is now ready for implementation. The same was forwarded to SMDs in August 2017 to identify the relevant point and initiate action on them. There are joint collaraborative projects and training programmes in the PoA. Action for the publication of *India ASEAN Newsletter on Agriculture and Forestry* is also being initiated for which Project Director, DKMA was intimated.
- The detailed training programmes that can be conducted/offered for the participants from the ASEAN member countries were forwarded to ASEAN Secretariat for further necessary action in the matter.

BIMSTEC

- The Fifth Meeting of Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) Expert Group on Agricultural Cooperation was held in Thimpu, Bhutan. Indian participation was ensured by nominating suitable scientists from ICAR.
- A Note on 'South South-East Asian Diagnosis Network for Ensuring Bio-decurity and Bio-safety' covering the area of crop/animal/fisheries was approved and sent to MEA for consideration of BIMSTEC Secretariat.

Consultative Group on International Agricultural Research

- 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).

- India is now one of the voting members in the CGIAR System Council representing the South Asia Constituency of the Council along with other two alternate representatives from South Asia namely Bangladesh and Sri Lanka. Additional Secretary, DARE & Secretary, ICAR is the official member in the CGIAR System Council from India. Besides, Dr Rajendra Singh Paroda, Chairman, Trust for Advancement of Agricultural Sciences (TAAS), New Delhi was appointed as Member in System Council's Strategic Impact Monitoring and Evaluation Committee (SIMEC) which assists the System Council in the review of research programme evaluations, oversight of the strategic direction of the CGIAR System Organization and efficiency, effectiveness and impact of the CGIAR Research according to a robust and rigorous results based management framework. Thus, India has assumed an important role to play in CGIAR System through representation in its Council and other entities.
- Government of India approved establishment of Food Legumes Research Platform (FLRP) at Amlaha, Sehore, Madhya Pradesh with Satellite Hubs in West Bengal and Rajasthan by International Center for Agricultural Research in Dry Areas (ICARDA), which is one the CGIAR Centres. For the purpose, a supplementary agreement has also been signed with ICARDA.
- During the period, several discussions focused on how existing bilateral relationships between ICAR and CGIAR system can further be deepened to address contemporary challenges of agricultural world over with specific reference to Indian Agriculture, have taken place. CGIAR have expressed their deep satisfaction to the pivotal role played by ICAR.

PROGRAMMES OF DARE

Germplasm exchange: In the area of exchange of genetic resources, cases received from friendly foreign governments/ government sponsored agencies/ International Organization agencies, were processed in accordance with the provisions of Biodiversity Act and further guidelines notified in this regard. Approval of competent authority in respect of 2 cases was conveyed.

Post-graduate course curriculum revision: Revision of Course Curriculum for Post-graduate students of YAU completed and will be implemented from 2017 to 18 academic session. This is a major achievement and will help to generate the most crucial skilled human resource for developing technologies for transforming Myanmar agriculture and ushering prosperity for the farmers.

Human resource development: Another major activity for capacity development was approved by MEA and DARE to admit six Advance Centre for Agricultural Research and Education (ACARE) staff to IARI for doing M.Sc. and Ph.D. every year. Four staff members of ACARE have already joined PG programme at IARI. This single initiative will contribute a great deal in qualitative improvement in research quality in the university and will help proper implementation of ACARE agenda. Besides, ACARE, other staff members have already joined at CCS Haryana Agricultural University (4), IARI (2), and University of Agricultural Sciences (1) for higher studies under ICCR scholarship.

Participatory knowledge management: One Self-Help Group of 20 farm-women was formed in Thar Yar Kone village. They collected Kyat 500,000 and matching contribution was provided from the project with which they started micro-finance among the members, and now effort is to link them with industry. Myanmar Agro-Foods Limited have agreed to be the partner. Meeting were organized with the farmers in villages, namely GO Min, Aung Pan Chaung Sauk for field demonstration for blackgram in post-rainy season.

Content development for touch screen: Presently farmers depend on input dealers for modern technologies, who propagate greater use of inputs available with them thus increasing the cost of cultivation. The faculty from YAU was assisted to develop content on all major field crops and fruits and vegetables, and make available new technologies to the farming community through Touch screen. Good progress has been made in developing content for rice, and for other crops the exercise is on.

CENTRAL AGRICULTURAL UNIVERSITIES

The Central Agricultural Universities are sponsored by DARE. Activities of CAU situated in Jhansi (Uttar Pradesh), Imphal (Manipur) and Pusa (Bihar) are given here.

Rani Lakshmi Bai Central Agricultural University, Jhansi

The Rani Lakshmi Bai Central Agricultural University, Jhansi made steady progress. Laboratories, instruction facilities and crop cafeteria and demonstration units undergraduate programmes in Agriculture, Horticulture and Forestry B. Sc. (Hons) Agriculture programme, B.Sc. (Hons.) Horticulture, and B.Sc. (Hons.) Forestry), were developed.

The research work was primarily focused to enhance chickpea production in Bundelkhand region with multi-pronged approach of breeding, disease-resistance, seed production, intercropping and nutrient and water management

Central Agricultural University, Imphal

The Central Agricultural University, Imphal having

13 constituent colleges is a fully residential university covering all the North-Eastern Hills states under its jurisdiction except Asom. The University offers 9 undergraduate, 37 Masters and 20 Ph.D. Degree programmes in different subjects/ disciplines at its 13 constituent colleges. A total of 1,970 students are currently studying in the university (including the newly admitted students in undergraduate 484; postgraduate 173 and Ph.D. 22 students). At present the university has 75 ongoing internally funded research projects and 110 externally funded projects including 35 All India Coordinated Research Projects and 4 All India Network Research Projects. A total of 41 location specific recommendations and scientific findings in agriculture and allied sciences for NEH region were developed by the university.

Krishi Vigyan Kendra, East Siang, Arunachal Pradesh under Central Agricultural University, Imphal received the prestigious Pandit Deendayal Upadhyay Rashtriya Krishi Vigyan Protshahan Puruskar for Zone VI on 15 March 2017 at New Delhi. The KVK has mobilized farmers for adopting innovative technologies in the region.

Dr Rajendra Prasad Central Agricultural University, Pusa

Dr Rajendra Prasad Central Agricultural University, Pusa notified by the Gazette of India on 7 October 2016 to be a Central Agricultural University, has presently six faculties, five colleges, seven research institutes/stations and fourteen Krishi Vigyan Kendras. The operational area of DRPCAU, Pusa covers Agro-Climatic Zone-I consisting of East and West Champaran, Siwan, Saran, Gopalganj, Vaishali, Muzaffarpur, Sheohar, Sitamarhi, Darbhanga, Madhubani, Begusarai and Samastipur districts. With 285 total available seats, 265 students were enrolled in different UG and PG programmes with 93% admission. Under UG programme 148 students, in M. Sc. Program out of 98 students and in Ph. D. 18 students. The varieties 'Rajendra Nilam' (Rice), 'Rajendra Dhania-1' (Coriander) and 'Rajendra Kauni-1' (Foxtail millet) were released. A boat-based solar pumping system developed at the university was launched in the river *Burhi Gandak* at *Gorain Ghat* of Pusa. The system was developed with the objective of providing a solution to the irrigation related issues of the farmers of *diara/ dhab/chaur* areas which are spread over 1.5 million ha in Bihar alone.

Integrated Bee Keeping Development Centre was established at KVK, Piprakothi, East Champaran (Bihar) with the financial assistance of ₹ 17.80 million from National Bee Board, New Delhi. Jaggary Processing Unit was inaugurated at KVK, Piprakothi, East Champaran.

***Seeds*:** Breeder seed 208 q, Foundation seed 1,079 q, Certified seed 11 q and Truthfully labeled seed 134 q of different paddy varieties were sold during *kharif* 2017.

AGRINNOVATE INDIA LIMITED

Agrinnovate India Limited is steadily moving towards meeting its objectives and building 'A world of Innovative Partnerships'. During 2016-17 the Company has earned Net Profit of ₹ 21,052,092/- as against Net Profit of ₹ 24,670,104 in 2015-16.

Business development activities

AgIn participated in various workshops such as Workshop on Sales, Marketing and Business Development and their integration with other Corporate Functions and departments. The Company also initiated collaboration with various reputed organizations like Asia-Pacific Centre for Technology Transfer and African-Asian Rural Development Organization.

Promotional activities with embassies: AgIn has promoted its service to various Embassies located in India which included High Commission of the Republic of Botswana, Embassy of Burundi, Bangladesh High Commission, Embassy of Italy, Embassy of the Republic of Maldives, Mauritius High Commission, etc. The Company also organized the visit of officials from New Zealand Embassy in India to explore the collaboration opportunities.

Capacity building programmes: A five days delegation visit for five members from M/s Tigray Biotechnology Centre, Government of Ethiopia was coordinated by AgrInnovate India Limited on behalf of ICAR. The delegation from M/s Tigray Biotechnology Centre visited ICAR Institutes. to have hands-on-experience on developments and finalize the technologies and services of ICAR, which can be transferred/adopted by M/s Tigray Biotechnology Centre.

Policy Initiatives: The Board has approved the Guidelines for commercialization of technologies developed under ICAR and Institutions under National Agricultural Research System for implementation by the Company. The commercialization guidelines include: Guidelines for Intellectual Property Protection and Management, Guidelines for Commercialization of Technologies, Guidelines for organizing Training Programmes, Guidelines for Consultancy and Research Projects, and Guidelines for engagement External Agency/ Consultants

Implementation of commercialization guidelines: As per the commercialization guidelines, the techno-commercial assessment and expert committees were constituted to carry out techno-commercial assessment and prepare the standard terms for potential technologies of all ICAR Institutes.

In line with commercialization guidelines, AgIn had organized and conducted Techno-commercial and Expert committees meeting for selected technologies of various ICAR Institutes like Central Tuber Crops Research Institute, Kerala; National Dairy Research Institute, Karnal; Central Institute of Brackish Water Aquaculture,

Chennai; Indian Institute of Horticultural Research, Bengaluru; Central Coastal Agricultural Research Institute, Goa; Indian Institute of Rice Research, Hyderabad and Indian Institute of Millet Research, Hyderabad.

Trainings

(i) Processing of applications for various training programmes abroad under various foreign governments, announced by DBT/DST etc. The Government of India against open advertisements, United Nations/International organizations, International agencies in various fields of agricultural research and education.

(ii) Processing of applications for various fellowships/ scholarships announced by ICAR, HRD, foreign governments, etc for higher studies/ research / Ph.D/ Post-Doctoral Research abroad.

(iii) Forwarding of applications of the scientists for foreign assignments in foreign governments and International organizations.

(iv) Circulation of vacancies notified by CGIAR organizations, other International organizations/ agencies such as ADB, Work Bank, Commonwealth Secreariat, United Nations, etc.

CONSULTANCIES

- Dr Umesh Chander Sud, Director, IASRI, New Delhi, consultancy service for Bhutan Living Standard Survey to finalize sampling design for Living Standard Measurement Survey in Bhutan as a Sampling Expert from 23 to 28 January 2017.
- Dr Kaushik Banerjee, Principal Scientist, NRCG, Pune for grant of extension to continue to act as a member of the Programme Advisory Committee Food Nutrition and Quality Sub-Committee of the Malaysian Palm Oil Board, Ministry of Plantation Industries and Commodities, Malaysia for the tenure of 1 Janury 2017 to 31 December 2019, and also to participate in the Programme Advisory Committee meeting of Malaysian Palm Oil Board, Ministry of Plantation Industries and Commodities, Malaysia scheduled on 3 to 7 April 2017 in Kuala Lumpur, Malaysia.
- Re-submission of Consultancy Institutional Project proposal of IASRI, Pusa, New Delhi entitled 'Pilot Study on measurement of private food grains stock including of on-farm post-harvest losses under Input Survey of Agriculture Census in India' funded by of the United Nations, Delhi Office to carry out the project activities till 31 July 2017 instead of 15 June 2017 on the request/direction of Food and Agriculture Organization of the United Nations and also permission to sign the revised letter of Agreement on behalf of the Council as the Consultancy proposal is under Institutional project mode.
- Dr Ranjit Kumar Paul, Scientist, Division of Statistical Genetics, IASRI, New Delhi, consultant, 'Identification of Principal Markets and Framework of Market Co-integration' under 'Strengthening Agricultural Market Information Systems in India (AMIS) using Innovative Methods and Digital Technology' funded by Food and Agriculture Organization of the United Nations, Delhi Office.
- Dr U.B. Angadi, Senior Scientist, Centre for Agricultural Bioinformatics, IASRI, Pusa, New Delhi, Consultancy, entitled 'Development of database and package for data analysis and feed resources in Ethiopia' funded by ILRI, ICRISAT Campus, Patancheru (Telangana), India.
- Dr Hukum Chandra, National Fellow, IASRI, Pusa, New Delhi to Myanmar to provide short-term FAO consultancy service under Global Strategy to Improve Agricultural and Rural Statistics in Myanmar for 45 days in 3 (three) missions during 2017 and 2018 as a Sampling Expert.
- Dr P. Routray, Principal Scientist, CIFA, Bhubaneshwar (Odisha), Consultancy/Deputation, Food and Agriculture Organization of United Nations, Khartoum, Sudan to provide technical consultancy services in the field of 'Tilapia Broodstock and Seed Production (ITBS)' under FAO Project to Government of Sudan as a FAO Expert Consultant for 30 days (Second Mission) starting from 1 July 2017. Re-scheduling of Consultancy visit for 30 days (Second Mission) starting from 28 August 2017 instead of 1 July 2017 to 30 July 2017 .

INTERNATIONAL WORKSHOPS/ CONFERENCES/SYMPOSIA

- First Asian Conference on 'Water and Land Management for Food and Livelihood Security' was held from 20 to 22 January 2017 (3 days) at Swami Vevekananda Auditorium, Indira Gandhi Agricultural University, Raipur (Chhattisgarh).
- Indo-United States Bilateral Workshop on 'Genomic approaches for Yield Enhancement and Biological Nitrogen-fixation in Chickpea' was held from 29 January 2017 to 31 January 2017 at IARI, New Delhi.
- International Conference on 'Climate Change Adaptation and Biodiversity : Ecological Sustainability and Resource Management for Livelihood Security was held from 8 to 10 December 2016 at CIARI, Port Blair (A & N Islands).
- International Conference on 'Sustainable Natural Resource Management: From Science to Practice' was held on 12-13 January 2017 at Department of Farm Engineering, Institute of Agricultural

Sciences, Banaras Hindu University, Varanasi (Uttar Pradesh).

- International Conference on ICT4D 2017 was held from 15 to 18 May 2017 at Hyderabad International Convention Centre, Hyderabad (Telangana).
- Organized (*i*) an International Symposium on 'Aquatic Animal Health and Epidemiology of Sustainable Asian Aquaculture' during 20-21 April 2017, and followed by (*ii*) a 'Strategic Planning Workshop on Aquatic Animal Disease Surveillance in India' on 22 April 2017 at NBFGR, Lucknow.
- Seventh International Conference on Silicon in Agriculture (ICSA) was held from 24 to 28 October 2017 at University of Agricultural Sciences, GKVK, Bengaluru.
- Holding of 12th International Society of Sugar Cane Technologists Pathology Workshop at Sugarcane Breeding Institute, Coimbatore (Tamil Nadu) from 3 to 7 September 2017.
- Seventh Asian Cotton Research and Development Network (ACRDN) Meeting was held from 15 to 17 September 2017 at Hotel Le MERIDIAN, Nagpur (Maharashtra).
- ICBC 2018 : First International Conference on Biological Control: Approaches and Applications from 27 to 29 September 2018 at National Bureau of Agricultural Insects Resources, Bengaluru.
- International Symposium on Sugarcane Research since Co 205: 100 Years and Beyond (SucroSym-2017) was held at SBI, Coimbatore (Tamil Nadu) from 18 to 21 September 2017.
- International Congress on 'Cotton and Other Fibre Crops' at ICAR Research Complex for NEH Region, Umiam (Meghalaya) to be held from 20 to 23 February 2018.
- International Symposium on 'Horticulture : Priorities and Emerging Trends' ws held from 5 to 8 September 2017 at Indian Institute of Horticultural Research, Bengaluru.
- Societal Applications in Fisheries and Aquaculture using Remotely-Sensed Imagery (SAFARI-2) International Symposium on 'Remote Sensing for Ecosystem Analysis and Fisheries' at Central Marine Fisheries Research Institute, Kochi (Kerala) was held from 12 to 17 January 2018.
- 13th International Dryland Development Commission (IDDC) Conference : Converting Grey Areas into Green at Central Arid Zone Research Institute, Jodhpur from 19 to 22 November 2019.
- Hosting the 11th Indian Fisheries and Aquaculture Forum (11ifaf) with the theme "Fostering Innovations in Fisheries and Aquaculture – Focus on Sustainability and Safety" by ICAR-Central Institute of Fisheries Technology (CIFT) on behalf of the Asian Fisheries Society, Indian Branch (AFSIB) at Kochi from 21 to 24 November 2017.

PROTOCOL ACTIVITIES

VVIP delegations

- His Excellency Mr Jon Georg Dale, Norwegian Minister of Agriculture visits Indian Agricultural Research Institute, Delhi and Gene Bank of National Bureau of Plant Genetic Resources, Pusa Campus- New Delhi on 15 February 2017.
- His Excellency the Ambassador of Norway to India Mr Nils Ragnar Kamsvag visits Director, CIFA, Bhubaneshwar on 23 March 2017.
- His Excellency the Ambassador of Thailand Mr Chutintorn Gongsakdi, New Delhi and officials from Foreign Affairs Ministry of Thailand visits IARI, New Delhi on 9 June 2017.
- His Excellency Hifikepunye Pohamba, Former President of the Republic of Namibia visits NDRI, Karnal on 27 July 2017.
- His Excellency the Ambassador of Suriname, Mr Aashna Kanhai visits NRRI, Cuttack on 21 or 24 July 2017.
- Parliamentary Delegation of 12 member from Seychelles visits at Secretary, DARE and DG, ICAR and visits IARI, New Delhi on 10 August 2017.
- His Excellency Dr Thani AI Zeyoudi, UAE Minister of Climate Change and Environment, Government of the UAE visits IARI, New Delhi on 31 August 2017.
- A delegation from Germany headed by Dr Arnd Nenstiel, Chairman of Indo-German Business consortium along with representative of Indian and German business companies called on Shri C. Roul (Additional Secretary, DARE and Secretary, ICAR) on 6 March 2017 at Krishi Bhawan, New Delhi to discuss the issues of mutual interest.
- Dr David Bergvinsion (Director General, ICRISAT) signed the Work Plan with ICAR on 15 March 2017 at Krishi Bhawan, New Delhi

for strengthening the mutual collaboration between both sides. Dr Trilochan Mohapatra (Secretary, DARE and Director General, ICAR) signed the Work Plan from the Indian side. Shri C. Roul (Additional Secretary, DARE and Secretary, ICAR) and other dignitaries from ICRISAT and ICAR/ DARE were present during the occasion.

- A senior level delegation led by Mr. Elwyn Grainer-Jones, Executive Director of Consultative Group of International Agricultural Research (CGIAR) accompanied with Ms Karmen Bennett (Head of Board and Council Relations, CGIAR) called on Dr T. Mohapatra (Secretary, DARE and DG, ICAR) on 26 April 2017 at New Delhi to discuss issues of mutual interest and how the existing cooperation between CGIAR and ICAR could be further strengthened with special focus on the effort of CGIAR to evolve the new governance structure for managing the global activities of CGIAR more effectively. Shri Chhabilendra Roul (Additional Secretary, DARE and Secretary, ICAR) Dr Arabinda Kumar Padhee, (Director Country Relations and Business Affairs at ICRISAT) and other senior officials from DARE/ICAR attended the meeting.
- A delegation from INRA and CIRAD France visits Additional Secretary, DARE and Secretary, ICAR on 27 May .2017 at Krishi Bhawan, New Delhi to discuss the possibility for co-organizing a joint seminar in New Delhi (tentatively during October – November 2017) to present the findings of study undertaken by INRA and CIRAD titled 'Agrimonde Terra'.
- A six member delegation from Nikita Botanical Garden, Russia called on Shri C. Roul (Additional Secretary, DARE and Secretary, ICAR) on 31 May 2017 at Krishi Bhawan, New Delhi as a part of their India visit from 30 May to 7 June 2017.
- A six member delegation from Nikita Botanical Garden, Russia visited IARI, New Delhi on 6 June 2017 to hold discussion on issues of mutual interests.
- A three member delegation from Argentina headed by Dr Amadeo Nicora, President INTA (National Institute of Agricultural Technology) Argentina called on Dr Trilochan Mohapatra (Secretary, DARE and DG, ICAR) on 16 June 2017 at Krishi Bhawan, New Delhi to discuss issues of mutual interests. The INTA (National Institute of Agricultural Technology) is the Argentine Federal Agency in charge of the generation, adaptation and diffusion of technologies, knowledge and learning procedures for the agriculture, forest and agro-industrial activities.
- Dr T Mohapatra (Secretary, DARE and DG, ICAR) and Dr Ruben G. Echeverria (DG, International Centre for Tropical Agriculture) signed a Work Plan for 2017-2020 between ICAR and International Centre for Tropical Agriculture (CIAT) on 11 September 2017 at New Delhi under the existing MoA between two sides.

