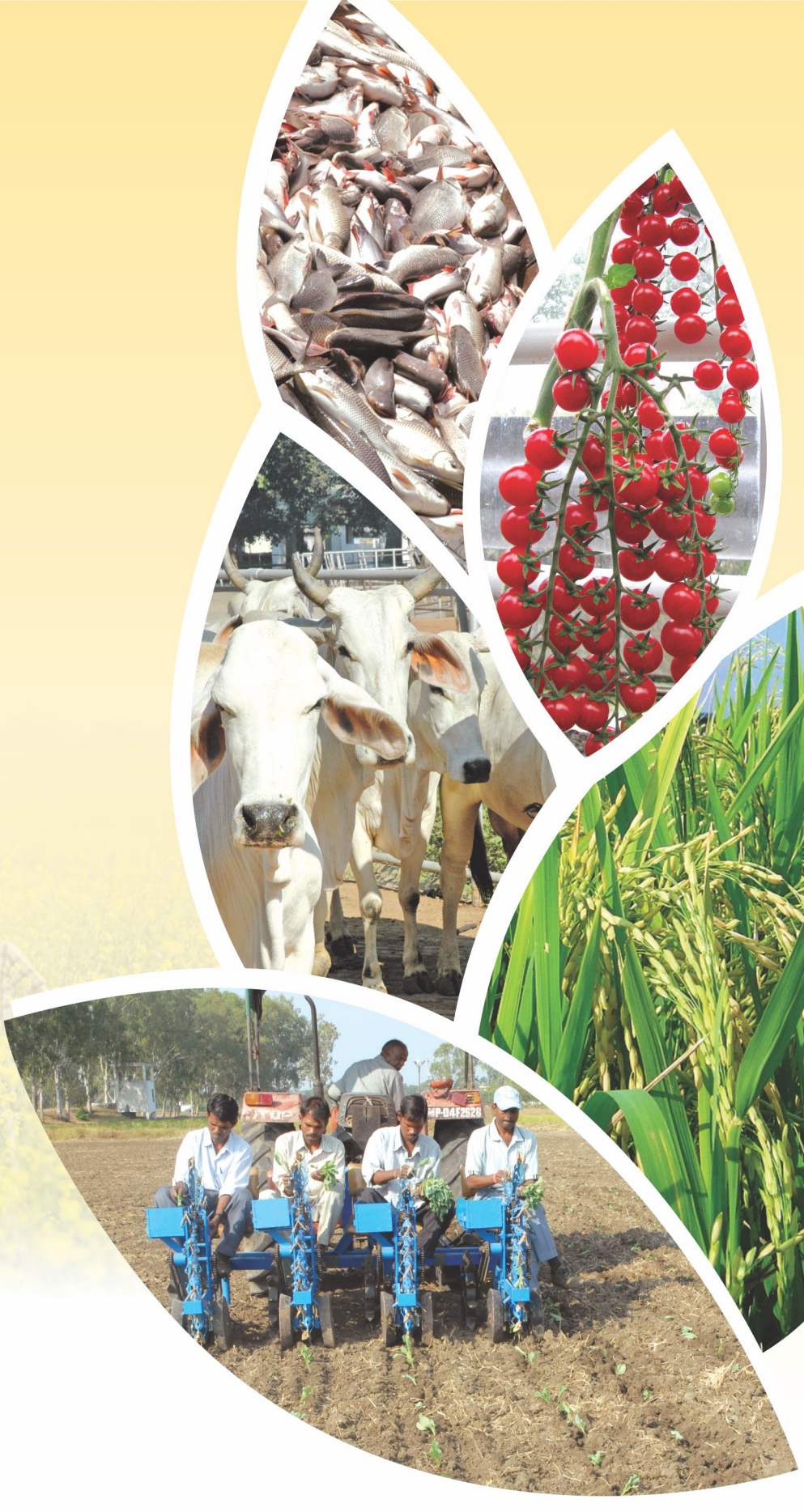
ANNUAL REPORT
2018-19



सत्यमेव जयते

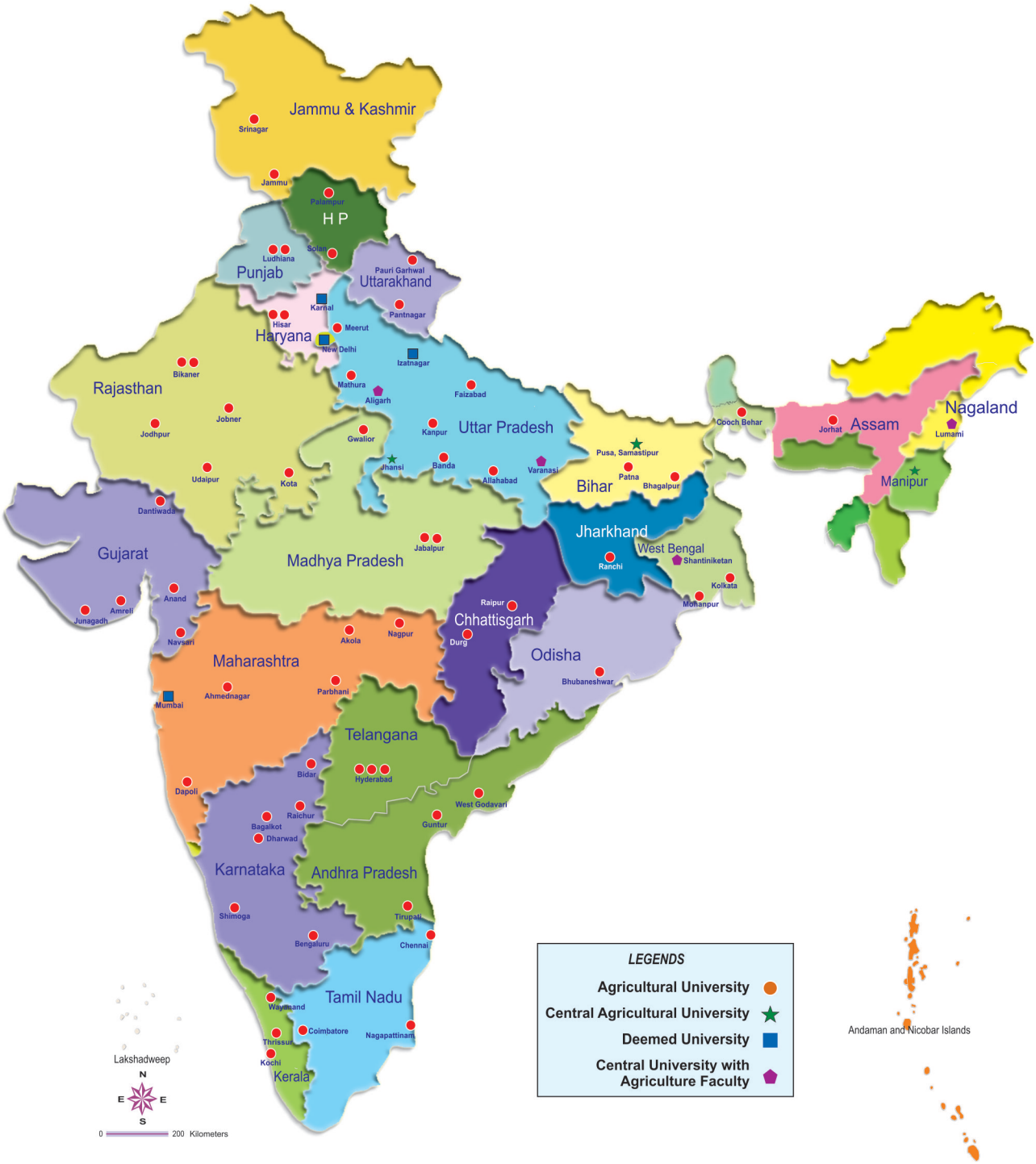
Department of Agricultural Research and Education
Ministry of Agriculture & Farmers Welfare
Government of India

भाकृअनुप
ICAR

Indian Council of Agricultural Research
New Delhi

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Agricultural Universities



- 63 State Agricultural Universities (SAUs)
- 3 Central Agricultural Universities
- 4 Deemed Universities
- 4 Central Universities having Faculty of Agriculture

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Foreword

The present government has taken strategic initiatives to accelerate agricultural growth and to transform the farm sector with an aim to increase production and suitably empower the farmer. Doubling farmers' income, securing their endeavours, making them tech savvy, boosting agricultural research and education, and building farm-related infrastructure are some of the major goals achieved promoting the growth of agricultural sector. Farmers' welfare is an integral part of the New India envisioned by Hon'ble Prime Minister Shri Narendra Modi, which runs on a motto of *Sabka Saath, Sabka Vikas*. The government's inspiring initiatives such as Lab-to-Land, *Har Khet Ko Pani,* and Per Drop More Crop have raised awareness about the need to create systems that turn the farming activity into a hub of productivity and prosperity. From technology to crop insurance, from easier credit access to modern irrigation methods, we are implementing a comprehensive action plan to empower farmers throughout the farming cycle under the umbrella of *Beej Se Bazaar Tak.*

During the year 2018, a total of 372 high yielding varieties/hybrids comprising 200 of cereals, 49 oilseeds, 47 pulses, 47 commercial crops and 29 of forage crops were released. To address malnutrition issues of the country, eight biofortified varieties of rice, wheat, maize, pearl millet and lentil having high iron, zinc, selenium and protein, were also released. During the reporting period, total breeder seed production in field crops was 116,999 q against the indent of 98,048.4 q while quality seed production including all classes was 597,992 q against the target of 366,059 q. Similarly, in the horticultural crops, 120 varieties have been developed in vegetables, fruits, spices and tuber crops.

A total of 24 new breeds of livestock and poultry were registered taking the total number of registered indigenous breeds in the country to 184 including 43 of cattle, 16 of buffalo, 34 of goat, 43 of sheep, 7 of horses and ponies, 9 of camel, 8 of pig, 2 of donkey, 1 of yak, 19 of chicken, 1 of duck and 1 of geese. In Frieswal female cattle, the average of 300 days milk yield was 3,340.26 (unit) and peak yield (PY) was 14.91 kg. Selection in indigenous breeds, viz. Gir, Kankrej and Sahiwal improved the average age at first calving, lactation days, lactation length and peak yield. Himsamridhi, a multi-coloured dual purpose bird suitable for backyard poultry production in hilly areas was developed. A male cloned calf named as Sach-Gaurav of Assamese buffalo was born through a normal delivery at Sirsa (Haryana). To facilitate the dairy farmers Forewarning-Mobile Application 'LDF-Mobile App' was developed for extending the reach of the National Animal Disease Referral Experts System (NADRES), which gave forewarning report of 13 economically important livestock diseases in the country.

In fishery sciences, indigenous ornamental fish, *Pethia narayani* was bred under captive conditions. Large-scale stocking of carp seeds in river Ganga was undertaken to augment their natural population, which has declined due to various anthropogenic activities. Cadalmin^{TM} Ate, a nutraceutical product with bioactive ingredients having role in stimulating thyroid releasing hormone was extracted from seaweeds. CIFTest, a consumer friendly test kit was developed which detects unsafe levels of formaldehyde between 20–100 mg/kg and presence of more than 300 mg/kg ammonia.

Efforts were made to promote zero-budget farming and other indigenous agricultural technologies to control pest population using pheromones in fruits. To address the issue of paddy straw management portable briquetting machine was developed, which can be used at farm site. To degrade lignin and cellulose, seven thermophilic fungi, four bacteria and two actinomycetes were isolated from municipal solid waste. These consortia of microbes enhanced the decomposition process as well as compost reached its maturity and stability within 21–30 days.

Quality assurance of Agricultural universities was ensured through accreditation and ranking system. Financial support to state universities was provided for strengthening, renovation and modernization of infra-structure pertaining to student and faculty amenities.

Informative messages (175,941) sent by KVKs benefitted 612.95 lakh farmers on various aspects of agriculture, horticulture and animal husbandry, weather forecast, pest management and disease control. Pulses Seed-hubs set-up at 97 KVKs produced 40,077.37 q seeds of pigeon pea, black gram, green gram, lentil, chickpea, field pea and lathayrus contributing to the highest ever pulses production in the country. The static soil and water test laboratory in KVKs analysed soil samples and distributed 879,574 Soil Health Cards among the farmers.

Tribal welfare programmes were supported in 17 agricultural universities with financial support of ₹ 23.54 crore. Training programmes, workshops and demonstrations etc. were executed for capacity building and creating awareness among nearly 21 lakh tribal farmers. It is worthy to note that 47 patents were granted during this year taking ICAR's cumulative

number of granted patents to 259. The ICAR Awards for year 2017 were given in 17 different categories to 168 awardees. It is heartening to note that out of the 116 scientists and 24 farmers, 23 were women scientists and 3 were women farmers.

DARE hosted the 4th ASEAN India Ministerial meeting on Agriculture and Forestry during this year, which was attended by representatives from 10 ASEAN Countries and ASEAN Secretariat. India played an important role in developing trained human resource for agricultural research in Afghanistan and also helped in establishing Afghan National Agricultural Sciences and Technology University.

The DARE/ICAR is immensily contributing to the development of Indian Agriculture by strengthening research and development, education and extension of technologies. During the year 2018, our reach and connect to farmers has increased many folds through KVKs, Krishi Unnati Melas and several other programmes at national and state levels. We need to give more emphasis in this area and equip the small and marginal farmers with latest technology and information related to soil, water and weather. I am sure that the *DARE/ICAR Annual Report 2018–19* will present insights into the agriculture domain of the diverse stakeholders, and would provide valuable information for planning future course of action.