Foreign deputation

- Dr Trilochan Mohapatra (Secretaty, DARE and DG, ICAR) participated in the 5th Indo – German Joint Working Group meeting in Hanover, Germany from 15 to 18 November 2016.
- Dr N. S Rathore (DDG, Agricultural Education) participated in the Expert Consultation and APAARI General Assembly meeting in Taiwan from 1 to 3 November 2016.
- Dr Joykrushna Jena (DDG, Fisheries Science) visits Dhaka, Bangladesh to attend the 28 Network of Aquaculture Centres in Asia Pacific Governing Council Meeting (GCM – 28) from 25 to 28 April 2017.
- Dr Sanjeev Saxena (ADG, Intellectual Property & Technology Management) visits Taiwan to participate in the workshop on 'E – Business Modeling for Women Entrepreneur' from 19 to 23 June 2017.
- Dr S.K Chaturvedi (ADG, Oilseeds and Pulses) visits Tanzania as member of delegation led by Joint Secretary (East and South Africa), Ministry of External Affairs to discuss bilateral cooperation, esp. in the field of pulses from 10 to 14 July 2017.
- Dr D.K. Yadava (ADG, Seed) visits Kazakhstan as member of a delegation led by Minister of Petroleum and Natural Gas to attend 13th India-Kazakhstan Intergovernmental Commission from 19 to 20 September 2017.
- Dr R. N Chatterjee (Director, Directorate of Poultry Research, Hyderabad) visits Indonesia from 17 to 18 April to attend 4th meeting of India–Indonesia Joint Working Group on Agriculture.
- Dr J.K. Sundaray (Director, CIFA, Bhubaneshwar) visits Dhaka, Bangladesh to attend the 28th Network of Aquaculture Centres in Asia Pacific Governing Council Meeting (GCM – 28) from 25 to 28 April 2017.
- Dr R.K. Tyagi (Principal Scientist and Head Germplasm Conservation Division, NBPGR, New Delhi) visits Bangkok, Thailand to participate in the Executive Committee of APAARI held on 14 July 2017.
- Dr Sanjay Srivastava (Principal Scientist, Indian Institute of Soil Science, Bhopal) and Shri T.B. Baviskar (Under Secretary, DARE) visits Tunisia as a member of a delegation being led by Shri Mohit Yadav (IFS, Director, East & South Africa), MEA from 19 to 21 July 2017 to assess the ground conditions for establishment of Soil Water and Tissue Testing laboratory under IAFs programme.
- Dr S.K. Jha (Principal Scientist, O&P, ICAR) and Dr Aditya Pratap (Principal Scientist, IIPR, Kanpur) visits Mozambique to finalize the site and other logistic arrangements for establishment of the proposed Pigeonpea Seed Production Demonstration and Training Centre from 14 to 17 November 2016.
- Dr K. Ambasankar (Principal Scientist, CIBA) visits Chennai for his participation in 'Regional Consultation on responsible production and use

of feed and feed ingredients for sustainable growth of aquaculture in Asia Pacific' at Bangkok, Thailand from 7 to 9 March 2017.

- Dr Satish Kumar Sain (Senior Scientist,CICR Regional Station Sirsa) and Dr A. Manikandan, Scientist,CICR, Nagpur) visits Uganda for implementation of Cotton Technical Assistance Programme (TAP) under Indo – Africa Forum Summit – II (IAFS – II) from 19 to 30 August 2017.
- Dr Kajal Chakraborty (Senior Scientist, CMFRI, Kochi) participates in the 'Expert consulation on Best Practices in Agri-Food Innovation in Asia and the Pacific' meeting to be organized by Asia Pacific Association of Agricultural Research Institutions (APAARI) in Taiwan from 1 to 3 November 2016.

Foreign visits

- Dr N.P. Singh (Director, IIPR, Kanpur) participated in the Seminar 'Celebrating the Pulses in SAARC Region' on 8 December 2016 in Bangladesh.
- Dr Azad Singh Panwar (Director, IIFSR, Modipuram) participated in the AgMIP Collaborative Project Meeting from 9 to 10 January 2017 in Columbia University and New York University, United States America.
- Dr Gyanendra Pratap Singh (Director, IIWBR, Karnal) participate in the Project Inception Workshop for ACIAR funded project entitled Mitigating the effect of Stripe rust on wheat production in South Asia and East Africa from 27 to 28 February 2017 in Dubai.
- Dr R. Kalpana Sastry (Joint Director & Director (Acting), NAARM, Hyderabad) participates in the Advisory and Strategy Meeting from 21 to 22 March, 2017 in Washington DC.
- Dr Gyanendra Pratap Singh (Director, IIWBR, Karnal) participated in the International Wheat Yield Partnership meetings including the Global Wheat Programme field day from 20 to 24 March 2017 held in Mexico.
- Dr Ramesh Chandra Srivastava (Vice-Chancellor, Dr Rajendra Prasad Central Agricultural University, Samastipur, Bihar) participates in the Foresight Workshop and Dialogue on 'Sustainability and Resilience in the Eastern Gangetic Plain in South Asia' on 17 March 2017 at Kathmandu, Nepal.
- Dr Himanshu Pathak (Director, NRRI, Cuttack) participates in the Workshop on Opportunities for Diversification in 'Rice-based Systems' during 28 to 29 March 2017 in Bangkok, Thailand.
- Shri Chhabilendra Roul (Additional Secretary DARE & Secretary, ICAR, New Delhi) participates in the 15th Independent Science and partnership Council (ISPC) Meeting of CGIAR Centres and Funders from 4 to 5 April 2017 in Italy.
- Dr R.K. Mittal (OSD, ICAR, Krishi Bhawan, New Delhi) attends 4th CGIAR System Council Meeting during 9-12 May 2017 in Netherlands.
- Dr J. S. Sandhu (DDG, Crop Science, ICAR, Krishi Bhawan, New Delhi) participated in the South and South-east Asia Seed Policy Workshop held during 9 to 10 June 2017 in Cambodia and also visits International Rice Research Institute, Philippines from 11 to 13 June 2017.
- Dr Sujay Rakshit (Director, IIMR, Ludhiana), Dr J.C. Shekhar (Principal Scientist, IIMR, Hyderabad) and Dr V.K. Sehgal (Professor, IARI, New Delhi) participates in the Planning meeting-cum-workshop on 'Mapping maize mega-environment of South Asia' which was held in Dubai from 10 to 11 July 2017.
- Shri Chhabilendra Roul (Additional Secretary DARE and Secretary ICAR) participates in the 16th CGIAR, Independent Science and Partnership Council (ISPC) meeting from 18 to 19 September 2017 in Rabat, Morocco.
- Dr A.S. Panwar (Director), Dr N. Ravi Shankar (Principal Scientist), Dr Ashish K. Prusty (Scientist), Dr P.C. Ghasal (Scientist, IIFSR, Modipuram) and Dr B.P. Bhatt (Director, RCER, Patna) participates in the workshop on 'Farming Systems Analysis' from 22 to 24 2017 at Wageningen University, The Netherlands.
- Dr Sujay Rakshit (Director, IIMR, Ludhiana) attends the Heat Stress Tolerant Maize for South Asia (HTMA) meeting from 9 to 10 August 2017 in Bangladesh.
- Dr H. Pathak (Director, NRRI, Cuttack) participated in the 21st annual meeting of Council for Partnerships on Rice Research in Asia from 20 to 21 September 2017 in Hangzhou, China.
- Dr K.K. Singh (Director, CIAE, Bhopal) attends the 4th Regional Forum on Sustainable Agricultural Mechanization in Asia and Pacific of CSAM at Hanoi, Vietnam from 23 to 25 November 2016.
- Dr K. Alagusundaram (DDG, Agricultural Engineering) attended the 4th Regional Forum on Sustainable Agricultural Mechanization in Asia and Pacific of CSAM at Hanoi, Vietnam from 23 to 25 November 2016.
- Dr K. Alagusundaram (DDG, Agricultural Engineering), ICAR, New Delhi attends the 3rd Annual Meeting of Asian and Pacific Network for Testing of Agricultural Machinery (ANTAM) at Colombo, Sri Lanka from 8 to 10 December 2016.
- Dr. Kanchan K. Singh (ADG, Engineering) attended the 3rd Annual Meeting of Asian and Pacific Network for Testing of Agricultural Machinery at Colombo, Sri Lanka from 8 to 10 December 2016.
- Sh. Chhabilendra Roul (Additional Secretary, DARE and Secretary, ICAR, New Delhi) participates in the 397th Executive Council

Meeting of Centre for Agriculture and Biosciences International at London, UK from 1 to 2 February 2017.

- Dr Suresh Pal (Director, NIAP, New Delhi) attends the 13th Session of the Governing Council of the Centre for alleviation of Poverty through Sustainable Agriculture at Bogor, Indonesia on 28 February 2017.
- Dr A. Arunachalam (Principal Scientist, ICAR Headquarter, Krishi Bhawan, New Delhi) attends 7th Meeting of the BRICS Ministers of Agriculture and Agrarian Development in Nanjing, China from 15 June 2017 to 17 June 2017.
- Dr C.R. Mehta (Project Coordinator, AICRP on FIM, ICAR-CIAE, Bhopal) for participation in the 3rd meeting of the Technical Working Group of the Asian and Pacific Network for testing of Agricultural Machinery at Dhaka, Bangladesh from 24 to 27 May 2017.
- Dr K.K. Singh (Director, CIAE, Bhopal) for participation in the Regional Workshop for Research and Academic Institutions on 'Establishing a Cooperation Mechanism for Human Resource Development on Sustainable Agricultural Mechanization' of CSAM at Nanjing, China from 13 to 15 April 2017.
- Dr K. Alagusundaram (DDG, Agricultural Engineering), visits Nanjing, China for participation in Regional Workshop for Research and Academic Institutions on 'Establishing a Cooperation Mechanism for Human Resource Development on Sustainable Agricultural Mechanization' from 13 to 15 April 2017.

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18. Supporting Basic and Strategic Research

The 'National Agricultural Science Fund' supports basic and strategic research in agriculture and aim 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. It has an outlay of ₹ 164.5 crore from 2017-18 to 2019-20. The scheme has already funded 145 projects, mostly in consortium mode out of which 64 are on-going projects and 61 are multi-institutional in nature. Besides supporting, reviewing, monitoring and evaluation of the ongoing projects during 2017-18, the NASF initiated for funding of new projects. A total of 976 pre-proposal were received against the call VII. A total of 32 projects were approved and remaining proposals are in the process of being evaluated. The ongoing projects are being monitored at three levels, Advisory Committee, Experts Committee and the Empowered Committee. More than 26 advisory committee meetings and six annual review meetings were held to mentor, monitor and evaluate the projects. Besides, the Empowered Committee also reviewed the progress of two mega projects viz. 'Stock characterization, captive breeding, seed production and culture of hilsa (*Tenualosa ilisha*)' and 'Phenomics of Moisture Deficit Stress Tolerance and Nitrogen Use Efficiency in Rice and Wheat – Phase II' in August 2017.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.

Workshop on transgenic chickpea and pigeon pea: A workshop on 'Transgenic Chickpea and Pigeon Pea - Way Forward' was held at NASC Complex, on 22 April 2017. Following decisions were made. (i) All the *Cry* 1 Ac events across centres need to be evaluated at IIPR, Kanpur. Lines/ Events with insect mortality more than 90% may be taken further. (ii) A comprehensive bio-efficacy analysis may be made under contained net house conditions both for chickpea and pigeon pea. (iii) The disruption of native gene, if any need to be looked into. (iv) Based on bioefficacy and the expression analysis, one event in chickpea and one event in pigeon pea need to be identified and requisite molecular and biochemical data should be generated to obtain regulatory approvals for BRL1 and BRL2 trials. (v) The transgenic plants should also be compared with non-GM crops for their agronomic performance.

Salient achievements

During 2017-18, besides having 79 research publications in reputed journal, NASF had three patents and 16 technologies. The research highlights of some selected projects are as follows:

Phenomics of moisture deficit and low temperature in rice: A diverse set of 60 rice genotypes was used to standardize image acquisition, segmentation and analysis for VIS, IR and NIR shoot imaging platforms. Work was done to develop rational models to predict component traits of drought tolerance and nitrogen use efficiency. Similarly 60 diverse rice genotypes and 150 wheat genotypes were evaluated in the phenomics facility for WUE, NUE and drought tolerance.

State-of-art plant phenomics facility

A state-of-art automated high throughput plant phenomics facility for non-destructive and accurate characterization of a large number of germplasm and recombinant inbred lines under defined environmental treatment conditions was established at IARI, New Delhi. The facility named as Nanaji Deshmukh Plant

Phenomics Facility was inaugurated by the Hon'ble Prime Minister of India on 11 October 2017. The facility consists of hi-tech climate controlled greenhouses, moving field for handling of 1,200 plants within the greenhouse and to transport them to imaging stations, different imaging platforms, viz., IR Thermal, Chlorophyll fluorescence, Visual RGB, NIR root, NIR shoot, VNIR Hyper spectral, SWIR Hyperspectral sensors for assessing drought and input use efficiency.

Double herbicide tolerant transgenic rice for weed management: Two mutated EPSPS and ALS were cloned to a single plant transformation vector and simultaneously transformed into rice and the transgenic lines showed significant tolerance to glyphosate and sulfonylurea without any yield penalty for the agronomic traits. The transgenic lines expressing double amino acids mutants were evaluated for different doses of herbicide (glyphosate). The transgenic plants tolerated up to 6X dosage of glyphosate without any visible harm to the transgenic

plants whereas the control plants dried and died at the recommended dose of glyphosate.

Development of transgenic pigeon pea and chickpea: A total of 597 T0 plants for pigeon pea and 393 T0 plants of chickpea were established. Based on the molecular and insect bioassay, five events of chickpea and five events of pigeon pea were selected. The selected events are under 'Event Selection Trial' at the IIPR, Kanpur.

Seed viability in soybean: Testing of seed coat permeability and viability was done in the seeds of 100 RILs that were stored for 3 years in ambient conditions. Seed coat permeability ranged from 0 to 100%, and viability ranged from 0 to 83%. At least 3 seed storability QTL from each linkage group C1, L and F were analyzed. qRGR-F harbored 48 genes of which 3 contained non-synonymous mutations. Out of these 3 genes, one is involved in mucilage biosynthesis and the other 2 genes encode uncharacterized protein.

Molecular mechanism of Induction of biotic stress tolerance by *Trichoderma spp.* in castor: Early events of colonization of castor roots by *Trichoderma* had established that the fungus entered roots through the intercellular spaces and colonized in the apoplastic region of the roots. It had been demonstrated that1-hydroxy-3-methyl anthraquinone (IH3MAQ), present only in the secretome of P+T (Plant + Trichoderma) treatment but not in either P or T treatments, was found as a candidate elicitor triggering the ISR in castor. To study the ability of 1H3MAQ and its analogs to ISR in a fungal free system, 1H3MAQ and six analog derivatives were synthesized chemically. These were confirmed with spectral readings and properties. These seven compounds (1H3MAQ and six derivatives) were checked for direct antifungal activity against various plant pathogenic fungi like *Fusarium oxysporum, Aspergillus niger, Phytophthora infestans* and *Botrytis ricini*. The parent compound demonstrated reduction in fungal growth in comparison to the other analogs.

Diapausing and nondiapausing spotted stem borer in sorghum and maize: Studies were conducted on development and survival of non-diapausing *C. partellus* populations from different agro-ecological regions on different maize genotypes; and the larvae feeding on these genotypes were profiled for variability in various amino acid and the lipophilic compounds. These studies revealed significant variation in biological parameters on various genotypes, which could be due to existence of genetically diverse *C. partellus* populations in different agro-climatic zones of India. The *C. partellus* larvae of different populations reared on various maize genotypes revealed significant differences in amounts and proportions of different amino acids and the lipophilic compound. The lipophilic profiling of *C. partellus* larvae showed that the Hisar population of *C. partellus* reared on susceptible maize genotype (Basi Local) had significantly higher amount of oleic acid, and significantly and positively associated with larval growth. Myristic acid, palmitoleic acid and oleic acid in different *C. partellus* populations reared on CPM 19 were significantly and negatively associated with larval survival. These biochemical compounds have implications for nutritional physiology, development and survival, and play important role in plant resistance to *C. partellus* in maize.

Adaptive mechanisms and captive breeding in hilsa: Hilsa was successfully bred with 98% fertilization. The eggs were incubated in the laboratory in glass aquaria using filtered pond water. Larvae were reared in outdoor FRP tanks. During 46 days of rearing period, larval survival was achieved up to 61.3 % at lowest stocking density (300 m-3). Hilsa was cultured in two ponds of 0.1 ha each at 15,000 and 30,000/ha stocking density, where fish grew to 134.71 mm/ 24.63 g and 119.7 mm/14.64 g from the initial size of 29.5 mm/0.27 g during 300 days of culture period.

Hilsa growth in freshwater pond

Hilsa fry could be weaned to accept artificial feed under pond culture condition. Transportation trial of eggs and larvae of hilsa revealed that the survival of eggs and larvae at 100 and 50 nos./litre were 80 and 98%, respectively. After 31 months of culture, hilsa attained average growth of 383.80±27.38 g/ 339.33±9.68 mm from initial body weight/length of 1.37±0.18 g / 52.97±5.50 mm. Significant number of matured female (358.18g-425.52g/ 352mm- 370mm) with V- stage of oocyte maturation and matured male (139.35 g/260 mm) in the cultured pond were found during October-November and January-February after 2 years of culture indicating possibility of brood stock maturation in captivity. The study also revealed that the main reason for decline of hilsa, is increased overfishing and altered flow regime. It was observed that 100 or 110 mm mesh gillnet for hilsa fishing should be followed for harvesting of fishes.

Harvesting of hilsa

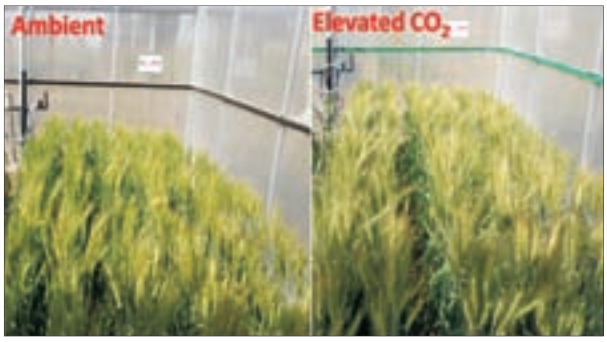
Green fishing systems for the tropical seas: The designing, fabrication and construction of the 19.75m energy efficient fishing vessel, christened as 'FV Sagar Harita' has been completed at the Goa Shipyard Ltd. Long line and Gillnet multiday fishing operations for 4-5 days in the depth of 1,500-1,900 m were being carried out onboard the fishing vessel, operations from 24 stations for high sea gillnetting and 6 stations for long lining were conducted. The solar energy is used in meeting 20% of the energy needs onboard. Average diesel consumption was 42 litres/hr in deep sea experimental fishing operations. Low drag shrimp trawls (33 m head rope length) and fish trawls (27 m

head rope length) were developed by optimizing the cutting rate which helps in reduction of drag. The same operations in the commercial trawlers operated at Munambam and Vypeen of Kerala showed a reduction of fuel by 2.5%.

Lactation stress associated postpartum anestrus SNP array in buffaloes: Biochemical and endocrine parameters revealed that high serum free fatty acids and low leptin levels are concerted negative energy balance (NEB) indicators in buffaloes. On the basis of these parameters, NEB was found to be confined to 1-1.5 months of postpartum in buffaloes. Liver and adipose tissue biopsies were collected from heifers and buffaloes, which calved later. A total of 509 and 332 significantly differentially expressed genes (DEG) were identified by NGS analysis in the liver and adipose tissues, respectively, between heifers and early lactation (15^{th} and 30^{th} day) buffaloes. Functional annotation and network analysis of DEG revealed that immune tolerance and insulin resistance are the major adaptive mechanism in the liver and adipose tissues respectively in buffaloes during early postpartum.