(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** **Shri Gajendra Singh Shekhawat** **Smt Krishna Raj**
Secretary, DARE, and Director General, ICAR	:	**Dr Trilochan Mohapatra**
Additional Secretary, DARE and Secretary, ICAR	:	**Shri Chhabilendra Roul** **(Till 31 December 2018)**
Additional Secretary and Financial Adviser, DARE/ICAR	:	**Shri B. Pradhan (Since 13 June 2018)**
Special Secretary and Financial Adviser, DARE/ICAR	:	**Shri Jaideep Govind** **(From 29 February to 12 June 2018)**

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

Agriculture has played a major role in the development of human civilization and remarkable progress in agriculture sector has brought out a fundamental and vibrant change in the world socio-economic situation. Sustainable agriculture requires successful management of resources to satisfy human needs in current times, without endangering the ability of future generations. From agriculture-for-subsistence-farming to now the problem-of-plenty, it has passed through many transforming stages. There has been an emphasis now to consider agriculture sector at par with industrial sector to ensure substantial income from farming. Technological advancements have provided farmers with tools and resources to make farming more handy and sustainable. The DARE/ICAR has played major role in providing long-term sustained yields through use of ecologically sound management and innovative technologies—which ushered in Green Revolution and enabled the nation to enhance the production of foodgrains four times, horticultural crops six times and fish nine times and eggs twenty-seven times since 1951—a way forward for nutritional and food security. The ICAR/DARE played a major role in promoting excellence in higher education in agricultural sciences and reaching to the farming community through its KVKs and extension activities.

Soil and water productivity: Soil maps at 1:10,000 scale were prepared for 62 different blocks covering 60 agro-ecological sub-regions (AESRs) of the country. Landscape ecological unit (LEU) consisting of land forms, land use and slope was taken as the base map for LRI (land resource inventory) instead of land forms alone. The global soil carbon (SOC) map consisting of national SOC maps covering a depth of 0–30 cm, were developed by FAO in collaboration with ICAR-NBSS & LUP, Nagpur and ICAR-IISS, Bhopal. Around two lakh geo-referenced soil organic carbon stock data were generated. Soils of Northeastern states, Jammu and Kashmir, Uttarakhand and Himachal Pradesh are richer in SOC than the adjoining Indo-Gangetic plains. Total potential runoff volume for the period 2011 to 2015 was estimated using SCS CN (Soil conservation service-curve number) method in Dhanora block, Seoni district, Madhya Pradesh. The average total potential runoff volume generated from the block was about 202.017×10^6 m^3 and average depth of runoff was 367 mm. An android based cell phone applications on Land Resource Information System of Goa (LRIS Goa) and potential crop zone (PCZ) mapper have been developed for the stakeholders. LRIS Goa is capable of visualizing, disseminating, sharing and data mining of the land resources in digital manner. PCZ mapper facilitates easy visualizing, disseminating, sharing of database on crop suitability and potential crop zone of the country. Drip irrigation (DI) has been designed and used to enhance water productivity and profit in rice-based cropping sequence in an irrigated command of Odisha. Use of in-line DI system in rice–capsicum–baby corn sequence enhanced productivity by 7.6 times higher than that of rice–rice system under surface irrigation (9.5 tonnes/ha/year). A new method was developed to convert low grade potash bearing feldspar mineral into organo-mineral fertilizer (OMF) by mixing it with chemically treated leonardite, the oxidizing form of lignite, which is found abundantly in the country. The response of pearl millet, wheat and mungbean to OMF is comparable to that of conventional potassium fertilizer—muriate of potash. Wheat grain yield increased by 14.2, 10.9 and 17.9% in treatment of bioformulations of Halo-Azo, Halo-PSB and Halo-Azsp, respectively.

Climate change and resilient agriculture: The wheat yield potential was simulated under future climate scenarios of 2020, 2050 and 2080 periods and compared with that of base line (1976–2005) using InfoCrop-Wheat model. The results indicated that the climatic potential yield of wheat is projected to reduce in future climates with significant reduction in central India and in eastern parts. Results of the study on the effect of climate change parameters on plant growth, nutrient uptake and water use in wheat crop, indicated that with recommended crop fertilization, elevation in atmospheric CO_2 concentration by about 150 ppm increased the grain yield by 12%, whereas increased temperature declined the yield by about 6%. Submergence tolerant varieties of rice Jalashree and Jalkuwari were demonstrated in the farmers' fields which gave 50 to 60% higher grain yield than the existing varieties. A low-cost shelter was designed and fabricated for sheep and goats at Leh and Ladakh. This shelter maintains nearly 15°C in the incubator as compared to 5°–6°C in ambient.

Genetic resources: A total of 5,775 accessions of orthodox seed species were added to the National Genebank for long-term storage and 12,615 accessions from genebank were regenerated. In the Cryogenebank, 447 accessions of different crop species, which included seed (171), pollen (9) and genomic resources (267) were successfully cryopreserved, making the total holding of 13,323 accessions. Promising germplasm introductions were, wheat cultivar Wirtas with significant resistance to fungal pathogens combined with high protein content from Poland; improved lines

of paddy with submergence and bacterial blight tolerance from Nepal; Salinity tolerant, resistant to *Phytophthora* rot and high yielding lines of safflower from USA and Superior quality berriers of seabuckthorn with good taste from Russia. A total of 123,126 imported samples, including transgenic and trial materials were processed for quarantine clearance. Population structure and genetic tree of 330 rice landraces was generated using 30 HvSSR markers.

In animal genetic resources, an image based system was developed for the identification of individuals, breeds and diseases of pig and goat. Breed Registration Committee approved the registration of 24 new breeds of livestock and poultry, viz. cattle (Lakhimi, Laddakhi and Konkan Kapila); buffalo (Luit, Bargur, Chhattisgarhi); goat (Kahmi, Rohilkhandi, Assam Hill, Bidri, Nandidurga, Bhakarwali, Salem black, Sumi-Ne); sheep (Panchali); horse (Kachchhi-Sindhi); pig (Ghurrah, Zovawk); yak (Arunachali yak); donkey (Halari); duck (Pati duck); geese (Kashmir Anz), and chicken (Uttara, Hansli). The total number of registered indigenous breeds in the country is now 184 (43 for cattle, 16 for buffalo, 34 for goat, 43 for sheep, 7 for horses and ponies, 9 for camel, 8 for pig, 2 for donkey, 1 for yak, 19 for chicken, 1 for duck, and 1 for geese). Ladakhi donkey a pack animal for transportation of manure/ fuel-wood/fodder/construction/trekking-camping materials by local people, food-logistics supply by Indian Army and secondarily for manure is being reared by Buddhist communities mostly in rural areas. The Ladakhi donkey has the ability to easily cross small ridges (Bonchangs) and can travel 15–20 km in 5–6 hr with 40–50 kg load in high terrain, thus making it the most suitable animal of the cold desert. Diversity analysis of Indian buffalo population allowed the grouping of all the populations into 11 groups, largely by region-wise. The first group consists of swamp buffaloes of North East region of Asom and Manipur, the second group of Chilika buffaloes, the third group of Murrah and Nili Ravi buffaloes and the fourth group of Surti, Mehsana, Nagpuri and Banni buffaloes. Kerala buffaloes, Toda and Kalasthi form separate clusters or groups, Tarai and Bhadawari forming separate two groups and rest of the Uttar Pradesh buffaloes formed another two groups. The genotypes of exon 6 fragments of 2'-5'oligoadenylate synthetase-1 (OAS1) gene had a significant association with milk production traits, whereas, genotypes identified in exon 2 and exon 5 did not reveal any association in both Frieswal and Sahiwal cattle populations. Study on correlation of different semen quality parameters with expression profiles of genes like A-kinase anchor Protein 4 (AKAP4), PRM1 and CAT showed positive correlation on both acrosome integrity and post-thaw motility in Frieswal bull semen. A putative mapping of internal ribosome entry sites (IRES) was identified in bovine heat shock protein gene for the first time, which was showed to be functional and an Indian patent has been filed for this. Total 23,975 semen doses from 8 cattle breeds and 400 somatic cell doses each of Katchi camel and Marwari horse were successfully cryopreserved.

Studies on population genetic structure and genetic diversity of chocolate mahseer, *Neolissochilus hexagonolepis* from nine geographically isolated populations from Asom, Arunachal Pradesh and Meghalaya, showed high polymorphisms, parsimony and haplotype diversity in most of population, indicating genetically healthy stocks. Sequencing, assembly and annotation were completed for the whole genomes of three important fishes, hilsa, *Tenualosa ilisha*; rohu, *Labeo rohita,* and magur, *Clarias magur;* a fungus, causing epizootic ulcerative syndrome EUS; oomycete, *Aphanomyces invadans;* and a pathogen of shrimps causing white spot syndrome virus (WSSV).