Diversity and synthesis of immunoglobulins in the Indian major carps: Immunoglobulin IgZ and IgM expression has been analyzed in rohu and catla. TLR4 gene was cloned and characterized in rohu. The expression in various tissues including blood showed wide range of variations among the tested tissues. In response to LPS-stimulation and Gm-negative bacterial infection, activation of TLR-4, the signaling pathway was reported. The B-lymphocyte of rohu was purified from PBMC following panning with rohu specific anti-IgM and anti-IgZ antibody. Study on transcriptomic and proteomic expression profile of TLR2, TLR3, TLR4, TLR5 and downstream signaling molecules (MyD88, ERK, NF-kB, TNFá) and IgM and IgZ, indicated that both IgM and IgZ expression are regulated by PAMPs mediated TLR activation *via* ERK and NF-kB signaling pathway. The ELISA results depicted a dramatic increase in the phospho-ERK (pERK) levels in all the treatment conditions. But there was no changes in the total-ERK levels with respect to the control recorded. Immunoblotting results corroborated with ELISA and qRT-PCR results. The qRT-PCR, ELISA and FACS analysis indicated that PGN and flagellin can potentially activate the ERK-signalling in kidney cells to induce IgM and IgZ synthesis as compared to Poly I:C (7.8-folds; 13.88-folds) and LPS (1.75-folds, 6.48-folds).

Effect of elevated CO_2 and temperature on water productivity and nutrient use in soybean-wheat cropping system: Significant positive effect of elevated CO_2 and temperature on plant growth parameters, pod attributes and grain yield was observed in soybean-wheat cropping system. Under the recommended dose of fertilizer, above ground biomass at harvest was higher by 31-47% under elevated CO_2 and/or elevated temperature conditions as compared to ambient chamber. The difference in the biomass under open field and ambient chamber was not significant. The increase in grain yield over ambient conditions varied from 30% under elevated temperature to 51% and 65% under elevated CO_2 and under elevation of both CO_2 and temperature, respectively. The seed index as measured through weight of 100 numbers of seeds, was significantly higher under elevated CO_2 and/or elevated temperature treatments than the ambient chamber and open field treatments. The study on functional properties of soybean seed indicated a trend of significant reduction in water absorption index and water hydration capacity under elevated CO_2, elevated temperature and under elevation of both CO_2 and temperature.



Wheat crop under ambient and elevated CO_2 conditions

Capacity building of farming families

Life Skills Awareness Camps were organized at the Lead as well as at the three cooperating centres to identify Peer Support Volunteers (PSVs). Rural youth were sensitized about mental health issues and need for psychological first aid. A total of 1,129 applications received till date and selection of PSVs is underway through a structured interview. Further, for the capacity building of PSVs, training instruments are being developed and tested. A pilot training was held on the modules related to suicidal ideation, recognizing and managing stressors, understanding of depressive ruminations and negative cognitions. On the evaluation front, piloting of baseline survey was started at multiple locations including pockets of suicides with a sample of 80 vulnerable farming households through eight psychological tools (GHQ, Connor-Davidson Resilience Scale, Cognitive Distortions Scale, BDI-II, Rosenberg Self-Esteem Scale, Suicide Behaviours, Questionnaire-Revised, Modified Scale for Suicidal Ideation and Friedman's Well-being Scale). Software for undertaking psychological tests of farmers to know their Cumulative Stress Index (CSI) and Psychological Resources Index (PRI) was developed and is being tested.

Eliciting soil microbiome responses of rice for enhanced water and nutrient use efficiency under anticipated climate changes: Elevated carbon dioxide (eCO_2) promotes the population of EPS producing


Open top chambers at NRRI, Cuttack

bacteria and as regard to the moisture level, no significant difference was observed among the flooded and stressed moisture condition. Application of increased doses of N or P also increased the EPS population. Higher quantity of root exudates, which are short chain aliphatic acids (mainly malic acid and tartaric acid) are observed under eCO_2 conditions that acts as nutrient medium for the EPS producing bacteria. Nitrogen and phosphorus use efficiency (NUE and PUE) increased under eCO_2 conditions. Under eCO_2 an increase in water productivity was observed. Elevated CO_2 inside OTCs helped the plant to cope up the adverse effects of water deficit stress by increasing the relative water content, decreasing the electrolyte leakage and leaf water potential which is more pronounced water deficit stress conditions. Interaction of eCO_2 and N can be exploited in modulating the EPS producing bacterial population, thereby affecting the total EPS/soil carbohydrate, which will alleviate soil moisture deficit stress.

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19. Strengthening the Research System

Direct Recruitment/Lateral Entry

The ASRB recommended 15 applicants on lateral entry basis, comprising eight Directors, two Project Coordinators and five Heads of Divisions, during the period. Recruitment process of the remaining posts which were advertised vide Advt. No. 3/2016, 4/2016, 5/2016, 1/2017 and 2/2017 was deferred due to proposed revision of score card for direct recruitment.

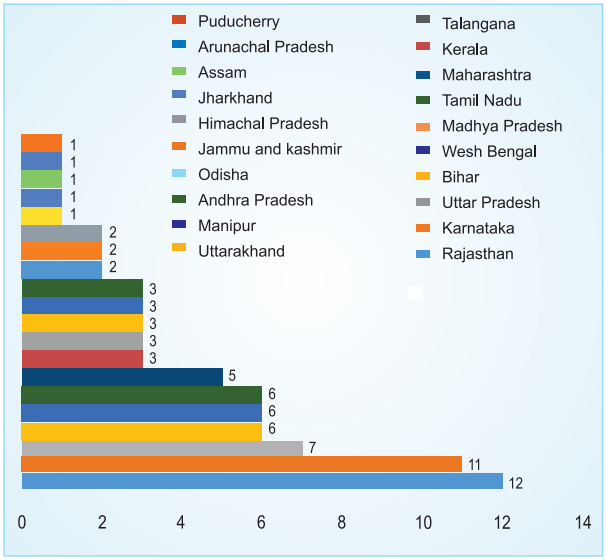
Agricultural Research Service Examination 2015

Analysis of data showed that in Agricultural Chemicals discipline, number of vacancies and number of candidate clearing the Main Examination were almost equal, while in Agricultural Statistics and Informatics, and Agricultural Structure and Environment Management, numbers of candidates qualified were lesser than the number of earmarked vacancies.

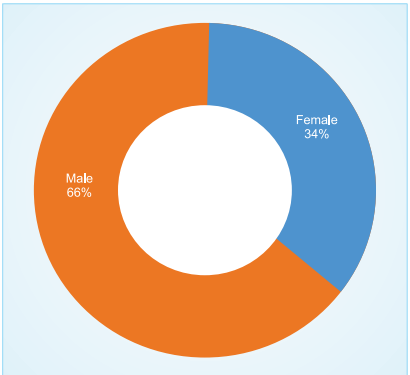
Organization-wise contribution in ARS: Out of 79 recommended candidates, 35 were from four Deemed-to-be-Universities (IARI, New Delhi; CIFE, Mumbai; IVRI, Izatnagar; and NDRI, Karnal), 37 from 14 State Agricultural Universities, 4 from BHU, Varanasi and 3 from General Universities.

State-wise distribution: Out of 79 successful candidates, 53 came from 7 states (Rajasthan, Karnataka, Uttar Pradesh, Bihar, West Bengal, Madhya Pradesh and Tamil Nadu) and the remaining 26 from 13 states.

Gender-wise distribution: Out of 79 candidates 34% were women candidates, reflecting a positive trend, interest and participation of women candidates in agricultural sciences.



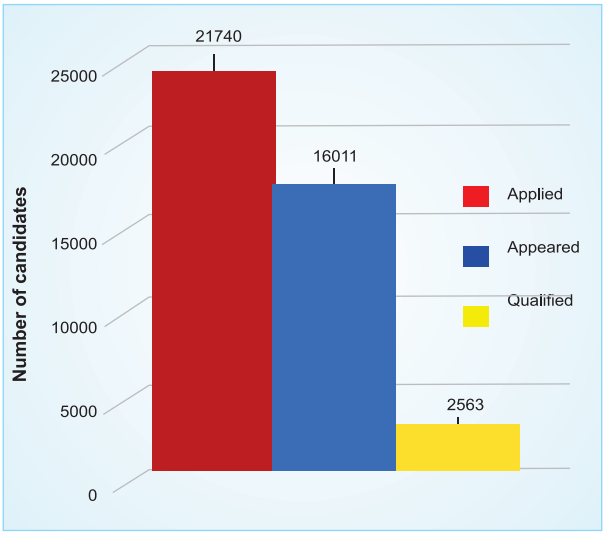
State-wise successful candidates in ARS 2015



Gender wise details of successful candidates in ARS-2015

Agricultural Research Service Examination 2016

A combined examination for ARS (preliminary) 2016 and NET 2017(I) was conducted from 16 to 21 May 2017 in online mode for 180 vacancies in 31 disciplines at 23 centres across India. A total of 21,740 candidates registered for the examination, while 16,011 candidates appeared in the examination. A total of 2,563 (16%) candidates qualified for the ARS (main) held on 8 July 2017 at 12 centres. The *viva voce* is scheduled to be held in October and November 2017.



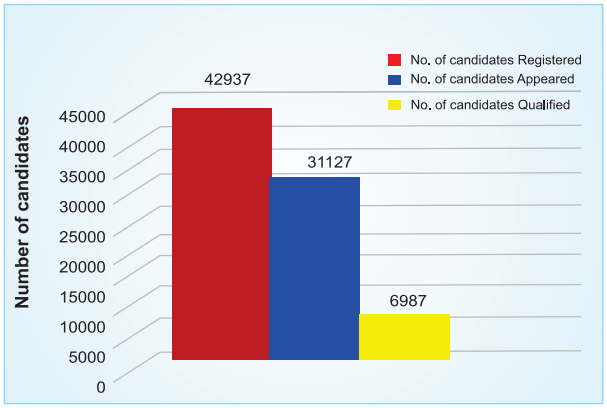
Details of ARS 2016 examination

National Eligibility Test (NET) Examination 2017 (I)

A total of 42,937 candidates registered for NET (I)-2017 examination; 31,127 candidates appeared in examination; and 6,987 candidates (22.45%) qualified it.

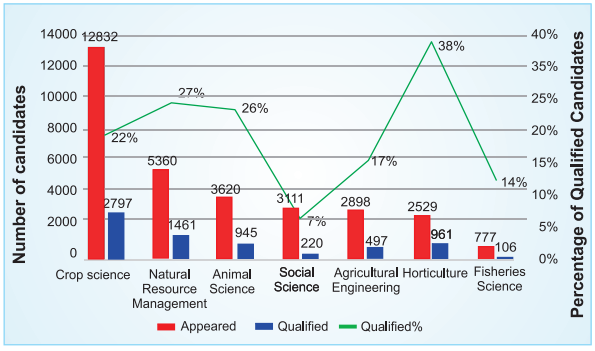
Major discipline-wise details of candidates registered and appeared in the examination are as follows:

The highest percentage of candidates qualified in the discipline of Animal Genetics and Breeding (79%)



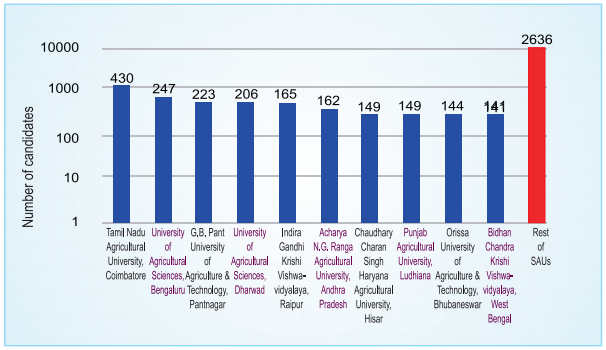
Details of NET-2017 examination

followed by Floriculture and Landscaping (58.20%), Fish Nutrition (52.00%), Poultry Science (48.57%), Veterinary Anatomy (47.37%), Veterinary Parasitology (46.15%) and Agricultural Business Management (0.24%). In eight disciplines, i.e. Agricultural Biotechnology, Economic Botany and Plant Genetics Resources, Nematology, Spices, Plantation and Medicinal and Aromatic Plants, Veterinary Surgery, Agricultural Business Management, Agricultural Extension and Home Science, the success rate was even lesser than 5 %. In Fish Health discipline, 49 candidates appeared and none qualified.



Major discipline wise details of candidates

Out of 6,987 qualified candidates, 776 (11%) were from Deemed-to-be Universities (IARI, New Delhi; IVRI, Izatnagar; NDRI, Karnal ,CIFE; Mumbai; and Sam Higginbottom Institute of Agriculture, Technology and Science , Allahabad); 2,016 (29%) from 10 State Agricultural Universities (TNAU, Coimbatore; UAS, Bengaluru; GBPUA&T, Pantnagar; UAS, Dharwad; IGKV, Raipur; ANGRAU, Hyderabad; CCSHAU, Hisar; PAU, Ludhiana; OUA&T, Bhubaneswar; BCKV, Nadia); 2,636 (38%) from rest of SAUs; 151 (2%) from Central Agricultural Universities; and 1,408 (20%) were from general universities having agricultural faculties.

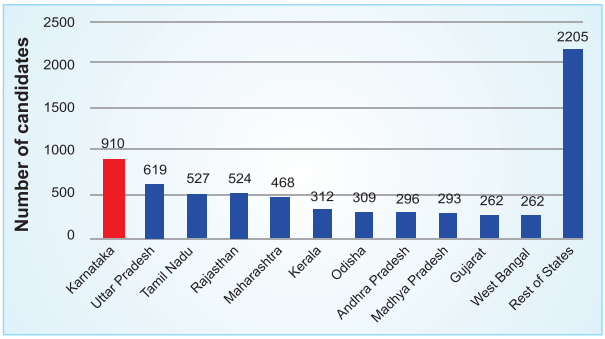


Universities wise performance of candidates in NET 2017

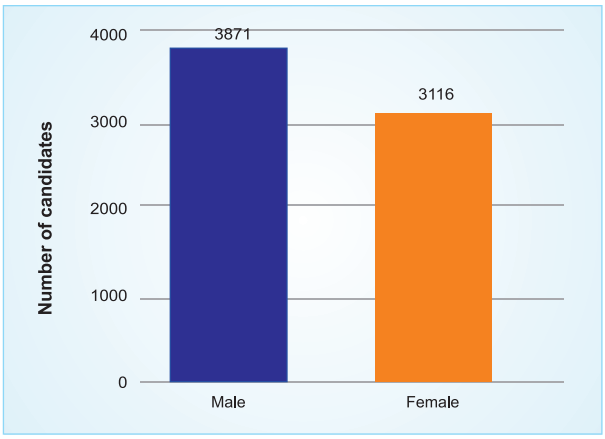
Out of 6,987 qualified candidates, 68% of successful candidates came from Karnataka, Uttar Pradesh, Tamil Nadu, Rajasthan, Maharashtra, Kerala, Odisha, Andhra Pradesh, Madhya Pradesh, Gujarat and West Bengal. Only one candidate qualified from Goa.

Among 6,987 qualified candidates, 45% were female candidates.

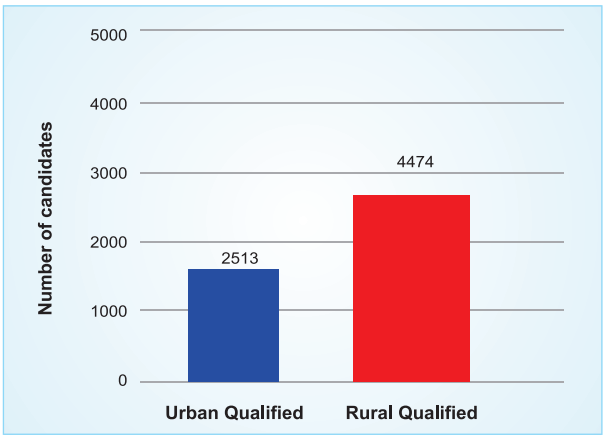
Out of 6,987 qualified candidates 64% were from rural areas.



State wise performance in NET Examination 2017



Gender wise details of successful candidates in NET Examination 2017



Area wise details of successful candidates in NET Examination 2017

Common Written Examination 2016 for Technical Assistant (T-3)

Final results of the common written examination for filling up of positions of Technical Assistant (T3) in ICAR Institutes-conducted on 17 July 2016 at 27 centres has been communicated to the concerned Institutes.

Common Written Examination 2016 for LDCs

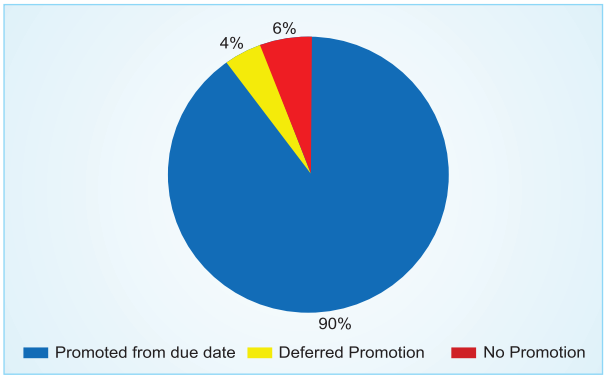
For filling up positions of Lower Division Clerks LDCs in 63 research Institute of the ICAR, computer-based online examination is to be held in the last week of October 2017 at 32 centres. About 8,700 candidates had registered for this examination.

Stenographer Grade-III and LDC Competitive examination 2017

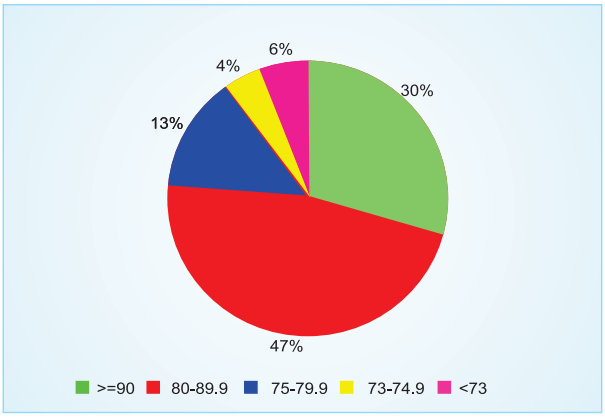
For filling up 95 posts of Stenographer Grade-III for ICAR Headquarters, New Delhi and its research Institutes, including vacancies in KVKs and for 78 positions of LDC at ICAR Headquarters, New Delhi, Online examination is to be held in the last week of October 2017 at 29 centres and skill test on 10 centres. Nearly four lakh applicants had registered for this examination.

Career Advancement Scheme (CAS) -2016

Assessment cases (179) of senior scientists for promotion to higher grade of principal scientists under the Career Advancement Scheme (CAS) were considered at the level of ASRB. The performance in



Details of assessment under the Career Advancement Scheme (CAS)



Performance of candidates assessed for promotion

respect of assessment promotion was about 90% and in addition 4% deferred promotions of the candidates were recommended for promotion to the next higher grade.

Out of successful candidates, 30% secured more than 90% marks while 47% secured more than 80 %, 4% candidates secured 73-74.9% marks amongst successful candidates, and only 6% candidates secured less than 73% marks. This in fact reflects positively on the strength of the ICAR research system.

The analysis of the data showed that out of 51 disciplines except eight disciplines, viz. Agricultural Economics, Agricultural Entomology, Biochemistry (AS), Biotechnology (PS), Farm Machinery and Power, Fish and Fishery Science, Plant Physiology and Soil Chemistry/ Fertility/ Microbiology candidates got hundred per cent promotion in all disciplines.

Career Advancement Scheme (CAS) 2017

About more than 200 proposals were received from different ICAR institutes for the promotion/assessment from Senior Scientist (GP-9000) to the grade of Principal Scientist (GP-10000) under the revised Career Advancement Scheme (CAS). For these proposals interview schedule has been fixed from 4 September to 16 October 2017. Major discipline-wise breakup of CAS proposals is as follows:

❑

20. Training and Capacity Building

Training is the process of enhancing the knowledge, skills and capabilities of employees for performing their job efficiently and effectively, but many employers in the present era find such development opportunities expensive. Training gives the employees a greater understanding of their responsibilities within their role, and in turn builds their confidence. Keeping this in view, recently created Human Resource Management Unit at ICAR HQs promoted Systematic Approach to Training in ICAR and took several initiatives to strengthen training and capacity building of all categories of ICAR employees. Some accomplishments attained during 2016-17 are enumerated below.

Developing database of training in ERP system: Availability of complete and comprehensive database of training details of all the employees provide a logical backup for assessing the training needs/gaps and helps in planning current and the future training programmes. The complete training details of 3,082 Scientists (57.0%), 1,572 Technical (38.3%), 1,400 Administrative staff (25.6%) and 961 SSS (16.3%) are now available in the system. This is a continuous activity. There would be a complete database of training of all the employees of ICAR in near future.

Identification of training need areas: All Institutes identified the training areas for different categories of employees which were compiled at the ICAR HQs with the listing of 136 training areas for Scientists, 56 areas for Technical, 39 areas for Administrative and 31 areas for Skilled Supporting Staff. This has paved the way for further designing and developing the new training programmes for different categories of employees.