Crop improvement: Major emphasis was on the development of new varieties and hybrids tolerant to various biotic and abiotic stresses with enhanced quality. During the year 2018, total 372 varieties were developed—200 high yielding varieties/hybrids of cereals; 49 of oilseeds, 47 of pulses, 47 of commercial crops, and 29 of forage crops; and were released for cultivation in different agro-ecologies. Based on the agronomics performance, Cry toxin expression, reaction to sucking pests and diseases and fibre quality parameters, 8 Bt cotton varieties were released for commercialization. Seven varieties of rice were developed by using the modern molecular tools. These varieties have resistance/tolerance to various biotic and abiotic stresses, which was introgressed through marker assisted backcross breeding. Eight biofortified varieties of various crops including rice, wheat, maize, pearl millet and lentil were released during 2018. These varieties have high concentration of iron, zinc, selenium and protein. Major quantitative trait loci (QTLs) were identified for aluminium resistance using simple sequence repeat (SSR) markers in F2 and F3 mapping populations derived from contrasting parents. RIL (recombinant inbred line) mapping population was developed by using groundnut CS8 × TG 37A cross and used for QTL mapping for stem-rot resistance. A cost-effective molecular marker assay for high oleic trait in safflower, was developed. This marker can be used in large scale for marker assisted breeding to develop high oleic safflower cultivars. RNA-guided genome editing based on CRISPR-Cas9 was standardized in rice mega variety MTU 1010. Mutations in drought and salt tolerant genes were induced by using genome editing in MTU 1010. Genome editing in soybean for regulating phytate-flux was carried out. Editing/mutagenesis of *GmIPk 1* gene responsible for terminal step enzyme (Inositol pentakisphosphate-2-kinase) was done using sg RNAs. HPLC-PDA analysis for phytate levels in the mutants revealed 6–7 fold reduction compared to control. During 2017–18, total breeder seed production in field crops was 116,999 q against the indent of 98,048.4 q. Total production of quality seed including all classes was 597,992 q against the target of 366,059 q.

In the horticultural crops 120 varieties were developed during this year—62 in vegetable crops (tomato, brinjal, okra, cabbage, cauliflower, onion, french bean, Indian bean, radish, kale, chilli, winged bean, pointed gourd, bottlegourd, cucumber, chenopod, pumpkin, sponge gourd, garden pea, round melon etc.), two in fruit crops (mango, papaya) and 22 in spices and tubers (cardamom, potato, cassava, ginger, coriander etc.). An inter-specific grafting on resilient brinjal rootstocks was identified as an alternate strategy to combat the deleterious effects of flooding in tomato. Brinjal variety Arka Neelkant was identified as the best flood resilient and compatible rootstock for tomato and yields up to 70%.

Livestock improvement: In Frieswal female cattle the overall means of 300 days, total milk yield, peak milk yield (PY) and lactation length were 3340.26, 3358.86, 14.91 kg and 322.09 days, respectively. Selection in indigenous breeds, viz. Gir, Kankrej and Sahiwal breeds improved the average age at first calving, first lactation length and first peak yield. Under the Network Project on Buffalo Improvement, test mating from 16th set of 15 test bulls was completed. The weighted average of 305 days or less lactation milk yield in the year was highest ever (2,487 kg). Location specific pig varieties, namely, Mannuthy white, Lumsniang and Landlly were released. Himsamridhi, a multi-coloured dual purpose bird suitable for rural poultry production in hilly areas was developed. The body weight of male was 1.8 kg at 20 week; age at sexual maturity-165 days; annual egg production in layer-160 eggs. In PD-4 (improved Aseel) there was an improvement in shank length at 8 weeks of age. In Ghagus population (G-5), body weight and shank length of male birds at 40 weeks of age were 2.6 kg and 128.5 mm, respectively. The naked neck and dwarf gene lines were maintained as resource populations. Under AICRP on poultry breeding, all the 12 centres are working on the development of location-specific chicken varieties, conservation, improvement, characterization and application of local native, elite layer and broiler germplasm; and development of package of practices for village poultry along with development of entrepreneurships in rural, tribal and backyard areas.

Under species diversification, breeding protocol for ornamental fish, *Pethia narayani* was developed and also breeding and rearing protocol for pengba, *Osteobrama belangeri* was standardised and these were introduced in farmers' ponds. Pacific white shrimp, *Penaeus vannamei* farming in Sangat Kalan, Bathinda, Punjab, was demonstrated with a production of 6.25 tonnes/ha in 120 days. Three-tier rearing model of seabass (*Lates calcarifer*) in cages in a coastal village Vennangupattu, Tamil Nadu, was demonstrated with a production of 12 kg/m^3. Large scale seed ranching programme was undertaken to augment the natural population of Indian major carps (IMC) in river Ganga.

Crop management: Storability of cowpea seed using zeolite seed 'drying beads' was evaluated. Ultra-dried seed maintained germination well above Indian Minimum Seed Certification Standards after 36 months of storage. A trial conducted to find out effective herbicides for control of broadleaved weeds in wheat, showed that halauxifen methyl + florasulam + carfentrazone + surfactant was the best treatment in controlling broad leaf weeds in all the wheat growing zones. Application of pacobutrazol increased number of flowers and mature pods/plant and significantly increased pod yield in groundnut as compared to control. Evaluation of five endophyte bacteria with fine levels of irrigation water with groundnut cultivar TG 37A revealed that application of endophytes and four irrigations can provide as much pod yield (average 1,873 kg/ha) as that obtained with 10 supplementary irrigations after emergence (1,766 kg/ha). Three microbial consortia developed for alleviating moisture stress in chickpea gave 14.1–17.4% more mean grain yield than control across the locations. In zero-budget farming, productivity of potato Kufri Mohan (41.7 tonnes/ha) and Kufri Surya (41.7 tonnes/ha) was found very good.

To overcome the problem of leaf rust in wheat, work was initiated to develop near-isogonics or lines in the background of a locally adapted variety NP 4. NILs carrying leaf rust genes *Lr13, Lr18, Lr19* and *Lr26* were developed by backcrossing NP 4 line with Thatcher lines carrying these genes. A method for simultaneous identification and quantification of 101 pesticides using LC-MS/MS was developed for assessment of pesticide residues in fruit and vegetables. The larvae of populations of pink bollworm were subjected to 1 ppm concentrations of toxins, viz. Cry1Ac, Cry2Ab, BGII seed powder under controlled conditions. Guntur and Kurnool populations were least susceptible to toxins and rest of the populations attained >60% mortality. Field efficacy of newer insecticides was tested against mango thrips under field conditions. Spraying of neem oil, Fipronil and Thiomethoxam reduced the thrips incidence up to 90.0, 82.2 and 72.9%, respectively. The efficacy of indigenously synthesized sex pheromone was tested against citrus leaf miner for the management of citrus groves at ICAR-CCRI, Nagpur. This pheromone lure helps to check the pest population under economic threshold levels. An integrated strategy for managing bacterial wilt of ginger was developed. It involves solarizing of soil for 30–40 days prior to ginger sowing and soil amendment with calcium chloride or *Bacillus licheniformis* at the time of planting and at 30, 45, 60 and 90 days intervals.

Livestock management: Buffalo had less methanogens and fibre degrading bacteria as compared to cattle. Defatted silkworm pupae meal (DSWP) could be incorporated in the ration of cattle up to 30% by replacing SBM (soybean meal) without compromising the rumen fermentation and nutrient utilization. Twenty isolates of hyperammonia producing bacteria (HAB)

were isolated from rumen of buffaloes and they had very high rate of ammonia production and had low16S rRNA gene similarity to cultured bacteria indicating that many more HABs exist than known so far. *Salix* silage making in polythene bags is an alternative way of conservation of green fodder to address the winter feed scarcity when yaks lose around 25% of their live body weight due to non-availability of fodder. For clean poultry meat production, synbiotic was found beneficial as its inclusion showed significant improvement in performance, immuno-competence, structural and microbial gut health, physio-biochemical characteristics and reduced entero-pathogen counts in fresh as well as stored meat. Feed cost of broiler meat production was reduced by 3.3–6.7% through use of additives (synbiotics and betaine) during hot-dry and hot-humid conditions.

The sperm parameters accounting to high variability were identified. Based on these results fertility prediction model was developed, which would help in selecting superior quality semen for use in artificial insemination thus facilitating high conception rates at field level. Salivary proteins such as cullin associated NEDD8-dissociated protein 1, heat shock 70 kDa protein 1A, 17-beta-hydroxysteroid dehydrogenase type 1, inhibin beta A chain, testin were identified as estrus-specific. A study indicated that epithelial cells can be cultured from stored semen and they can also be used as donors to produce cloned embryos of breeding bulls. Animals expressing 'Doka' were found cyclic and showed normal ultrsonographic and hormonal levels except PGFM which showed high concentration during this phenomenon. Pre-pubertal supplementation of organic Cu and Zn advanced the puberty by 28–35 days in indigenous bucks. A device for thawing of frozen semen straws and for proper lubrication of fetus during handling of dystocia, was developed. A male cloned calf named as Sach-Gaurav of Assamese buffalo was born through a normal delivery at Sirsa, Haryana. The birth weight of the cloned calf was 54.2 kg.