Development of Annual Training Plan (ATP): The development of Annual Training Plan (ATP) based on training need assessment is necessary as per National Training Policy of GoI. A total 109 Institutes/ICAR HQs developed the ATP for all categories of employees for 2016-17 in the beginning of the year.

Training of Technical staff at CIFT, Cochin

New training programmes for technical staff: Suitable training programmes for Technical Staff of ICAR were lacking in the system. Therefore, 41 new training programmes were designed, developed and organised by 15 leading and competent ICAR-Institutes based on identifying training needs. In these training programmes, 787 technical staff participated, out of which 37% got first time opportunity after joining ICAR service.

Training programme for regular drivers (technical grade): For the first time new training programme '*Automobile Maintenance, Road Safety and Behavioural Skills*' was organized by CIAE, Bhopal in coordination with HRM Unit, ICAR HQs. In this programme, 37

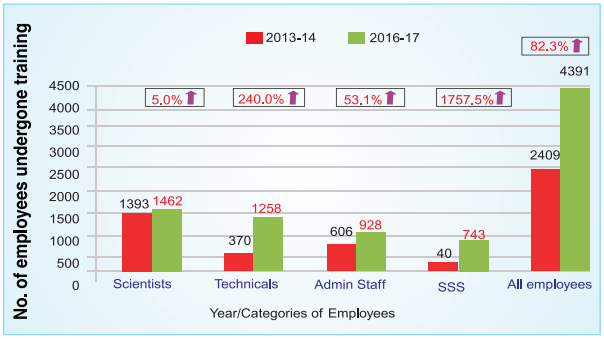
Training of Regular Drivers at CIAE, Bhopal
(20-24 February, 2017)

Regular Drivers participated in 02 batches during 2016-17, out of which about 87% got first time opportunity after joining ICAR service. The programme was very much appreciated by the Drivers and requested to continue on long term basis.

Training Programme for Stenographers: NAARM, Hyderabad, for the first time organised a new training programme "***Enhancing Efficiency and Behavioural Skills***" during 2016-17 in coordination with HRM Unit, ICAR HQs in three batches. In this programme, **99** stenographer in various grades participated, out of which about **63%** got training first time after joining ICAR services.

Training of Stenographer grades at NAARM, Hyderabad

Training and Capacity Building of Employees: During 2016-17, a total of 4,391 employees undergone various types of training and capacity building programmes, out of which scientists, technical, administrative including finance, and skilled supporting staff (SSS) were 1,462, 1,258, 928 and 743, respectively Compared to 2013-14, there was considerable improvement in number of employees undergone trainings particularly in case of Administrative, Technical and Skilled Supporting Staff, where % improvement was 53.1, 240.0 and 1757.5, respectively with 5.0 % improvement in Scientific Staff along with overall improvement of 82.3 % in all the categories of employees during 2016-17.



Improvement in Capacity Building of ICAR Employees since Caretion of HRM Unit

During 2016-17, Crop Science Division deputed highest number of scientists (295), technical staff (411) and SSS (219) while highest number of administrative staff was deputed by ICAR HQs (253) for various capacity building programmes. Overall, maximum number of employees were trained in Crop Science Division (1,089) followed by Animal Science Division (652) out of 4,391 employees trained in the ICAR system (Table 1).

In terms of % employees trained under each category, scientists (29.4%), technical (24.8%), administrative including finance (26.1%) and skilled supporting staff (14.5%) were trained in various aspects as per their training needs with overall 23.4 % employees across the categories got opportunity for capacity building during 2016-17. This is evident that 17.5, 9.6 and 13.8% more technical, administrative including finance and skilled supporting staff, respectively got training opportunities during 2016-17 as compared to 2013-14 with overall improvement of 10.7 % in capacity building of all the categories of employees.

Based on the number of institutes among the larger Divisions of ICAR, maximum percentage of employees

Training of SSS of CITH, Srinagar

Table 1. SMD-wise number of employees undergone training during 2016-17

SMDs	No. of employees undergone training					% Employees undergone training				
	Scientists	Tech.	Admin	SSS	Total	Scientists	Tech.	Admin	SSS	Total
Crop Science	295	411	164	219	1,089	18.7	29.3	19.5	15.5	20.8
Horticultural Science	205	161	94	116	576	27.4	21.4	21.2	19.9	22.8
Natural Resource Management	200	231	100	101	632	24.9	21.0	21.4	13.9	20.4
Agricultural Education	52	54	53	37	196	38.2	48.6	46.1	51.4	45.2
Agricultural Engineering	76	63	38	75	252	39.6	21.3	26.6	43.4	31.3
Animal Science	278	164	121	89	652	35.6	23.2	20.3	5.6	17.7
Fisheries Science	292	131	82	105	610	48.1	22.7	25.2	21.6	30.6
Agricultural Extension	26	10	23	1	60	61.9	25.0	27.4	9.1	33.9
ICAR (HQs)	38	33	253	0	324	46.9	37.1	46.5	0.0	41.1
Total	**1,462**	**1,258**	**928**	**743**	**4,391**	**29.4**	**24.8**	**26.1**	**14.5**	**23.4**

Table 2. Number of Trainings organized by various SMDs (Hq) during 2016-17

SMDs/Hqs	Scientists	Technical	Administrative	SSS	All Employees
Crop Science	61	54	17	43	175
Horticultural Science	42	21	4	21	88
Natural Resource Management	20	6	2	2	30
Agricultural Education	53	17	13	2	85
Agricultural Engineering	21	17	1	3	42
Animal Science	27	17	2	6	52
Fisheries Science	14	8	1	9	32
Agricultural Extension	3	5	0	0	8
ICAR (Hqs)	0	0	0	0	0
Total	**241**	**145**	**40**	**86**	**512**

undergone training and capacity building programmes in Horticultural Science (22.8) followed by Crop Science Division (20.8). In comparison to cadre strength, Education Division deputed the highest number of scientists, technical and administrative staff with overall average of 45.2 %.

During 2016-17, the training programmes organized for scientists, technical, administrative including finance, and skilled supporting staff were 241, 145, 40 and 86, respectively. Compared to 2013-14, ICAR-Institutes organized 116.4 and 1620.0 % more training programmes for technical and skilled supporting staff, respectively, with overall 16.9 % more training programmes were organised during 2016-17.

Crop Science Division organized maximum number of trainings for scientists (61), technical (54), administrative (17) and skilled supporting staff (43) with overall maximum number of trainings (175) during 2016-17 for all the categories of staff (Table 2). ❑

(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	1
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	4
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	5
	Total	49

NAMES OF THE IMPORTANT FUNCTIONARIES

Sl.No.	Name	Designations
1.	Dr Trilochan Mohapatra	Secretary (DARE) and DG (ICAR)
2.	Shri Surendra Nath Tripathi	Additional Secretary and Financial Advisor
3.	Shri Chhabilendra Roul	Additional Secretary (DARE) and Secretary (ICAR)
4.	Shri Rajan Agrawal	Director
5.	Shri Mohinder Kumar	Principal Staff Officer
6.	Shri A.R. Sengupta	Deputy Secretary
7.	Shri Jitendra Misra	Under Secretary
8.	Shri T. B. Baviskar	Under Secretary
9.	Shri Prem Prakash Maurya	Under Secretary
10.	Shri A.G. Subramanian	Under Secretary
11.	Shri Rajesh Kumar	Under Secretary
12.	Shri R. Vijayaraghavan	Under Secretary
13.	Shri U.S. Pandey	Under Secretary
14.	Shri V. Kurien John	Principal Private Secretary
15.	Shri Sanjeev Kumar Sharma	Principal Private Secretary
16.	Shri V. S. R. Murthy	Principal Private Secretary
17.	Dr Puran Singh	Assistant Director (Official Language)

APPENDIX III

ACTIVITY PROGRAMME CLASSIFICATION

Budget Estimates (BE) and Revised Estimates (RE) for the year 2016-17 and BE 2017-18 in r/o DARE Secretariate Contribution, CAUs and NAAS and IAUA are given in Table-1

Table 1. Budget Estimates and Revised Estimates of DARE

(Rupees in Lakh)

Items		Budget Estimates 2016-17		Revised Estimates 2016-17		Budget Estimates 2017-18
		Plan	Non-Plan	Plan	Non-Plan	Unified Budget
Major Head '3451'						
090	Secretariat-Economic Services	–	1336.00	–	688.00	760.00
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					
020031	Grants in Aid General	200.00	–	100.00	–	200.00
020035	Grants for creation of Capital Assets	6700.00	–	3349.68	–	3000.00
020036	Grants in Aid Salaries	100.00	–	100.00	–	700.00
03	Grant-in-Aid Central Agricultural University Bihar					
030031	Grants in Aid General	1000.00	–	600.32	–	1000.00
030035	Grants for creation of Capital Assets	1700.00	–	850.00	–	100.00
030036	Grants in Aid Salaries	3000.00	–	3000.00	–	6500.00
04	Grants-in-Aids to Central Agricultural University, Barapani					
040031	Grants in Aid General	–	–	–	–	
040035	Grants for creation of Capital Assets	–	–	–	–	
040036	Grants in Aid Salaries	–	–	–	–	
05	Grants-in-Aids to National Academy of Agricultural Sciences and Indian Agricultural Universities Association					
050031	Grants in Aid General	150.00	–	133.00	–	192.00
050035	Grants for creation of Capital Assets	30.00	–	17.00	–	8.00
050036	Grants in Aid Salaries	120.00	–	–	–	–
80.798	International Co-operation (Minor Head)					
01	India's Membership Contribution to Commonwealth Agricultural Bureau					
010032	Contribution	–	–	–	25.00	25.00
02	India's Membership Contribution to Consultative Group on International Agricultural Research					
020032	Contribution	–	–	–	549.05	549.75
03	Other Programmes					
030012	Foreign Travel Expenses	–	–	–	–	
030020	Other Administrative Expenses	–	–	–	–	
030032	Contribution	–	–	–	–	
04	Asia Pacific Association of Agricultural Research Institutions					
040032	Contribution	–	–	–	7.30	14.60
05	N.A.C.A.					
050032	Contribution	–	–	–	44.00	44.00
06	Regional Coordination Centre for Research & Development of Coarse Grains, Pulses, Roots & Tuber Crops (CGPRT) in the Humid Tropics of Asia & the Pacific					
060032	Contribution	–	–	–	–	
07	International Seed Testing Association, Zurich, Switzerland					
070032	Contribtion	–	–	–	4.25	4.25
08	International Society for Horticulture Science, Belgium					

(continued)

Items		Budget Estimates 2016-17		Revised Estimates 2016-17		Budget Estimates 2017-18
		Plan	Non-Plan	Plan	Non-Plan	Unified Budget
080032	Contribution	–	–	–	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	2900.00	–	1500.00	–	1300.00
010035	Grants for creation of Capital Assets	7000.00	–	3500.00	–	1900.00
010036	Grants in Aid Salaries	7000.00	–	7000.00	–	8800.00
02	Grant-in-Aid-General to Central Agricultural University, Barapani					
020031	Grants in Aid General	34.00	–	–	–	–
020035	Grants for creation of Capital Assets	33.00	–	–	–	–
020036	Grants in Aid Salaries	33.00	–	–	–	–
	Total	30000.00	1336.00	20150.00	1318.00	25098.00

MINISTRY OF AGRICULTURE & FARMERS WELFARE

Demand No. 2 Department of Agricultural Research and Education

(Rs. In crores)

Schemes	Actual 2015-2016			B.E. 2016-2017			R.E. 2016-2017			B.E. 2017-2018		
	Revene	Capital	Total	Revene	Capital	Total	Revene	Capital	Total	Revene	Capital	Total
Gross	5572.90	–	5572.90	6620.00	–	6620.00	6238.00	–	6238.00	6800.00	–	6800.00
Recoveries	-186.64	–	-186.64	–	–	–	–	–	–	–	–	–
Receipts	–	–	–	–	–	–	–	–	–	–	–	–
Net	5386.26	–	5386.26	6620.00	–	6620.00	6238.00	–	6238.00	6800.00	–	6800.00
A. The Budget allocations, net of recoveries, are given below :												
Centre's Expenditure												
I. Establishment Expenditure of the Centre												
1. Secretariat	10.34	–	10.34	13.36	–	13.36	13.28	–	13.28	13.98	–	13.98
Central Sector Schemes/Projects												
2. Agricultural Extension	663.89	–	663.89	755.99	–	755.99	855.71	–	855.71	232.51	–	232.51
3. Agricultural Engineering	186.00	–	186.00	221.31	–	221.31	191.31	–	191.31	42.68	–	42.68
4. Management of Natural Resources												
Natural Resource Management Institutes including Agro-Forestry Research	599.80	–	599.80	666.37	–	666.37	619.23	–	619.23	167.68	–	167.68
5. Climate Resilient Agriculture Initiative	95.00	–	95.00	110.00	–	110.00	70.50	–	70.50	50.00	–	50.00
Total-Management of Natural Resources	694.80	–	694.80	776.37	–	776.37	689.73	–	689.73	217.68	–	217.68
6. Crop Science	1273.05	–	1273.05	1385.48	–	1385.48	1380.02	–	1380.02	387.41	–	387.41
7. Horticultural Science	500.88	–	500.88	560.71	–	560.71	528.87	–	528.87	154.90	–	154.90
8. National Agricultural Science Fund	45.00	–	45.00	70.00	–	70.00	35.00	–	35.00	48.80	–	48.80
Total Crop Science	1818.93	–	1818.93	2016.19	–	2016.19	1941.89	–	1941.89	591.11	–	591.11
9. Animal Sciences												
Animal Science	733.37	–	733.37	842.68	–	842.68	823.25	–	823.25	271.97	–	271.97
10. Fisheries Science	343.40	–	343.40	404.70	–	404.70	397.14	–	397.14	115.85	–	115.85
Total Animal Science	1076.77	–	1076.77	1247.38	–	1247.38	1220.39	–	1220.39	387.82	–	387.82
Agricultural Education												
11. Agricultural Universities and Institutions	609.75	–	609.75	674.75	–	674.75	726.46	–	726.46	663.37	–	663.37
12. Economic Statistics & Management	49.17	–	49.17	69.44	–	69.44	65.51	–	65.51	31.29	–	31.29
Total Agricultural Education	658.92	–	658.92	744.19	–	744.19	791.97	–	791.97	694.66	–	694.66
13. Actual Recoveries	-186.64	–	-186.64	–	–	–	–	–	–	–	–	–
Total - Central Sector Plan Schemes	4912.67	–	4912.67	5761.43	–	5761.43	5691.00	–	5691.00	2166.46	–	2166.46

(Continued)

Schemes	Actual 2015-2016			B.E. 2016-2017			R.E. 2016-2017			B.E. 2017-2018		
	Revene	Capital	Total	Revene	Capital	Total	Revene	Capital	Total	Revene	Capital	Total
Other Central Sector Schemes/Projects												
Autonomous Bodies												
14. ICAR Headquarter	285.65	–	285.65	545.21	–	545.21	322.22	–	322.22	4382.56	–	4382.56
15. Central Agriculture Universities	175.20	–	175.20	297.00	–	297.00	200.00	–	200.00	235.00	–	235.00
16. National Academy of Agriculture Sciences	2.40	–	2.40	3.00	–	3.00	1.50	–	1.50	2.00	–	2.00
Total- Autonomous Bodies	463.25	–	463.25	845.21	–	845.21	533.72	–	533.72	4619.56	–	4619.56
Total - Central Sector Plan Schemes	463.25	–	463.25	845.21	–	845.21	533.72	–	533.72	4619.56	–	4619.56
Grand Total	5386.26	–	5386.26	6620.00	–	6620.00	6238.00	–	6238.00	6800.00	–	6800.00
B. Developmental Heads												
Economic Servcies												
1. Agricultural research and Education	5381.05	–	5381.05	6236.64	–	6236.64	5914.12	–	5914.12	6469.55	–	6469.55
2. Secretaries-Economic Services	5.21	–	5.21	13.36	–	13.36	6.88	–	6.88	7.45	–	7.45
Total-Economic Services	5386.26	–	5386.26	6250.00	–	6250.00	5921.00	–	5921.00	6477.00	–	6477.00
Others												
3. North Eastern Areas	–	–	–	370.00	–	370.00	–	–	317.00	323.00	–	323.00
Total -Others	–	–	–	370.00	–	370.00	317.00	–	317.00	323.00	–	323.00
Grand Total	5386.26	–	5386.26	6620.00	–	6620.00	6238.00	–	6238.00	6800.00	–	6800.00

APPENDIX 1

INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

(i) *Minister-in-charge of the portfolio of Agriculture in the Union Cabinet- President of the Society*

1. Shri Radha Mohan Singh *Ex-officio*
Minister of Agriculture & Farmers Welfare
Government of India
Krishi Bhavan, New Delhi-110 001

(ii) *Minister of State in the Union Ministry of Agriculture & Farmers Welfare dealing with ICAR*

2. Shri Gajendra Singh Shekhawat *Ex-officio*
Minister of State for Agriculture & Farmers Welfare
Krishi Bhavan, New Delhi-110 001

(iii) *Union Ministers holding charge of Finance, Planning, Science & Technology, Education and Commerce (in case the Prime Minister is holding any of these portfolios, the Minister of State in the Ministry / Department concerned)*

3. Shri Arun Jaitley *Ex-officio*
Minister of Finance
Government of India
North Block, New Delhi-110 001
4. Shri Rao Inderjit Singh *Ex-officio*
Minister of State for Planning
Government of India
Room No. 132, NITI Aayog,
New Delhi 110 001
5. Dr Harsh Vardhan *Ex-officio*
Minister of Science & Technology
Government of India
CSIR Building, 2 Rafi Marg
New Delhi-110 001
6. Shri Prakash Javadekar *Ex-officio*
Minister of Human Resource Development
Government of India
Shastri Bhavan, New Delhi-110 001
7. Shri Suresh Prabhu *Ex-officio*
Minister of State for Commerce & Industry,
Government of India,
Udyog Bhavan, New Delhi-110 001

(iv) *Other Ministers in the Union Ministry of Agriculture & Farmers Welfare*

8. Shri Parshottam Rupala, Minister of *Ex-officio*
State for Agriculture & Farmers Welfare
Krishi Bhavan, New Delhi-110 001
9. Smt. Krishna Raj, Minister of State *Ex-officio*
for Agriculture & Farmers Welfare
Krishi Bhavan, New Delhi-110 001

(v) *Ministers in the States in-charge of Agriculture/ Horticulture/Animal Husbandry/ Fisheries.*

ANDHRA PRADESH

10. Shri Somireddy Chandramohan Reddy *Ex-officio*
Minister for Agriculture & Horticulture
Government of Andhra Pradesh
A.P. Secretariat
Hyderabad, Andhra Pradesh-500 022
11 Ch. Adi Narayana Reddy
Minister for Animal Husbandry & Fisheries
Government of Andhra Pradesh
A.P. Secretariat
Hyderabad, Andhra Pradesh-500 022

ARUNACHAL PRADESH

12. Shri Wangki Lowang *Ex-officio*
Minister for Agriculture
Government of Arunachal Pradesh
CM Secretariat, Itanagar
Arunachal Pradesh-791 111
13. Shri Pema Khandu *Ex-officio*
Chief Minister and holding the charge of
Minister for Animal Husbandry and Fisheries
Government of Arunachal Pradesh
CM Secretariat, Itanagar
Arunachal Pradesh-791 111
14. Dr Mohesh Chai *Ex-officio*
Minister for Animal Husbandry
Government of Arunachal Pradesh
CM Secretariat, Itanagar
Arunachal Pradesh-791 111

ASOM

15. Shri Atul Bora *Ex-officio*
Minister for Agriculture and Horticulture
and Animal Husbandry
Government of Asom
Asom Secretariat, Dispur
Guwahati -781006, Asom
16. Shri Parimal Suklabaidya *Ex-officio*
Minister of Fisheries
Government of Asom
Asom Secretariat, Dispur
Guwahati -781006, Asom

BIHAR

17. Shri Pashupati Kumar Paras *Ex-officio*
Minister for Animal Husbandry and
Fisheries Resources
Government of Bihar
Vikas Bhavan, New Secretariat
Bailey Road, Patna, Bihar-800 015
18. Dr Prem Kumar *Ex-officio*
Minister for Agriculture & Horticulture
Government of Bihar
Vikas Bhavan, New Secretariat
Bailey Road, Patna, Bihar-800 015

CHHATTISGARH

19. Shri Brijmohan Agarwal *Ex-officio*
Minister of Agriculture, Animal
Husbandry and Fisheries
Government of Chhattisgarh
Mahanadi Bhawan, Mantralaya
Naya Raipur - 492002, Chattisgarh

DELHI

20. Shri Gopal Rai *Ex-officio*
Minister for Development
Delhi Secretariat, I.P. Estate
New Delhi-110 002

GOA

21. Shri Manohar Parrikar *Ex-officio*
Chief Minister holding the charge of
Ministry of Horticulture & Animal Husbandry
Government of Goa, Secretariat
Panaji, Goa-403 001

22. Shri Vijai Sardesai
Minister of Agriculture
Government of Goa, Secretariat
Panaji, Goa-403 001

23 Shri Vinoda Paliencar
Minister of Fisheries, Government of Goa
Secretariat, Panaji, Goa-403 001

GUJARAT

24. Shri Ranchhod Faldu *Ex-officio*
Minister for Agriculture, Horticulture,
Fisheries & Animal Husbandry,
Government of Gujarat
Swarnim Sankul-I
New Sachivalaya, Gandhinagar
Gujarat-382 010

HARYANA

25. Shri Om Prakash Dhankar *Ex-officio*
Minister for Agriculture,
Fisheries and Animal Husbandary
Government of Haryana, Haryana Civil Secretariat
Chandigarh, Haryana

HIMACHAL PRADESH

26. Shri Virender Kanwar *Ex-officio*
Minister of Animal Husbandry & Fisheries
Government of Himachal Pradesh
H.P. Secretariat, Shimla
Himachal Pradesh-171 002

27. Shri Ram Lal Markanda *Ex-officio*
Minister for Agriculture
Government of Himachal Pradesh
H.P. Secretariat, Shimla
Himachal Pradesh-171 002

28. Shri Mahender Singh Thakur *Ex-officio*
Minister for Horticulture
Government of Himachal Pradesh
H.P. Secretariat, Shimla
Himachal Pradesh-171 002

JAMMU and KASHMIR

29. Mr Ghulam Nabi Lone *Ex-officio*
Minister for Agriculture Production
Government of Jammu and Kashmir
Civil Secretariat, Jammu-180 001
Jammu and Kashmir

30. Mr Abdul Ghani Kohli *Ex-officio*
Minister for Animal Husbandry and Fisheries
Government of Jammu and Kashmir
Civil Secretariat, Jammu-180 001
Jammu and Kashmir

31. Syed Basharat Ahmed Bukhari *Ex-officio*
Minister for Horticulture
Government of Jammu and Kashmir
Civil Secretariat, Jammu-180 001
Jammu and Kashmir

JHARKHAND

32. Shri Randhir Kumar Singh *Ex-officio*
Minister of Agriculture, Animal
Husbandry and Fisheries
Government of Jharkhand
Project Building HEC, Dhurva
Ranchi, Jharkhand-834 002

KARNATAKA

33. Shri S.S. Mallikarjuna Davangere *Ex-officio*
Minister of Horticulture
Government of Karnataka
Vidhan Soudha, Bengaluru
Karnataka-560 001

34. Shri Pramod Madvaraj *Ex-officio*
Minister of Fisheries
Government of Karnataka
Vidhan Soudha, Bengaluru
Karnataka-560 001

35. Shri A. Manju *Ex-officio*
Minister of Animal Husbandry
Government of Karnataka
Vidhan Soudha, Bengaluru
Karnataka-560 001

36. Shri Krishna Byre Gowda *Ex-officio*
Minister of Agriculture
Government of Karnataka
Vidhan Soudha, Bengaluru
Karnataka-560 001

KERALA

37. Shri V.S. Sunil Kumar *Ex-officio*
Minister for Agriculture
Government of Kerala
Secretariat Annexe
Thiruvananthapuram
Kerala-695 001

38. Shri K. Raju *Ex-officio*
Minister for Animal Husbandry
Government of Kerala
Secretariat Annexe
Thiruvananthapuram, Kerala-695 001

39. Smt J. Mercykutty Amma *Ex-officio*
Minister for Fisheries
Government of Kerala
Secretariat Annexe
Thiruvananthapuram, Kerala-695 001

MADHYA PRADESH

40. Shri Gaurishankar Chaturbhuj Bisen *Ex-officio*
Minister of Agriculture Development
Government of Madhya Pradesh
Vallabh Bhavan
Bhopal, Madhya Pradesh-423 006

41. Shri Surya Prakash Meena *Ex-officio*
Minister of State for Horticulture
Government of Madhya Pradesh
Vallabh Bhavan
Bhopal, Madhya Pradesh-423 006

42. Shri Antar Singh Arya *Ex-officio*
Minister of Animal Husbandry and Fisheries
Government of Madhya Pradesh
Vallabh Bhavan
Bhopal, Madhya Pradesh -423 006

MAHARASHTRA

43. Shri Pandurang Pundalik *Ex-officio*
Minister for Agriculture and Horticulture
Government of Maharashtra
Mantralaya, Mumbai
Maharashtra-400 032

44. Shri Mahadev Jankar *Ex-officio*
Minister for Animal Husbandry and
Fisheries Development
Government of Maharashtra
Mantralaya, Mumbai
Maharashtra-400 032

MANIPUR

45. Shri V. Hangkhalian *Ex-officio*
Minister for Agriculture and
Animal Husbandry
Government of Manipur
Secretariat
Imphal, Manipur-795 001

46. Shri Thounaojam Shamkumar *Ex-officio*
Minister for Horticulture
Government of Manipur, Secretariat
Imphal, Manipur-795 001

47. Shri N. Kayishii *Ex-officio*
Minister for Fisheries
Government of Manipur, Secretariat
Imphal, Manipur-795 001

MEGHALAYA

48. Dr Mukul Sangma *Ex-officio*
Chief Minister holding the Charge of
Ministry of Agriculture and Horticulture
Government of Meghalaya
Meghalaya Secretariat (C)
Shillong, Meghalaya-793 001

49. Shri H. Donkupar R. Lyngdoh *Ex-officio*
Minister for Animal Husbandry
Government of Meghalaya
Meghalaya Secretariat (C)
Shillong, Meghalaya-793 001

MIZORAM

50. Shri R. Lalzirliana *Ex-officio*
Minister for Agriculture
Government of Mizoram
Aizwal, Mizoram - 796 001

51. Shri P.C. Lalthanliana *Ex-officio*
Minister for Horticulture
Government of Mizoram
Aizwal, Mizoram - 796 001

52. Shri C. Ngunlianchunga *Ex-officio*
Minister of State for Animal Husbandry
Government of Mizoram
Aizwal, Mizoram - 796 001

53. Smt. Vanlalawmpuii Chawngthu *Ex-officio*
Minister of State for Fisheries
Government of Mizoram
Aizwal, Mizoram - 796 001

NAGALAND

54. Shri Y.M. Yollow *Ex-officio*
Minister of State for Agriculture
Government of Nagaland
Civil Secretariat Complex
Kohima, Nagaland-797 004

55. Shri Kejong Chang *Ex-officio*
Minister of State for Horticulture
Government of Nagaland
Civil Secretariat Complex
Kohima, Nagaland-797 004

56. Shri S. Chuba Longkumer *Ex-officio*
Minister of State for Animal Husbandry
Government of Nagaland
Civil Secretariat Complex
Kohima, Nagaland-797 004

57. Shri Shetoyi *Ex-officio*
Minister of State for Fisheries
Government of Nagaland
Civil Secretariat Complex
Kohima, Nagaland-797 004

ODISHA

58. Shri Damodar Rout *Ex-officio*
Minister for Agriculture, Fisheries and
Animal Resource Development
Government of Odisha
Odisha Secretariat
Bhubaneswar, Odisha-751 001

PUNJAB

59. Captain Amarinder Singh *Ex-officio*
Chief Minister holding the Charge of
Ministry of Agriculture, Horticulture, Animal
Husbandry & Fisheries
Government of Punjab
Punjab Civil Secretariat, Chandigarh, Punjab

PUDUCHERRY

60. Shri R. Kamalakannan *Ex-officio*
Minister for Agriculture
Government of Puducherry
Puducherry-605 001

61. Shri A. Namassivayam *Ex-officio*
Minister for Animal Husbandry Government
of Puducherry, Puducherry-605 001

62. Shri Malladi Krishna Rao *Ex-officio*
Minister for Fisheries
Government of Puducherry
Puducherry-605 001

RAJASTHAN

63. Shri Prabhu Lal Saini *Ex-officio*
Minister for Agriculture, Horticulture
Animal Husbandry and Fisheries
Government of Rajasthan, Rajasthan
Secretariat, Mantralaya Bhawan
Jaipur, Rajasthan - 302 005

SIKKIM

64. Shri Somnath Poudyal *Ex-officio*
Minister for Agriculture Development
and Horticulture, Animal Husbandry,
Livestock Fisheries, Government of Sikkim
New Secretariat, Development Area
Gangtok, Sikkim-737 101

TAMIL NADU

65. Shri Thiru R. Doraikkannu *Ex-officio*
Minister for Agriculture and Horticulture
Government of Tamil Nadu
Chennai, Tamil Nadu-600 009

66. Shri Thiru D. Jayakumar *Ex-officio*
Minister for Fisheries
Government of Tamil Nadu
Chennai, Tamil Nadu-600 009

67. Shri Udumalai Radhakrishnan *Ex-officio*
Minister for Animal Husbandry
Government of Tamil Nadu
Chennai, Tamil Nadu-600 009

TELANGANA

68. Shri Pocharam Srinivas Reddy *Ex-officio*
Minister of Agriculture, Horticulture
Room No. 261, D-Block
Government of Telangana
Telangana Secretariat
Hyderabad - 500 022, Telangana

69. Shri Talasani Srinivas Yadav
Minister of Animal Husbandry
& Fisheries
Room No.261, D-Block
Government of Telangana,
Telangana Secretariat
Hyderabad - 500 022, Telangana

TRIPURA

70. Shri Aghore Debbarma *Ex-officio*
Minister for Agriculture
and Animal Resource Development
Government of Tripura
Civil Secretariat
Agartala, Tripura-799 001

71. Shri Khagendra Jamatia *Ex-officio*
Minister for Fisheries
Government of Tripura
Civil Secretariat,
Agartala, Tripura-799 001

UTTARAKHAND

72. Shri Subodh Uniyal *Ex-officio*
Minister for Agriculture and Horticulture
Government of Uttarakhand
Uttarakhand Vidhan Sabha Bhawan
Dehradun, Uttarakhand

73. Smt. Rekha Arya *Ex-officio*
Minister for Animal Husbandry
and Fisheries Government of
Uttarakhand, Uttarakhand
Vidhan Sabha Bhawan
Dehradun, Uttarakhand

UTTAR PRADESH

74. Shri Dara Singh Chauhan — *Ex-officio*
Minister of Horticulture
Government of Uttar Pradesh
UP Civil Secretariat
Lucknow, Uttar Pradesh

75. Shri Surya Pratap Shahi — *Ex-officio*
Minister of Agriculture
Government of Uttar Pradesh
UP Civil Secretariat
Lucknow, Uttar Pradesh

76. Shri S. P. Singh Baghel — *Ex-officio*
Minister of Animal Husbandry & Fisheries
Government of Uttar Pradesh
UP Civil Secretariat
Lucknow, Uttar Pradesh

WEST BENGAL

77. Dr Ashish Banerjee — *Ex-officio*
Minister for Agriculture
Government of West Bengal
"NABANNA", HRBC Building
Sarat Chatterjee Road
Shibpur, Howrah - 711 102
Kolkata, West Bengal

78. Sri Swapan Debnath — *Ex-officio*
Minister of State for Animal Resources
(Independent Charge)
Government of West Bengal
Prabi Sampad Bhavan
LB2, Sector-III, Salt Lake City
Kolkata-700 106, West Bengal

79. Sri Chandranath Sinha — *Ex-officio*
Minister for Fisheries Development Department
Government of West Bengal
Benfish, I.T. Tower, G.N. Block
Sector – V, Salt Lake City
Kolkata – 700 106, West Bengal

80. Sri Janab Abdur Rezzak Mollah — *Ex-officio*
Minister for Horticulture
Government of West Bengal
Mayukh Bhavan, Salt Lake
Kolkata -700 091, West Bengal

(vi) *Member, NITI Ayog, In-charge of Agriculture*

81. Dr Ramesh Chand — *Ex-officio*
Member (Agriculture)
NITI Ayog
Yojana Bhawan, New Delhi-110 001

(vii) *Six members of Parliament—four elected by Lok Sabha and two elected by Rajya Sabha*

82. Smt. Renuka Chowdhury — 2 April, 2018
Member of Parliament (RS)
H.No.8-1-116, Khanapuram (V)
Khammam Urban (M), Khammam District
Andhra Pradesh-507 002

Smt Renuka Chowdhury
Member of Parliament (RS)
76, Lodhi Estate
New Delhi-110 003

83. Vacant

84. Shri Dushyant Chautala — Till the expiry of term in Lok Sabha
Member of Parliament (LS)
18, Janpath, New Delhi - 110 001

85. Shri Sanjay Dhotre — Till the expiry of term in Lok Sabha
Member of Parliament (LS)
AB-95,Shahjahan Road
New Delhi - 110 013

86. Shri Raju Shetti — Till the expiry of term in Lok Sabha
Member of Parliament (LS)
Flat No. 102, Narmada
Dr Bishambar Das Marg
New Delhi - 110 001

87. Shri Ravneet Singh — Till the expiry of term in Lok Sabha
Member of Parliament (LS)
28, Dr Rajendra Prasad Road
New Delhi – 110 001

(viii) *Director-General, Indian Council of Agricultural Research*

88. Dr T. Mohapatra — *Ex-officio*
Director-General
ICAR, Krishi Bhavan
New Delhi-110 001

(ix) *All Secretaries in the Ministry of Agriculture and Farmers Welfare*

89. Shri S. K. Pattanayak — *Ex-officio*
Secretary, Deptt. of Agriculture,
Cooperation and Farmers Welfare
Ministry of Agriculture and Farmers Welfare
Krishi Bhavan
New Delhi-110 001

90. Shri Devendra Chaudhary — *Ex-officio*
Secretary, Deptt. of Animal Husbandry,
Dairying & Fisheries
Ministry of Agriculture and Farmers Welfare
Krishi Bhavan
New Delhi-110 001

(x) *CEO, NITI Ayog*

91. Shri Amitabh Kant — *Ex-officio*
CEO, Niti Ayog
Yojana Bhavan, Sansad Marg
New Delhi-110 001

(xi) *Secretary, Department of Bio-technology*

92. Prof K. Vijay Raghavan — *Ex-officio*
Secretary
Department of Biotechnology
Block 2, 7th Floor, CGO Complex
Lodhi Road, New Delhi-110 003

(xii) *Director-General, Council of Scientific and Industrial Research*

93. Dr Girish Sahni — *Ex-officio*
Director General
Council of Scientific and Industrial Research
Anusandhan Bhavan
2-Rafi Ahmed Kidwai Marg
New Delhi-110 001

(xiii) *Chairman, University Grants Commission*

94. Dr V. S. Chauhan — *Ex-officio*
Chairman
University Grants Commission
Bahadur Shah Zafar Marg
New Delhi-110 002

(xiv) *Chairman, Atomic Energy Commission (or Director, Bhabha Atomic Research Centre, if nominated by the Chairman, Atomic Energy Commission)*

95. Dr Sekhar Basu — *Ex-officio*
Chairman, Atomic Energy Commission
Department of Atomic Energy
Anushakti Bhavan
Chhatrapati Shivaji Maharaj Marg
Mumbai-400 001

(xv) *Member, Finance (Secretary/ Additional Secretary) in the Ministry of Finance, Government of India*

96. Shri Pramod Kumar Das — *Ex-officio*
Additional Secretary (Expenditure)
Department of Expenditure
Ministry of Finance, North Block
New Delhi-110 001

(xvi) *Four Vice-Chancellors of Agricultural Universities, nominated by the President*

97. Dr Ramesh Chandra Srivastava — 13 November, 2020
Vice Chancellor
Dr Rajendra Prasad Central Agricultural University

Pusa, Samastipur-848 125, Bihar

98. Dr V. Praveen Rao — 24 July, 2019
Vice Chancellor
Prof. Jayashankar Telangana State Agricultural University, Rajendranagar
Hyderabad-500 030, Telangana

99. Dr A. K. Singh — 23 May, 2019
Vice Chancellor
Bihar Agricultural University, Sabour
Bhagalpur

100. Dr A. R. Pathak — 28 December, 2018
Vice Chancellor, Junagadh
Agricultural University
Junagadh – 362001, Gujarat

(xvii) *Five Technical Representatives, namely Agricultural Commissioner, Horticultural Commissioner, Animal Husbandry Commissioner, Fisheries Development Commissioner, from the Union Ministry of Agriculture and Inspector-General of Forests, Government of India*

101. Dr S.K. Malhotra — *Ex-officio*
Agriculture Commissioner
Dept. of Agriculture and Co-operation
Ministry of Agriculture and Farmers Welfare
Krishi Bhavan, New Delhi-110 001

102. Dr B.N.S. Murthy — *Ex-officio*
Horticulture Commissioner
Dept. of Agriculture and Co-operation
Ministry of Agriculture and Farmers Welfare
Krishi Bhavan, New Delhi-110 001

103. Dr Suresh S. Honnappagol — *Ex-officio*
Animal Husbandry Commissioner
Dept. of Animal Husbandry, Dairying and Fisheries
Ministry of Agriculture and Farmers Welfare
Krishi Bhavan, New Delhi-110 001

104. Dr P. Paul Pandian — *Ex-officio*
Fisheries Development Commissioner
Dept. of Animal Husbandry, Dairying and Fisheries
Ministry of Agriculture and Farmers Welfare
Krishi Bhavan, New Delhi-110 001

105. Dr Anoop Badhwa — *Ex-officio*
Inspector General of Forests (NAEB)
Ministry of Environment and Forests
Paryavaran Bhawan, B-Block
CGO Complex, Lodi Road, New Delhi-110 003

(xviii) *Fifteen scientists from within and outside the Council including one representative from the Indian Council of Medical Research*

106. Dr A. Gopalakrishnan — 9 January, 2018
Director
Central Marine Fisheries Research Institute
Post Box No. 1603, Ernakulam North
P.O., Kochi-682 018

107. Dr D.P. Singh — 9 January, 2018
(Former VC, JNKVV, Jabalpur)
House No. 800, Sector-15 A
Hisar- 125 001, Haryana

108. Dr G. Trivedi — 9 January, 2018
(Former VC, RAU, Pusa, Samastipur)
Matlupur, Via-Piar, Muzaffarpur
Bihar-843 115

109. Dr Kamala Kanta Saharia — 9 January, 2018
Professor (Extension Education)
Department of Extension Education
College of Veterinary Science, AAU
Khanpara, Guwahati, Asom-781 022

110. Dr N.C. Gautam — 9 January, 2018
Vice-Chancellor
Mahatma Gandhi Chitrakoot
Gramodaya Vishwavidhyalaya
Chitrakoot, Satna,-485 334, Madhya Pradesh

111. Dr Vijay Singh Tomar — 9 January, 2018
Vice Chancellor
Jawaharlal Nehru Krishi Viswa Vidyalaya
Krishi Nagar, Adhartal
Jabalpur-482 004, Madhya Pradesh

112. Vacant

113. Dr Umesh Chandra Sharma — 9 January, 2018
President, Veterinary Council of India
A-Wing, 2nd Floor, August Kranti Bhawan
Bhikaji Cama Place, New Delhi-110 066

114. Dr A. K. Singh — 9 January, 2018
DDG (Horticultural Science)
Indian Council of agricultural Research
KAB-II, Pusa, New Delhi-110 012

115. Dr Bhagwati Prasad Bhatt — 9 January, 2018
Director
ICAR Research Complex for Eastern Region
ICAR Parisar,
P.O. Bihar Veterinary College
Patna-800014, Bihar

116. Dr Jitendra Chauhan — 9 January, 2018
Professor and Chairman, School of Social Science
College of Post Graduate Studies
Barapani (Umiam)
Shilong, Meghalaya- 793 103

117. Dr S.S. Sengar — 9 January, 2018
Director Farms (Farms and Seeds)
Indira Gandhi Krishi Vishwavidyalaya
Raipur, Chattisgarh-492 012

118. Dr Prakash Shastri — 9 January, 2018
Professor (Plant Pathology)
College of Agriculture (RVSKVV)
Khandwa-450 001 (MP)

119. VACANT

Representative from the Indian Council of Medical Research

120. Dr Rashmi Arora — 18 November, 2018
Scientist G, and Head (ECD)
ICMR Hqrs., P.O. Box No. 4911
Ansari Nagar, New Delhi - 110 029

(xix) *Three representatives of commerce and industry, nominated by the President*

121. Vacant
122. Vacant
123. Vacant

(xx) *One farmer from each region of the country as mentioned in Rule 60(a) and four representatives of rural interests, nominated by the President*

124. Sh Bhuvan Vikram Dabral — 8 December, 2019
Bhawanpura, Post – Rajawala
Distt.-Dehradun, Uttarakhand

125. Sh Kondela Saya Reddy — 8 December, 2019
H. No. – 11/1/1815, Maruti Nagar
Nizamabad, Telangana - 503 002

126. Sh Hurvi Zeliang — 8 December, 2019
Ekranipathar, Block – 15,
House No. – 144, Lhomithi,
Dimapur – 3
Dimapur – 797 112, Nagaland

127. Sh Sarvajeet Singh — 8 December, 2019
Village – Baranti
Post – Bidupur R.S.,
Thana – Rajapakar
District – Vaishali – 844 502, Bihar

128. Sh Ashok Parashar — 8 December, 2019
Kailash Nagar, Sujapur
District – Pathankot - 145 023, Punjab

129. Sh Rantanlal Daga — 8 December, 2019
(Organic Farmer)
6, Radhika, Saloon House, LIC Colony,
Ummed Club Road
Jodhpur, Rajasthan

130. Sh Rashid Mohan Gavit — 8 December, 2019
At – Dhanrat Village, Tehsil – Navapur
District – Nandurbar, Maharashtra

131. Sh B. K. Ramesh — 8 December, 2019
Bembila House, Palthady,
Putter Taluk, Dakshina Kannada
Karnataka - 574 210

Representatives of Rural Interests

132. Shri Sudhir Kumar Bhargava — 8 June, 2020
Director, Agroman Systems Pvt. Ltd.
25/2, Tardeo AC Market,Tardeo
Mumbai, Maharashtra–400 034

133. Shri Ratneshwari Prasad Singh — 8 April,2018
Village - Ratanpur
Post - Badahrwa
Distt. Sitamadi - 843 315, Bihar

134. Shri Suresh Chandel — 8 April,2018
Ex-Member of Parliament, Village - Beri
Post - Ropa, Distt.-Bilaspur-174 001
Himachal Pradesh

135. Shri Ram Krishna Kusmaria — 8 April,2018
Ex- Agriculture Minister
Government of Madhya Pradesh
Village - Sakora, Post - Hinota
Tehsil-Hata, Distt. - Damoh – 470 661
Madhya Pradesh

(xxi) *Four Directors of the Indian Council of Agricultural Research Institutes, nominated by the President*

136. Dr A.D. Pathak — 24 May, 2019
Director
Indian Institute of Sugarcane Research
Lucknow, Uttar Pradesh

137. Dr K.K. Singh — 24 May, 2019
Director, Central Institute of Agricultural Engineering, Nabi Bagh
Berasia Road, Bhopal-462 038
Madhya Pradesh

138. Dr P.C. Sharma — 24 May, 2019
Director, Central Soil Salinity Research Institute
Zarifa Farm, Kachhwa Road
Karnal 132 001, Haryana

139. Dr P.K. Mishra — 24 May, 2019
Director, Indian Institute of
Soil and Water Conservation
Kaulagarh Road, Dehradun
Uttarakhand 248 001

(xxii) *Secretary, Indian Council of Agricultural Research-Member Secretary*

140. Shri Chhabilendra Roul — *Ex-Officio*
Addl. Secretary (DARE) and Secretary
Indian Council of Agricultural Research
Krishi Bhavan, New Delhi-110 001

Alternative member for Ministry of Finance

141. Sh S. N. Tripathi — Ex-Officio
Addl. Secretary
& Financial Advisor (DARE/ICAR)

❑

APPENDIX 2

MEMBERS OF THE GOVERNING BODY OF THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

Rule 35(i)
Chairman

1. Dr Trilochan Mohapatra — *Ex-Officio*
   Director-General,
   Indian Council of Agricultural
   Research, Krishi Bhawan,
   New Delhi-110001

Rule 35(ii)
***Ex-Officio* Members**
Member, Finance

2. Shri Pramod Kumar Das — *Ex-Officio*
   Additional Secretary (Expenditure)
   Department of Expenditure,
   Ministry of Finance, North Block
   New Delhi - 110 001

Rule 35(iii)
Secretary, *NITI Ayog*

3. Shri Amitabh Kant — *Ex-Officio*
   CEO, NITI Ayog, Yojana Bhavan
   Sansad Marg, New Delhi - 110 001

Rule 35(iv)
Secretary, Agriculture

4. Shri S. K. Pattanayak — *Ex-Officio*
   Secretary (Agriculture, Cooperation and Farmers Welfare)
   Dept. of Agriculture, Cooperation and Farmers Welfare
   Ministry of Agriculture and Farmers Welfare
   Krishi Bhavan, New Delhi - 110 001

Rule 35(v)
Secretary, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture

5. Shri Devendra Chaudhary — *Ex-Officio*
   Secretary (ADF),
   Dept. of Animal Husbandry,
   Dairying, Fisheries and Farmers Welfare
   Ministry of Agriculture, Krishi Bhavan,
   New Delhi - 110 001

Rule35(vi)
Three Scientists (including one management expert who are not employees of ICAR-nominated by the President)

6. Dr N.C. Gautam — 09.01.2018
   Vice Chancellor
   Mahatma Gandhi Chitrakaoot
   Gramodaya Vishwavidhyalya, Chitrakoot
   Satna-485334 (M.P.)
7. Dr Kamala Kanta Saharia — 09.01.2018
   Professor (Extension Education.)
   Department of Extension Education,
   College of Veterinary Science, AAU,
   Khanpara, Guwahati, Asom-781 022
8. Dr Prakash Shastri — 09.01.2018
   Professor (Plant Pathology),
   College of Agriculture, Rajmata Vijayaraje
   Scindia Krishi Vishwavidyalaya (RVSKVV),
   Khandwa, Madhya Pradesh-450 001

Rule 35 (vii)
Five Vice-Chancellors of Agricultural Universities-nominated by the President)

9. Prof. A.K Mishra — Starting from 26.09.2017 Upto 25.03.2018
   Vice Chancellor
   G.B. Pant University of
   Agriculture & Technology
   Pantnagar, Distt Udham
   Singh Nagar-263 145
   Uttarakhand
10. Dr Ramesh Chandra Srivastava — 13.11.2020
    Vice Chancellor
    Dr Rajendra Prasad Central Agricultural University
    Pusa, Samastipur- 848 125, Bihar
11. Dr V Praveen Rao — 24.07.2019
    Vice Chancellor
    Prof. Jayashankar Telangana State
    Agricultural University, Rajendranagar
    Hyderabad - 500 030, Telangana
12. Dr Arvind R. Pathak — 28.12.2018
    Vice Chancellor,
    Junagadh Agricultural University,
    Junagadh, Gujarat- 362 001
13. Dr Ajoy Kumar Singh — 23.05.2019
    Vice Chancellor,
    Bihar Agricultural University, Sabour
    Bhagalpur, Bihar-813 210

Rule 35(viii)
Three Members of Parliament nominated by the President-(Two from Lok Sabha and one from Rajya Sabha)

14. Smt. Renuka Chowdhury — 02.04.2018
    Member of Parliament (RS)
    76, Lodhi Estate
    New Delhi-110 003

    Smt. Renuka Chowdhury
    Member of Parliament (RS)
    H.No.8-1-116, Khanapuram(V)
    Khammam Urban(M), Khammam District
    Andhra Pradesh-507 002
15. Shri Sanjay Dhotre — 11.02.2018
    Member of Parliament (LS)
    Ranpise Nagar,
    Distt. Akola (Maharashtra) 444 005

    Shri Sanjay Dhotre
    Member of Parliament (LS)
    AB-95, Shahjahan Road,
    New Delhi 110 003
16. Shri Ravneet Singh — 11.02.2018
    Member of Parliament (LS)
    Village – Kotla Afghana,
    District Ludhiana- 141 416

    Shri Ravneet Singh
    Member of Parliament (LS)
    H.No. 28, Dr Rajendra Prasad Road,
    New Delhi - 110 001

Rule 35(ix)
Four Farmers/Representatives of Rural Areas nominated by the President

17. Shri Sudhir Kumar Bhargava, — 08.06.2017
    Director, Agroman Systems
    Pvt. Ltd.
    25/2, Tardeo AC Market,
    Tardeo, Mumbai (Maharashtra) 400 034
18. Shri Ratneshwari Prasad Singh — 08.04.2018
    Village- Ratanpur
    Post- Badahrwa
    Distt. Sitamarhi, Bihar – 843 315
19. Shri Suresh Chandel — 08.04.2018
    Ex- Member of Parliament
    Village- Gandhi Ropa
    P.O. Beri,
    Tehsil and District Bilaspur,
    Himachal Pradesh

Preferred Contact Address:
Shri Suresh Chandel
Ex- Member of Parliament
House No. 70/5, Roura, Sector-3
Bilaspur, Himachal Pradesh

20. Dr Ram Krishna Kusmaria — 08.04.2018
Ex- Agriculture Minister
Government of Madhya Pradesh
Village- Sakora, Post- Hinota
Tehsil- Hata, Distt. Damoh, Madhya Pradesh

Rule 35(x)
Three Directors of Research Institutes of the Council nominated by the President

21. Dr Ashwini Dutt Pathak — 24.5.2019
Director, Indian Institute of
Sugarcane Research, Raebarieli Road
P.O. Dilkusha, Lucknow
Uttar Pradesh-226 002

22. Dr K.K. Singh — 24.5.2019
Director, Central Institute of Agricultural
Engineering, Nabi Bagh, Berasia Road,
Bhopal, Madhya Pradesh 462 038

23. Dr P.C. Sharma — 24.5.2019
Director, Central Soil Salinity
Research Institute, Zarifa Farm
Kachhwa Road, Karnal, Haryana 132 001

Rule 35(xi)
Four representatives of State Governments to be nominated zone-wise on a rotational basis by Director General, ICAR

24. Shri Jagdish Chander
Principal Secretary (Horticulture)
Room No. A-331
Government of Himachal Pradesh
H.P. Secretariat, Shimla-171 002

25. Shri M.K. Mero — 15.6.2020
Commissioner & Secretary, Veterinary
& Animal Husbandry, Tizama Road
New Secretariat, Nagaland, Kohima-797 001

26. Shri Nirmaljit Singh Kalsi — 15.6.2020
Additional Chief Secretary
Agriculture, 5th Floor
Mini Secretariat Punjab,
Sector 9, Chandigarh 160 001

27. Shri Bijay Kumar — 15.6.2020
Principal Secretary (Agri.),
Government of Maharashtra
Agriculture Dept
5th floor, Annex Bldg, Mantralaya
Mumbai-400 032

Rule 35(xii)
One representative of Agro and Agro-Processing Industries to be nominated by President .

28. Vacant

Rule 35(xiii)
One representative from a distinguished Non-Governmental Organization dealing with Agriculture/Extension nominated by President

29. Sh Alok Kumar Gupta — 07.12.2019
Chairman/President,
Surabhi Foundation,
UGF 118, World Trade Center,
Barakhamba Avenue,
Connaught Place
New Delhi-110 001

Preferred Address:
A-601, Vardhman apartment
Mayur Vihar, Phase-I, New Delhi-110 051

Rule 35(xiv)
Secretary, ICAR- Member Secretary

30. Shri Chhabilendra Roul
Additional Secretary (DARE) and Secretary, ICAR,
Krishi Bhawan,
New Delhi- 110 001

❑

APPENDIX 3

SENIOR OFFICERS AT THE HEADQUARTERS OF THE ICAR

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 Chhabilendra Roul**
   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 N.S. Rathore (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 P.K. Chakrabarty (PP&B)
2. Dr I.S. Solanki (F&FC)
3. Dr R.K. Singh (CC)
4. Dr P.K. Chakrabarty (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)
2. Dr S.N. Jha (PE)

Animal Sciences
1. Dr R.S. Gandhi (AP&B)
2. Dr B.S. Prakash (AN&P)
3. Dr Ashok Kumar (AH)

Fisheries Science
1. Dr P. Pravin (MF)
2. Dr Sudhir Raizada (IF)

Agricultural Extension
1. Dr V.P. Chahal
2. Dr Randhir Singh

Agricultural Education
1. Dr G. Venkateshwarlu (EQA&R)
2. Dr M.B. Chetti (HRD)
3. Dr P.S. Pandey (EP&HS)

Others
1. Dr A.K. Vasisht (PIM)
2. Dr Shiv Prasad Kimothi (Cdn.)
3. Dr A.K. Vyas (HRM)
4. Dr Sanjeev Saxena (IPTM&PME)
5. Dr S. Mauria (IR) (Acting)

National Agricultural Science Fund (NASF)
1. Dr P.K. Agrawal, ADG

Directorate of Knowledge Management in Agriculture (DKMA)
1. Dr S.K. Singh, PD (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 Ranvir Singh
2. Dr Manish Das
3. Dr Vikramaditya Pandey
4. Dr B.K. Pandey

Natural Resource Management
1. Dr P.P. Biswas
2. Dr S.K. Dhyani
3. Dr Adlul Islam

Agricultural Education
1. Dr M.K. Agnihotri
2. Dr (Mrs.) Vanita Jain
3. Dr K.L. Khurana
4. Dr K.P. Tripathi
5. Dr Neeraj Rana
6. Dr (Mrs.) Nidhi Verma

Fisheries Science
1. Sh Anil Agarwal
2. Dr (Mrs) Yasmeen Basade

Agricultural Engineering
1. Dr Devinder Dhingra
2. Dr Panna Lal Singh

Animal Sciences
1. Dr Rajan Gupta
2. Dr Vineet Bhasin
3. Dr (Mrs) Jyoti Misri
4. Dr (Mrs) Neelam Gupta

Agricultural 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. Katiha (PIM)
6. Dr A.S. Mishra (Tech. Cdn.)
7. Dr S. Mauria (IR)
8. Dr Shiv Datt (IPTM)
9. Dr R.K. Tomar (RFD & IR)
10. Dr S.K. Singh (DKMA)
11. Dr Ashok Kumar (NASF)

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. Dr A.K. Srivastava, Chairman (Additional Charge)
2. Dr A.K. Srivastava, Member
3. Sh J. Ravi, Secretary
4. Sh Rajiv Mangotra, Dy. Secy.
5. Sh S.P. Sanwal, Controller of Examination
6. Sh K.N. Choudhary, Dy. Secy.

Directorate of Knowledge Management in Agriculture

1. Dr S.K. Singh, Project Director (Acting)
2. Dr V.K. Bharti, Chief Production Officer and I/C Under Secretary
3. Dr (Mrs.) N. Kanaka Durga, Principal Scientist
4. Dr Himanshu, Scientist SS, AKMU
5. Dr Aruna T Kumar, Incharge, English Editorial Unit
6. Sh Ashok Singh, Incharge, Hindi Editorial Unit
7. Sh Vijender Singh, Incharge, ARIC
8. Sh S.K. Joshi, Business Manager
9. Sh Anil Sharma, Public Relations Officer

Administration

Senior Director

1. Sh G.R. Desh Bandhu (Crop Sc.)

Directors

1. Sh Sanjay Kant, Director (Extn.)
2. Sh S.K. Mitra, Director (Pers.)
3. Sh Devender Kumar, Director (F)
4. Sh V.P. Kothiyal, Director (Works)
5. Sh Kanhaiya Chaudhary, Director (GAC)
6. Smt Seema Chopra, Director (OL)

Deputy Secretaries

1. Sh Rajiv Maheshwari
2. Sh P. Sakthivel
3. Ms Namrta Sharma
4. Sh P.K. Bage
5. Sh Kanhaiya Chaudhary
6. Sh V.K. Sharma
7. Smt Kamla Bisht
8. Ms Sunita Sharma
9. Sh Ashok Kumar
10. Sh Girish Bhatt

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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 – 500030, Andhra Pradesh
6. Dr N.P. Singh
   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 A. Kundu (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 K.K. Singh
    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 and Kashmir
17. Dr R.K. Gupta
    Central Institute of Post Harvest Engineering
    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 P. Chowdappa
    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 K. Sammi Reddy (Acting)
    Central Research Institute for Dryland Agriculture
    Santoshnagar, Saidabad P.O.
    Hyderabad – 500 059, Andhra Pradesh
22. Dr Alok Nath Roy (Acting)
    National Institute of Research on Jute and
    Allied Fibre Technology, 12, Regent Park,
    Kolkata – 700 040,West Bengal
23. Dr Himanshu Pathak
    National Rice Research Institute,
    Cuttack – 753 006, Odisha.
24. Dr Parbodh Chander
    Central Soil Salinity Research Institute, Zarifa Farm
    Kachhwa Road, Karnal – 132 001, Haryana
25. Dr P.K. Mishra
    Indian Institute of Soil and 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 (Mrs) Archana Mukherjee
    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 N. Prakash (Acting)
    ICAR Research Complex for NEH Region
    Umroi Road, Umiam, Ri-Bhoi,
    Meghalaya – 793 103
31. Dr A.K. Choubey (Acting)
    Indian Agricultural Statistics Research Institute
    Library Avenue, Pusa Campus
    New Delhi – 110 0012
32. Dr R.V. Kumar (Acting)
    Indian Grassland & Fodder Research Institute
    Pahuj Dam, Gwalior Road
    Jhansi – 284 003, Uttar Pradesh
33. Dr M.R. Dinesh
    Indian Institute of Horticultural 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 Babu
    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 Bijendra 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, Uttrakhand
42. Dr Jiban Mitra (Acting)
Central Research Institute for Jute and Allied Fibres
Barrackpore, Kolkata – 700 120, West Bengal
43. Dr Azad Singh Panwar
Indian Institute of Farming System Research
Modipuram, Meerut – 250 110, Uttar Pradesh
44. Dr Sujoy Rakshit
Indian Institute of Maize Research, PAU Campus
Ludhiana – 141 004, Punjab
45. Dr Ravi Kumar Mathur
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
Andhra Pradesh
47. Dr P. Anand Kumar (Acting)
Indian Institute of Rice Research, Rajendranagar
Hyderabad – 500 030, Andhra Pradesh
48. Dr G.P. Singh
Indian Institute for Wheat and 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 (Mrs) Jitender Kishtwaria
Central Institute for Women in Agriculture
Plot No. 50, Mauza-Jokalandi,
P.O. Baramunda, Bhubaneswar – 751 003, Odisha
51. Dr O.P. Chaturvedi
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,
Andhra Pradesh
56. Dr V.S. Bhatia
Indian Institute of Soybean Research
Khandwa Road, Indore – 452 017, Madhya Pradesh

Animal Sciences and Fisheries

57. Dr A.B. Mondal (Acting)
Central Avian Research Institute
Izatnagar, Bareilly – 243 122, Uttar Pradesh
58. Dr Inderjeet Singh
Central Institute for Research on Buffaloes
Sirsa Road, Hisar – 125 001, Haryana
59. Dr Manmohan Singh Chauhan
Central Institute of Research on Goats
Makhdoom, Mathura – 281 122, Uttar Pradesh
60. Dr Basant Kumar Das
Central Inland Fisheries Research Institute
Barrackpore – 700 120, West Bengal
61. Dr K.K. Vijayan
Central Institute of Brackishwater Aquaculture
75, Santhome High Road, Raja Annamalai Puram
Chennai – 600 028, Tamil Nadu
62. Dr Ravishankar C.N.
Central Institute of Fisheries Technology
Willingdon Island, Matsyapuri
P.O.,Cochin – 682 029, Kerala
63. Dr J.K. Sundaray (Acting)
Central Institute of Freshwater Aquaculture
Kausalyaganga, Bhubaneshwar
Khurda – 751 002, Odisha
64. Dr A. Gopalakrishnan
Central Marine Fisheries Research Institute
P.B. No. 1603, Ernakulam North P.O.,
Kochi – 682 018, Kerala
65. Dr Arun Kumar (Acting)
Central Sheep and Wool Research Institute
Avikanagar – 304 501, Distt. Tonk, Rajasthan
66. Dr Raghevendra Bhatta
National Institute of Animal Nutrition and Physiology
Adugodi, Bengaluru – 560 030, Karnataka
67. Dr Vijendra Pal Singh
National Institute of High Security Animal Diseases
Anand Nagar, Bhopal – 462021, Madhya Pradesh
68. Dr Birham Prakash
Central Institute for Research on Cattle,
P.B. No. 17, Grass Farm Road,
Meerut Cantt. – 250 001, Uttar Pradesh
69. Dr Parimal Roy
National Institute of Veterinary Epidemiology
and Disease Informatics, H.A. Farm Post
Hebbal, Bengaluru-560 024, Karnataka

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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 Surendra Kumar Singh
   National Bureau of Soil Survey and Land Use
   Planning, Shankar Nagar P.O., Amravati Road
   Nagpur – 440 010, Maharashtra

Animal Sciences

5. Dr Arjava Sharma
   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

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APPENDIX 6

PROJECT DIRECTORATES, ATARI 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
6 Dr P. Manivel (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 B. Pattnaik (Acting)
   Directorate of Foot and Mouth Disease
   IVRI Campus, Mukteshwar – 263 138, Uttarakhand
10. Dr R. N. Chatterjee
    Directorate of Poultry Research
    Rajendranagar, Hyderabad – 500 030,
    Andhra Pradesh
11. Dr Atul Kumar Singh
    Directorate of Coldwater Fisheries Research
    Anusandhan Bhawan, Industrial Area
    Bhimtal – 263 136, Uttarakhand

Others

12. Dr Man Singh (Acting)
    Water Technology Centre, IARI
    New Delhi – 110 012

Agricultural Technology Application Research Institutes

13. Dr Rajbir Singh
    Agricultural Technology Application Research
    Institute, Zone-I, PAU Campus
    Ludhiana – 141 004, Punjab
14 Dr Sati Shankar Singh
    Agricultural Technology Application
    Research Institute
    Zone-II, Bhumi Vihar, Block-GB, Sector-III, Salt Lake,
    Kolkata – 700 097, West Bengal
15. Dr B.C. Deka
    Agricultural Technology Application
    Research Institute
    Zone-III, TOP, Umroi Road
    Barapani – 793 103, Meghalaya
16. Dr U.S. Gautam
    Agricultural Technology Application
    Research Institute
    Zone-IV, G.T. Road, Rawatpura
    Near Vikas Bhawan
    Kanpur – 208 002, Uttar Pradesh
17. Dr Y.G. Prasad
    Agricultural Technology Application
    Research Institute
    Zone-V, CRIDA Complex, Santoshnagar
    Hyderabad – 500 059, Andhra Pradesh
18. Dr S.K. Singh
    Agricultural Technology Application
    Research Institute, Zone-VI, CAZRI Campus
    Jodhpur – 342 003, Rajasthan
19. Dr Anupam Mishra
    Agricultural Technology Application
    Research Institute, Zone-VII, JNKVV Campus
    Jabalpur – 484 002, Madhya Pradesh
20. Dr Sreenath Dixit
    Agricultural Technology Application
    Research Institute
    Zone-VIII, ICAR Transfer of Technology Project
    MRS HA Farm Post, Hebbal
    Bengaluru – 560 030, Karnataka
21 Dr Anjani Kumar
    Agricultural Technology Application
    Research Institute, Patna
22 Dr Lakhan Singh
    Agricultural Technology Application
    Research Institute, Pune
23 Dr A.K. Tripathi
    Agricultural Technology Application Research Institute,
    Guwahati

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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 S.D. Sawant
   National Research Centre for Grapes
   P.B. No. 3, Manjri Farm Post, Solapur Road,
   Pune - 412 307, Maharashtra
3. Dr B. Ahuja (Acting)
   National Research Centre for Integrated
   Pest Management, LBS Building
   Pusa Campus, New Delhi – 110 012
4. Dr Vishal Nath
   National Research Centre for Litchi
   Mushahari Farm, Mushahari
   Muzaffarpur – 842 002, Bihar
5. Dr D. R. Singh
   National Research Centre for Orchids
   Pakyong, Gangtok – 737 106, Sikkim
6. Dr N.K. Singh (Acting)
   National Research Centre on Plant Biotechnology
   L.B.S. Building, Pusa, New Delhi – 110 012
7. Dr R.K. Pal
   National Research Centre on Pomegranate
   NH-9, Byepass Road, Shelgi
   Sholapur – 413 006, Maharashtra
8. Dr Gopal Lal
   National Research Centre on Seed Spices
   Tabiji – 305 206, Ajmer, Rajasthan

Animal Sciences and Fisheries

9. Dr N.V. Patil
   National Research Centre on Camel, Jorbeer
   P.B. No. 07, Bikaner – 334 001, Rajasthan
10. Dr B.N. Tripathi
    National Research Centre for Equines
    Hisar – 125 001, Haryana
11. Dr S. Vaithiyanathan (Acting)
    National Research Centre on Meat
    Chengicherla, P.B. No. 19, Uppal PO
    Hyderabad – 500 039, Andhra Pradesh
12. Dr Abhijit Mitra
    National Research Centre for Mithun
    Jharnapani, P.O. Medziphema– 797 106
    Nagaland
13. Dr D.K. Sarma
    National Research Centre on Pig
    Rani, Guwahati – 781 131, Asom
14. Dr S.M. Deb
    National Research Centre on Yak
    Dirang, West Kameng– 790 101,
    Arunachal Pradesh

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APPENDIX 8

ALL INDIA CO-ORDINATED RESEARCH PROJECTS AND NETWORK PROGRAMMES

1. AICRP on Maize, New Delhi
2. AICRP on Nematodes in Cropping System, New Delhi
3. All India Coordinated Rice Improvement Project, Hyderabad
4. AICRP on Chickpea, Kanpur
5. AICRP on MULLaRP, Kanpur
6. AICRP on Pigeon Pea, Kanpur
7. AICRP on Wheat and Barley, Karnal
8. AICRP on Forage Crops and Utilization, Jhansi
9. AICRP Sorgum , Hyderabad
10. AICRP on Pearl Millets, Jodhpur
11. AICRP on Small Millets, Bangalore
12. AICRP on Sugarcane, Lucknow
13. AICRP on Cotton, Coimbatore
14. AICRP on Groundnut, Junagarh
15. AICRP on Soybean, Indore
16. AICRP on Rapeseed and Mustard, Bharatpur
17. AICRP on Oilseed, Hyderabad
18. AICRP on Linseed, Kanpur
19. AICRP on Sesame and Niger, Jabalpur
20. AICRP on Biocontrol of Crop Pests, Bengaluru
21. AICRP - Honeybees and Pollinators, New Delhi
22. AICRP NSP(Crops), Mau
23. AICRP Fruits (Tropical and Sub Tropical), Bengaluru
24. AICRP Arid Zone Fruits, Bikaner
25. AICRP Mushroom, Solan
26. AICRP Vegetables, Varanasi
27. AICRP Potato, Shimla
28. AICRP Tuber Crops, Thiruvananthapuram
29. AICRP Palms, Kasargod
30. AICRP on Cashew, Puttur
31. AICRP Spices, Calicut
32. AICRP Floriculture, Pune
33. AICRP on Micro Secondary and Pollutant Elements in Soils and Plants, Bhopal
34. AICRP on Soil Test Crop Response, Bhopal
35. AICRP on Long Term Fertilizer Experiments, Bhopal
36. AICRP on Salt Affected Soils and use of Saline Water, Karnal
37. AICRP on Irrigation Water Management Research, Bhubaneshwar
38. AICRP Dryland Agriculture, Hyderabad
39. AICRP on Agrometeorology, Hyderabad
40. AICRP on Integrated Farming System, Modipuram
41. AICRP on Agroforestry, Jhansi
42. AICRP on Weed Management, Jabalpur
43. AICRP on Farm Implements and Machinery, Bhopal
44. AICRP on Ergonomics and Safety in Agriculture, Bhopal
45. AICRP on Energy in Agriculture and Agro based Industries, Bhopal
46. AICRP on Utilization Animal Energy, Bhopal
47. AICRP on Plasticulture Engineering and Technology, Ludhiana
48. AICRP on Post Harvest Engineering and Technology, Ludhiana
49. AICRP on Goat Improvement, Mathura
50. AICRP on Improvement of Feed Sources and Nutrient Utilisation, Bengaluru
51. AICRP on Cattle Research, Meerut
52. AICRP Foot and Mouth, Mukteshwar
53. AICRP on Poultry, Hyderabad
54. AICRP ADMAS, Bengaluru
55. AICRP on Pig, Guwahati
56. AICRP Home Science

NETWORK PROGRAMMES

1. AIC Research Network on Potential Crops, New Delhi
2. Network Progject on Transgenics
3. AINP on Soil Arthropod Pests, Durgapura, Rajasthan
4. AINP on Agricultural Acarology
5. AINP on Pesticides Residues, New Delhi
6. AINP on Arid Legumes, Kanpur
7. All India Network Research Project on Tobacco, Rajamundry
8. AINP on Jute and Allied Fibres, Barrackpore
9. AINP on Vertebrate Pest Management, Jodhpur
10. Network on Insect Biosystematics, New Delhi/ Bengaluru
11. Application of Micro-organisms in Agriculture and Allied Sectors(AMAAS) +Microbial Genomic Resources repository network, Mau
12. Network O and G (included in Directorate)
13. Network on Medicinal and Aromatic Plants, Anand
14. AINP on Biofertilizer, Bhopal
15. Network Programme on Organic Farming, Modipuram
16. Network project on Harvesting, Processing and Value Addition of Natural Resins & Gums, Ranchi
17. Network Project on Conservation of Lac Insect Genetic Resources, Ranchi
18. Network project on Animal Genetic Resources, Karnal
19. Network on Sheep Improvement, Avikanagar
20. Network Project on Buffalo Improvement, Hissar
21. Network on Gastro Intestinal Parasitism, Izatnagar
22. Network on Haemorrhagic Septcamia, Izatnagar
23. Network Programme on Blue Tongue Disease, Izatnagar
24. All India Network Program on Neonatal Mortality in Farm Animal(NNM), Izatnagar
25. All India Network Program on Diagnostic Imaging and Management of Surgical Condition in Animals, Izatnagar

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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. Haryana State University of Horticultural Sciences Karnal
22. Indira Gandhi Krishi Vishwavidyalaya Raipur (Chhattisgarh) 492 006
23. Jawaharlal Nehru Krishi Viswavidyalaya Jabalpur (Madhya Pradesh) 482 004
24. Junagadh Agricultural University Junagarh (Gujarat) 362 001
25. Kamdhenu University Amreli (Gujarat) 382 010
26. Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar (Karnataka) 585 401
27. Kerala Agricultural University Thrissur (Kerala) 680 656
28. Kerala University of Fisheries and Ocean Studies Panangad (Kerala) 682 506
29. Kerala Veterinary and Animal Sciences University Wayanad (Kerala) 673 576
30. Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar (Haryana) 125 001
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. Professor Jayashankar Telangana State Agricultural University, Hyderabad (Telangana) 500 030
39. Punjab Agricultural University Ludhiana (Punjab) 141 004
40. Rajasthan University of Veterinary and Animal Sciences Bikaner (Rajasthan) 334 001
41. Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya Gwalior (Madhya Pradesh) 474 002
42. Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (Uttar Pradesh) 250 110
43. Sardarkrushinagar Dantiwada Agricultural University Sardarkrushinagar (Gujarat) 385 506
44. Sher-e-Kashmir University of Agricultural Science and Technology of Jammu, Jammu, Jammu and Kashmir 180 009
45. Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar (Jammu and Kashmir) 190 025
46. Sri Karan Narendra Agriculture University Jobner (Rajasthan) 303 329
47. Sri Konda Laxman Telangana State Horticultural University, Rajendra Nagar Campus Hyderabad, Telangana 500 030
48. P.V. Narsimha Rao Telangana Veterinary University Rajendranagar, 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 Vidhyalaya Evem 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, Barielly (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

❑

APPENDIX 10

Total number of employees in the ICAR and its research institutes and number 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	4252	3667	505	13.77	204	5.56	733	19.99
b	Senior Scientist	1317	985	65	6.60	15	1.52	112	11.37
c	Pr. Scientist	776	459	15	3.27	3	0.65	27	5.88
d	RMP	176	126	8	6.35	5	3.97	17	13.49
	Total	**6521**	**5237**	**593**	**11.32**	**227**	**4.33**	**889**	**16.98**
2	**Technical Posts**								
a	Category I	3974	2618	512	19.56	278	10.62	395	15.09
b	Category II	2708	1746	302	17.30	138	7.90	278	15.92
c	Category III	755	567	95	16.75	62	10.93	97	17.11
	Total	**7437**	**4931**	**909**	**18.43**	**478**	**9.69**	**770**	**15.62**
3	**Administrative Posts**								
a	Category 'A' posts :- Director /Dy. Secretary/Under Secretary/CAOs/SAOs/AOs/ CF&AO/F&AO/LADirector(OL)/ DD(OL)/AD(OL)/	334	316	47	14.87	24	7.59	25	7.91
b	Category 'B' posts :- AF&AO/AAO/PS/SO/ALA/ Assistant/PA/JAO	2177	1790	279	15.59	124	6.93	197	11.01
c	Category 'C' posts :- UDC/Steno/LDC	2361	1437	266	18.51	123	8.56	284	19.76
	Total	**4884**	**3543**	**592**	**16.71**	**271**	**7.65**	**506**	**14.28**
4	**Skilled Supporting Staff**								
	Total	**8364**	**4967**	**1383**	**27.84**	**447**	**9.00**	**808**	**16.27**

APPENDIX 11

ICAR AWARDS 2016

AWARDS	AWARDEES
Sardar Patel Outstanding ICAR Institution Award	**Large Institutes** ICAR-Indian Institute of Soil and Water Conservation, Dehradun, Uttarakhand **Small Institutes** ICAR-Indian Institute of Wheat and Barley, Karnal (Haryana) **Agricultural Universities** CCS Haryana Agricultural University, Hisar (Haryana)
Chaudhary Devi Lal Outstanding All India Coordinated Research Project Award 2016	All India Coordinated Research Project on Chickpea, ICAR-Indian Institute of Pulses Research, Kanpur, Uttar Pradesh. (Best Centre- Sriganganagar, Rajasthan) All India Coordinated Research Project on Fruits, ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka. (Best Centre-Gandevi under Navsari Agricultural University, Gujarat)
Panjabrao Deshmukh Outstanding Woman Scientist Award	**Dr (Ms) Archana Mukherjee** Director, ICAR-CTCRI, Thiruvananthapuram **Dr (Ms) Tara Satyavathi Chellapilla** Pulse Laboratory, Division of Genetics, ICAR-Indian Agricultural Research Institute, New Delhi
Vasant Rao Naik Award for Research Application	**Dr B. Sahadeva Reddy (Team Leader)** **Associates – Dr B. Ravindranatha Reddy, Dr K. Bhargavi, Dr M. Vijaya Sankar Babu, Dr K. Madhusudhana Reddy, Dr G. Narayana Swamy, Dr C. Radha Kumari** AICRP for Dryland Agriculture, Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Anantapur (Andhra Pradesh).
N.G. Ranga Farmer Award for Diversified Agriculture	**Sh Harbir Singh, S/o Sh Narinder Singh** Vill. Dadlu, P.O. Rawa, Teh. Shahabad (M), Distt. Kurukshetra (Haryana)
Pandit Deen Dayal Upadhyay Antyodaya Krishi Puruskar (National and Zonal)	**Zone I** **Sh Nirbhai Singh** Village-Sukha Singh Wala, Bathinda (Punjab) **Zone II** **Sh Satpal Singh** Village-Gohran, Kaithal (Haryana) **Zone III** **Sh Raghupat Singh** Village-Samathal, Muradabad (UP) **Zone VI** **Sh Phoni Bora** Burakuri, Jorhat (Assam) **Zone VII** **Miss Thejano Makritsu, Sethikema A** Dimapur (Nagaland) **Zone IX** **Sh Lallu Ram Koreti** Village.-Aturgaon, Uttar Bastar Kanker (MP).
Haldhar Organic Farmer Award	**Smt K. Lavanya Ramana Reddy, w/o K.V. Ramana Reddy** Vill. Karwanga, Mdl. Telkapally, Distt-Nagarkurnool (Telengana)

AWARDS	AWARDEES
Fakhruddin Ali Ahmed Award for Outstanding Research in Tribal Farming Systems	**1. Dr Indra Singh Tomar-Team Leader** Senior Scientist & Head/ Associate Director Research, Zonal Agriculture Research Station (RVSKVV), Jhabua **Dr Rakesh Kumar Yadav** Scientist, Krishi Vigyan Kendra, Jhabua **Dr Anil Kumar Singh** Vice-Chancellor, Rajmata Vijayaraje Scindia Agricultural University, Gwalior, M.P. 2. Shared equally between teams (a) and (b) **(a) Dr T.P. Swarnam (Team Leader)** Senior Scientist (Agronomy)-Team Leader **Dr A.Velmurugan** Senior Scientist (Soil Science) **Dr Awnindra K. Singh** Senior Scientist (Plant Breeding) **Dr Sibnarayan Dam Roy** Director **Dr I. Jaisankar** Scientist (Forestry) ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman & Nicobar Islands(b) **(b) Dr D.K. Sarma** Director-Team Leader **Dr M.K. Tamuli** Principal Scientist **Dr Mohan N H** Senior Scientist **Dr R.Thomas** Scientist, ICAR-National Research Centre on Pig, Rani, Guwahati, Asom
Bharat Ratna Dr C. Subramaniam Award for Outstanding Teachers	**Crop and Hort Sciences**: **Prof. Sanjay Kumar Singh** Head (Fruits and Horticultural Technology), IARI, New Delhi **NRM and Ag. Engineering (shared)** **Dr Siba Prasad Datta** Principal Scientist, ICAR-IARI, New Delhi 110 012 and **Dr Arjamadutta Sarangi** Principal Scientist, ICAR-IARI, New Delhi 110 012 **Animal and Fisheries Sciences** **Dr A. Kumaresan** Senior Scientist, ICAR-NDRI, Karnal **Social Sciences (Shared)** **Dr Shivendra Kumar Kashyap** Prof. and Head (Agricultural Communication), GBPUAT, Pantnagar and **Dr (Mrs.) Rupasi Tiwari** Principal Scientist and In charge ATIC, IVRI, Izatnagar
Pandit Deen Dayal Upadhyay Krishi Vigyan Protshahan Puraskar (National & Zonal)	**National** KVK R.K. Mission Ashram, Morabadi, Ranchi, Jharkhand **Zone I** KVK R.S. Pura, Jammu, SKUAST, Jammu, J&K

AWARDS	AWARDEES
	Zone II KVK Borkhera, Kota, Rajasthan **Zone III** KVK Gopalgram, Gonda, U.P. **Zone IV** KVK East Champaran, Dr RPCAU, Pusa, Samastipur, Bihar **Zone V** KVK Uttar Dinajpur, UBKVV, Chopra, West Bengal **Zone VII** KVK Dimapur, ICAR Research Complex for NEH Region, Medziphema, Nagaland **Zone VIII** KVK Kosbad Hill, Dahanu, Palghar, Maharashtra **Zone IX** KVK Korea, IGKV Raipur, Madhya Pradesh **Zone X** KVK Utukur, Kadapa, YSR District, Andhra Pradesh **Zone XI** KVK Alappuzha, ICAR-CPCRI, Kerala
Dr Rajendra Prasad Puruskar for technical books in Hindi in Agricultural and Allied Sciences	**Crop and Hort Sciences** **Dr Jitendra Singh** Professor, Department of Fruit Science, College of Hort. & Forestry, Agri. Uni., Kota Campus, Jhalarapatan, Jhalawar, Rajasthan **NRM and Ag. Engineering** **Dr B.P. Bhatt** Director, ICAR R.C. for Eastern Region, Patna **Animal and Fisheries sciences** **Dr Arun Kumar (Team Leader)** ICAR-CSWRI, Avikanagar, Rajasthan **Dr Vineet Bhasin (Associate)** Pr. Sci. (AG&B), ICAR Hqrs., New Delhi **Dr S.M.K. Naqvi (Associate)** ICAR-CSWRI, Avikanagar **Dr R.S.Gandhi (Associate)** ADG (AP&B), ICAR Hqrs., New Delhi **Social Science** **Dr Chandra Bhan Singh (Team Leader)** Sr. Sci. (Agronomy), ICAR-IARI R.S., Pusa, Samastipur, Bihar **Dr J.P. Sharma (Associate)** Jt. Dir., ICAR-IARI, Pusa, New Delhi **Dr Ranbir Singh (Associate)** Sr.Tech. Officer, ICAR-IARI, Pusa, New Delhi
Lal Bahadur Shastri Outstanding Young Scientist Award	**Crop and Hort Sciences** **Dr Satendra Kumar Mangrauthia** Scientist(SS)-Plant Biochemistry, Crop Improvement Section, ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad **NRM and Ag Engineering** **Dr Priyabrata Santra** Sr. Scientist, ICAR-Central Arid Zone Research Institute, Jodhpur-342003, Rajasthan

AWARDS	AWARDEES
	Animal and Fisheries sciences **Dr Taruna Anand** Scientist (Sr. Scale), National Centre for Veterinary Type Cultures, ICAR-National Research Centre on Equines, Sirsa Road, Hisar-125 001, Haryana **Social Sciences** **Dr Ranjit Kumar Paul** Scientist, IASRI, Library Avenue, Pusa, New Delhi
Rafi Ahmed Kidwai Award for Outstanding Research in Agricultural Sciences	**Crop and Hort Sciences** **Dr Pritam Kalia** Principal Scientist and Former Head, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi **NRM and Ag. Engineering** **Dr Krishna Kumar Singh** Director, ICAR- Central Institute of Agricultural Engineering, Bhopal (MP) **Animal and Fisheries Sciences** **Dr Priyabrat Swain** Principal Scientist and National Fellow, ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar (Odisha) **Social Sciences** **Dr Pratap Singh Birthal** Principal Scientist, ICAR-National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi
Swami Sahajanand Saraswati Outstanding Extension Scientist Award	**Dr Anup Das** Principal Scientist (Agronomy), Division of Crop Production, ICAR Research Complex for NEH Region, Umiam, Meghalaya- 793 103 **Dr Rajbir Singh** Director, ICAR-Agricultural Technology Application Research Institute, Zone-I, PAU Campus, Ludhiana, Punjab, 141004
NASI-ICAR Award For Innovation and Research on Farm Implements	**Dr Ettannil Jayashree** ICAR-Indian Institute of Spices Research, Marikunnu P.O., Kozhikode, Kerala-673012
Hari Om Ashram Trust Award	**Crop and Hort Scinces** **Dr Parveen Kumar (Team Leader)** Principal Scientist,CSSRI, Karnal, Haryana, **Dr S.K. Pandey** Ex-Director **Dr Dinesh Kumar** Principal Scientist **Dr S.V.Singh** Ex-Principal Scientist, ICAR-Central Potato Research Institute, Shimla **NRM and Ag. Engineering** **Dr Sushil Kumar Kamra (Team Leader)** Principal Scientist, ICAR-CSSRI, Karnal **Dr Satyendra Kumar** Principal Scientist **Dr Bhaskar Narjary** Scientist, ICAR-CSSRI, Karnal **Animal and Fisheries sciences** **Dr Ashok K.Tiwari (Team Leader)** Head of Division (Biological Standardization), ICAR-IVRI, Izatnagar

AWARDS	AWARDEES
	Dr Ravi Kumar Senior Scientist
	Dr Aditya P. Sahoo Scientist
	Prof. N.S. Jadon Head of Division (Surgery & Radiology), ICAR-IVRI, Izatnagar
	Social Sciences **Dr Rajarshi Roy Burman (Team Leader)** Principal Scientist
	Dr J.P.Sharma Joint Director (Extension)
	Dr S.K.Dubey Principal Scientist, ATARI, Kanpur
	Dr K.Vijayraghavan Ex-Joint Director (Extension), ICAR-IARI, New Delhi
Jawaharlal Nehru Award for P.G. Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences	**Crop Sciences** **Dr Mehak Gupta** Department of Plant Breeding and Genetics, PAU, Ludhiana
	Dr M G Mallikarjuna Division of Genetics, ICAR-IARI, New Delhi
	Animal Sciences Dr Shrabani Saugandhika Contractual Scientist (Embryologist), Department of Obs. & Gyne., AIIMS, New Delhi
	Dr K Laxmana Naik N Scientist, DC Section, SRS of ICAR-NDRI, Bengaluru, Karnataka
	Fisheries **Dr Bineesh Kinattumkara** Scientist, ICAR-NBFGR, CMFRI Campus, Kochi, Kerala
	Dr Ginson Joseph Cochin, Kerala
	Biotechnology (Plant/Animal/Fisheries) Dr Bhogireddy Sailaja DBT-Research Associate, ICRISAT, Patnacheru, Hyderabad
	Dr Siddanna Savadi Scientist, ICAR-IIWBR, R.S, Flowerdale, Shimla, Himachal Pradesh
	Social Sciences Dr Reshma Gills (Agricultural Extension), ICAR-IARI,New Delhi
	Dr Prakashkumar Rathod Assistant Professor, Department of Veterianry & Animal Husbandry Extension, Veterinary College, Bidar, Karnataka
	Crop Protection Dr Kutubuddin Ali Molla Scientist, Crop Improvement Division, ICAR-NRRI, Cuttack, Odisha
	Dr Salini Santhamma Yelahanka, Bengaluru

AWARDS	AWARDEES
	Natural Resource Management **Dr Dipak Kumar Gupta** Scientist (Environmental Sciences), ICAR-CAZRI, RRS-Pali, Rajasthan **Dr Sanjeet Kumar** Assistant Professor, Applied Engineering Department, Vignas's Foundation for Science Technology & Research University, Vadlamudi, Guntur, Andhra Pradesh **Horticulture** **Dr Vijay Rakesh Reddy S** Scientist (Horticulture), ICAR-CIAH, Bikaner, Rajasthan **Dr Ponnam Naresh** Scientist, ICAR-IIHR, R.S., CHES, Bhubaneshwar, Odisha **Agriculture Engineering** **Dr Snehasis Chakraborty** Assistant Professor, Food Technology, Institute of Chemical Technology, Mumbai **Dr V Eyarkai Nambi** Scientist, TOT Division, ICAR-CIPHET, Ludhiana
Jagjivan Ram Abhinav Kisan Puruskar/ Jagjivan Ram Innovative Farmer Award (National/ Zonal)	**National** **Sh Karan Sikri** Village-Dhangali, PO-Jandheri, Shahabad Markanda, Distt.-Kurukshetra, Haryana 136 135 **Zone 2-Jodhpur (Shared)** **Sh Poonam Chand Patidar** PO Dityakhedi, Via-Raipur, P.S. Jhalaraphatan, Distt.-Jhalawar, Rajasthan 326 036 and **Sh Mahaveer Singh Rathore** Village and Post-Rupaheli Kalan, Tehsil-Hurda, Distt.-Bhilwara, Rajasthan 311 026 **Zone 3 (Shared)** **Sh Agya Ram Verma** Village-Kharkadewri, Post-Kodia, Distt.-Basti, Uttar Pradesh 272 131 and **Sh Raghupat Singh** Village-Samathal, Bilari, Distt.-Murabadad, Uttar Pradesh 202 411 **Zone 4** **Sh Sanjeev Kumar** Vill. Chakwara, PO. Hajipur, Distt.-Vaishali, Bihar 844 101 **Zone 6** **Sh Pankaj Kalita** Village-Pub Balitara, PO Balitara, Distt.-Nalbari, Assam 781 349 **Zone 7** **Sh R D Peter** Village Purul Akutpa, Distt.-Senapati, Manipur **Zone 8** **Smt Sunandabai Madanrav Shinde** Post-Manoli, Tq. Manwat, Pune, Distt.-Parbhani, Maharashtra 431 505 **Zone 9** **Sh Ram Patidar** Village Paltawad, Distt.-Dhar, Madhya Pradesh

AWARDS	AWARDEES
	Zone 11 **Sh Dhareppa P Kittur** Near Siddeshwar Temple, Terdal, Tq. Jamkhandi, Distt Bagalkot, Karnataka 587 315
Cash Award Scheme for Administrative/Technical/ Supporting category employees of ICAR Research Institutes/NRCs/Bureaus/ZCUs	**Administrative category (Shared)** **Smt Prem Kumari Mehta** Private Secretary, NDRI, Karnal and **Sh Harpal Thakur** Section Officer, ICAR Hqrs. **Technical category (Shared)** **Sh Mukesh Chand** Sr. Tech. Officer, NRC on Equines, Hisar and **Sh Mahesh Gupta** Sr. Tech. Officer, ICAR Hqrs. **Supporting category** **Sh Kulvinder Singh** SSS, NDRI, Karnal

Acronyms

AER	: Agro-ecological Region
AES	: Agriculture Expert System
AFC	: Age at First Calving
AFLP	: Amplified Fragment Length Polymorphism
AGID	: Agar Gel Immunodiffusion
AI	: Avian Influenza
AICRP	: All India Coordinated Research Project
AINP	: All India Network Project
ALV	: Avian Leukosis Virus
AMAAS	: Application of Micro-organisms in Agriculture and Allied Sectors
ARYA	: Attracting and Retaining Youth in Agriculture
ASAM	: Alkaline Sulfite Anthraquinone Methanol
ASEAN	: Association of South-East Asian Nations
ASRB	: Agricultural Scientists' Recruitment Board
ATIC	: Agricultural Technology Information Centre
BOD	: Biochemical Oxygen Demand
BoHV	: Bovine Herpes Virus
BRICS	: Brazil, Russia, India, China and South Africa
BTV	: Blue Tongue Virus
BVDV	: Bovine Viral Diarrhoea Virus
BVS	: Bovine Vaccinate Serum
CA	: Conservation Agriculture
CAFT	: Centres of Advanced Faculty Training
CAU	: Central Agricultural University
CAZRI	: Central Arid Zone Research Institute
CC	: Cellular Component
CCA	: Climate Change adaptation
CCHF	: Crimean Congo Hemorrhagic Fever
CeRA	: Consortium for e-Resources in Agriculture
CFL	: Current Fallow Land
CFT	: Complement Fixation Text
CGIAR	: Consultative Group on International Agricultural Research
CHAMAN	: Co-ordinated Programme in Horticultural Assessment and Management
CIAE	: Central Institute of Agricultural Engineering
CIARI	: Central Island Agricultural Research Institute
CIBA	: Central Institute of Brackish Water Aquaculture
CIFE	: Central Institute of Fisheries Education
CIMMYT	: Centro International de Mejormento de Maize Trigo
CLA	: Conjugated Linoleic acid
CP	: Crude Protein
CPC	: Corn Protein Concentrate
CPE	: Cumulative Pan Evaporation
CPP	: Caseinophosphopeptides
CRD	: Chronic respiratory disease
CSFV	: Classical Swine Fever Virus
CSISA	: Cereal Systems Initiatives for South Asia
CVM	: Congenital Vascular Malformation
DAS	: Days After Sowing
DAT	: Days After Transplanting
DEs	: Directorates of Extension
DG	: Distillers' Grains
DHA	: Docosahexanoid acid
DRWA	: Directorate of Research on Women in Agriculture
DSn	: Diagnostic sensitivity
DSS	: Decision Support System
ECPI	: Empowerment of Crop Production Index
EEE	: Eastern Equine Encephalitis
EHV	: Equine Herpes Virus
EIA	: Enzyme Immuno Assay
EIV	: Equine Influenza Virus
ELISA	: Enzyme-linked Immunosorbent Assay
EPA	: Eicosapentanoic acid
EPN	: Entomopathogenic Nematode
ETL	: Economic Threshold Level
EXPSS	: Expert System on Seed Spices
FAO	: Food and Agriculture Organization
FCR	: Feed Conversion Rate
FEC	: Faecal Egg Count
FMD	: Foot-and-Mouth Disease
FPT	: Field Progeny Testing Project
FSH	: Follicle-stimulating Hormone
FYM	: Farmyard Manure
GADVASU	: Guru Angad Dev Veterinary and Animal Sciences University
GBNV	: Groundnut Bud Necrosis Virus
GBPUAT	: Govind Ballabh Pant University of Agriculture and Technology
GDP	: Gross Domestic Production
GEF	: Global Environmental Facility
GIS	: Geographical Information System
GO	: Gene Ontology
GPA	: Global Plan of Action
GPS	: Global Positioning System
HAPA	: Hybridization-supplemented Apomixis Components Partitioning Approach
HPAI	: Highly Pathogenic Avian Influenza
HPNA	: Highly Pathogenic Notifiable Avian Influenza
HPTLC	: High Performance Thin Layer Chromatography
HRR	: Head Rice Recovery
HS	: Haemorrhagic Septicaemia
HSP	: Heat Shock Protein
IAA	: Integrated Agri-aquaculture
IBR	: Infectious Bovine Rhinotracheitis
ICARDA	: International Centre for Agricultural Research in Dry Areas
ICMV	: Indian Cassava Mosaic Virus
ICRISAT	: International Crops Research Institute for Semi-Arid Tropics
ICT	: Information and Communication Technologies
IDS	: Integrated Drying System
IFS	: Integrated Farming System
IHC	: Immuno-histochemistry
INM	: Integrated Nutrient Management
IPM	: Integrated Pest Management
IPNS	: Integrated Plant Nutrient System
IPR	: Intellectual Property Rights
IRES	: Integrated Ribosomal entry site
ITK	: Indigenous Technical Knowledge
IWMI	: International Water Management Institute

JE : Japanese Encephalitis
JNKVV : Jawaharlal Nehru Krishi Vishwa Vidyalaya
KAP : Knowledge, Awareness and Practice
KVAFSU : Kerala Veterinary, Animal Sciences and Fisheries University
KVK : Krishi Vigyan Kendra
LAT : Latency Associated Transcript
LD : *Longissmus dorsi*
LFA : Lateral Flow Assay
LRI : Land Resource Inventory
MAS : Molecular Marker-assisted Selection
MAT : Macroscopic Agglutination Test
MF : Molecular Function
MGMG : Mera Gaon Mera Gaurav
MoU : Memorandum of Understanding
MPP : Methane Production Potential
MS : Mass Spectrometry
MW : Molecular Weight
NABG : National Agricultural Bioinformatics Grid
NADRES : National Animal Disease Referral Expert System
NAE : Niche Area of Excellence
NAEAB : National Agricultural Education Accreditation Board
NARD : National Agricultural Research Database
NARS : National Agricultural Research System
NASF : National Agricultural Science Fund
NBSS&LUP : National Bureau of Soil Survey and Land Use Planning
NDF : Non-detergent Fibre
NDMI : Normalized difference moisture index
NDVI : Normalized difference vegetation index
NDRI : National Dairy Research Institute
NDWI : Normalised difference water index
NEH : North-Eastern Hills
NET : National Eligibility Test
NGOs : Non-Government Organizations
NIABI : Network of Indian Agri-business Incubators
NICRA : National Innovations in Climate Resilient Agriculture
NISAGENET : National Information System on Agricultural Education Network
NRC : National Research Centre
NRCC : National Research Centre on Citrus
NSP-Ab : Non Structural Protein Antibody
NSSO : National Sample Survey Office
NTM : Non-tuberculous *Mycobacterium*
NTS : National Talent Scholarship
NUE : Nitrogen Uptake
OAS1 : Oligoadenylate synthase 1
ODR : Overall discomfort rating
PBMCS : Peripheral blood mononuclear cells
PCA : Principal Component Analysis
PCR : Polymerase Chain Reaction
PDDUUKSY : Pandit Deen Dayal Upadhyay Unnat Krishi Shiksha Yojana
PGDTMA : Post-graduate Diploma in Technology Management in Agriculture
PIADC : Plum Island Animal Disease Center
PID : Participating Technology Development
PME : Priority Setting, Monitoring and Evaluation
PMIS : Personal Management Information System
PPGSE : Plausible Potato Growing Seasons Estimator
PPR : *Peste des Petitis Ruminants*
PPV and FRA : Protection of Plant varieties and Farmers' Rights Authority
PRRSV : Porcine Reproductive and Respiratory Syndrome Virus
PUFAs : Polyunsaturated fatty acids
QPM : Quality Protein Maize
QTL : Quantitative Trait Loci
RAWE : Rural Agricultural Work Experience
RDF : Recommended Dose of Fertilizers
RE : Revised Estimate
RFD : Results-Framework Document
RFLP : Restricted Fragment Length Polymorphism
RH : Relative Humidity
Risk MAP : Risk Mapping, Assessment and Planning
RMP : Research Management Positions
RNFE : Rural Non-farm Employment
RVF : Rift Valley Fever
SAARC : South Asian Association for Regional Co-operation
SAH : Solar Air Heater
SAUs : State Agricultural Universities
SCC : Somatic Cell Count
SCSMV : Sugarcane Streak Mosaic Virus
SNP : Single Nucleotide Polymorphism
SPR : Surface Plasmon Resonance
SRF : Senior Research Fellowship
SRI : System of Rice Intensification
SSD : Surface and Subsurface Drainage
SSLUP : Small Scale Lac Processing Units
SWYMOD : Surface-Water Yield Model
TFP : Total Factor Productivity
TiLv : Tilapia lake virus
TLCV : Tomato Leaf Curl Virus
TLR-1 : Toll Like Receptor-1
TKP : Tamarind Kernel Powder
TMY : Total Milk Yield
TNFU : Tamil Nadu Fisheries University
TOT : Transfer of Technology
TSP : Tribal Sub-Plan
TSS : Total Soluble Solids/Sugars
TTV : Transfusion Transmitted Virus
UG : Under-graduate
UGC : University Grants Commission
USST : Udder skin surface temperature
UV : Ultra Violet
VACV : Vaccinia Virus
VNTR : Variable Number Tandem Repeats
VPKAS : Vivekananda Parvatiya Krishi Anusandhan Sansthan
VRFA : Variable Rate Granular Fertilizer Applicator
VS : Vesicular Stomatitis
VTCC : Veterinary Type Culture Centre
WB : Western Blot
WBUFAS : West Bengal University of Fisheries and Animal Sciences
WCL : Whole Cell Lysate
WNF : West Nile Fever
WNV : West Nile Virus
WUE : Water Use Efficiency

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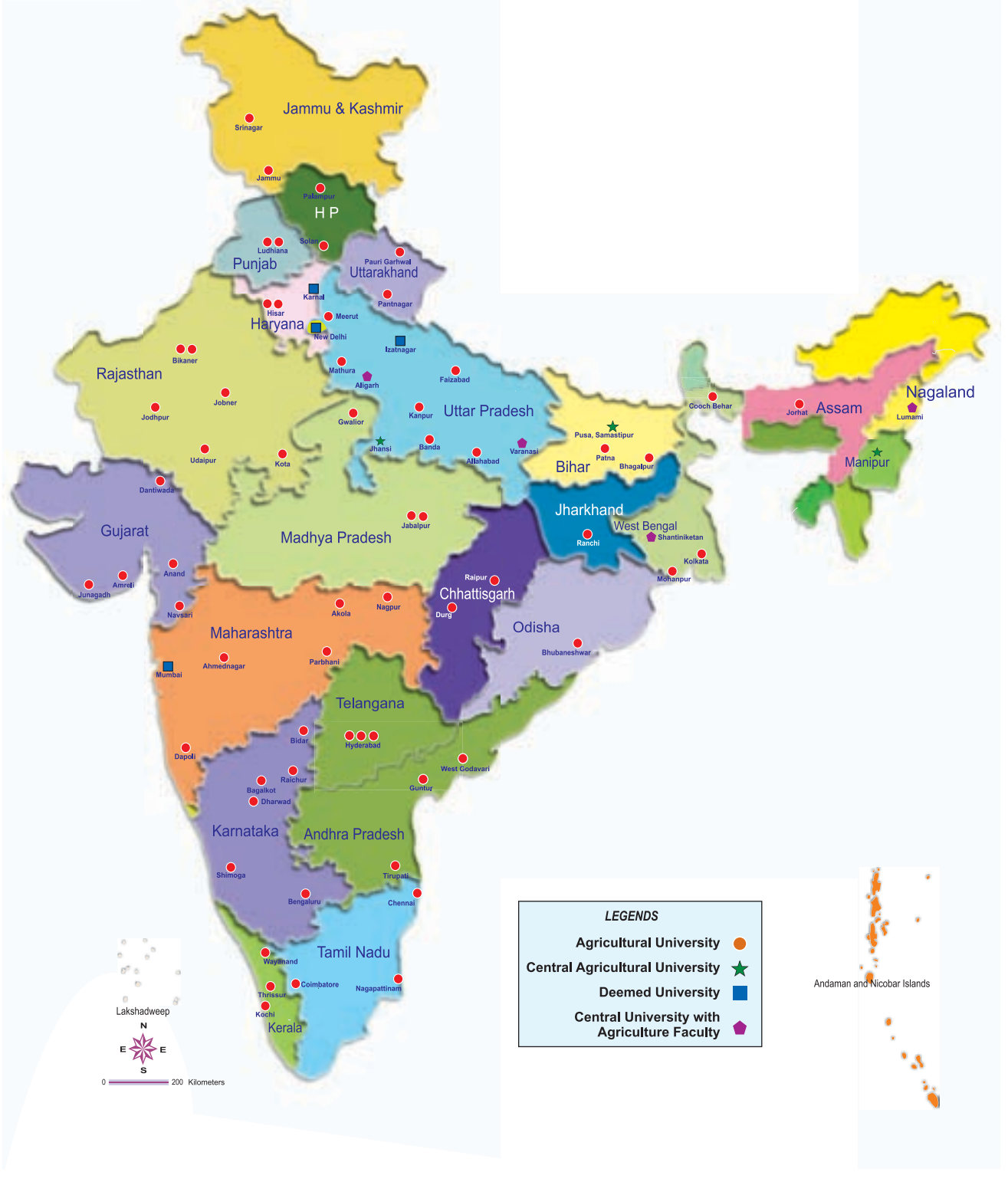
INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Agricultural Universities



- 63 State Agricultural Universities (SAUs)
- 3 Central Agricultural Universities
- 4 Deemed Universities
- 4 Central Universities having Faculty of Agriculture