Livestock disease Forewarning-Mobile Application 'LDF-Mobile App' (Version English) was developed for extending the reach of the National Animal Disease Referral Experts System (NADRES), which predicted forewarning report of 13 economically important livestock diseases in the country. Conditions for support based strip test were optimized for detection of subclinical mastitis. The developed test will be helpful in detection of subclinical mastitis in dairy animals under field conditions in minimum time. Surveillance for influenza A, Japanese encephalitis and trypanosomosis in north-eastern region was undertaken as there is continuous threat of emergence of trans-boundary infectious diseases from neighbouring countries. In view of the emergence of glanders in the country, 33,249 equines were tested for glanders, and 407 equines were found positive for this. In addition, 70 human serum samples from in-contact equine handlers tested negative for glanders. EHV1 vaccines currently in use in India induce short-lived humoral and cellular immunity. A recombinant EHV1 was developed as potent modified live vaccine candidate. ICAR-NRCE validated indirect ELISAs for glanders diagnosis; the overall activity was coordinated by World Organization for Animal Health (OIE)—Reference Laboratory on Glanders, Germany. A LAMP (loop mediated isothermal amplification) assay was developed for detection of porcine parvovirus (PPV) from pigs. It is rapid, cost effective and can even be used in field. IVRI-M antigen capture ELISA kit was developed for *peste-des-petitis-ruminants* (PPR). The pathogenicity of IBV–DPR isolate was characterized where a heterologous strain was detected having poor cross neutralization with wild type strains. A total of 149 incidences of FMD were recorded and investigated this year; almost 60% of the incidences were in the southern region of the country and 92% of these incidences were in Karnataka only. The vaccine strain demonstrated optimal antigenic coverage with 88% of the isolates showing antigenic match. The marker virus and its companion ELISA provide a basis to devise a marker vaccine strategy for FMD control, when the country reaches stage 4 of PCP-FMD (Progressive Control pathway for Foot-and-Mouth Disease). Complete genome sequence of seven H5N1 highly pathogenic avian influenza viruses isolated from chickens, ducks, turkey and crows in different epicenters, was determined. These findings indicate cross-border movement of the H5N1 virus in South Asia. Indirect ELISA kit for avian influenza was tested and demonstrated at Regional Disease Diagnostic Labs (RDDL) of the country.

Assessment of the impact of cage culture in Chhattisgarh, Jharkhand, Odisha, Maharashtra, Manipur and Asom revealed that the yield varied in cages from 2 tonnes in Odisha to 4 tonnes in Chhattisgarh. The cages provide employment to 7.46 lakh man-days per year in the country. Developed vaccines for nervous necrosis virus (NNV) revealed that the dual combination vaccine is useful for *Labeo rohita* against *Flavobacterium columnare* and *Edwardsiella tarda.* One-step PCR based Tilapia Lake virus detection kit was developed.

Mechanization and energy management: Farm mechanization has become the critical input of agriculture sector because of reduced labour availability. Considering the vast requirement of mechanization in Indian agriculture several machines were developed and steps were taken to develop reusable energy sources and to efficiently utilize energy. The significant achievements are, development of high clearance multipurpose vehicle for horticultural crops to carry out different operations like spraying, weeding, harvesting etc.; variable width raised bed former; three row automatic vegetable transplanter for potted seedlings; automatic vegetable transplanter; ginger planter; high ground clearance platform for small tractor; multi-crop planter for sowing on beds; planter-cum-herbicide applicator for direct sowing of paddy; sorghum and pearl millet ear-head separator; remote controlled

power tiller; bullock drawn fertilizer applicator-cum-ridger; deep furrow sugarcane cutter planter; solar energy for FCV tobacco curing; urea ammonium nitrate (UAN) applicator; equipment for small farm mechanization; animal drawn bio-fertilizer applicator-cum-maize planter etc.

Solar powered bird scarer was tested in maize crop for 45 days and no damage due to birds was observed. Its cost is approximately ₹ 2,600 and it can save 480 man-hours per crop season. To meet the future requirement of energy and food, an agri-voltaic system was designed and developed in which electricity generation, crop production and rain-water harvesting can be done on a single land unit. About 400 units of electricity (kWh) can be produced per day from the established system. Annual income from the developed agri-voltaic system has been estimated to be around ₹ 7.5–8.0 lakh/year. Micro-planning and management of rural energy system is a village level assessment of energy footprints in available energy flow pathways to find and suggest the need of energy intervention. Saving in the energy consumption is the main aim of energy planning and management at micro level. Renewable energy supplementation using briquettes was estimated to be 60±20 MJ/day/family. The replacement of 50–80% of the fuel wood consumption for cooking by rural families saved 20–25% energy. A continuous bio-char production unit was developed. The bio-char produced from agro residues can be used as soil amendment. Further, it can be pelletized to meet the energy required for both domestic and industrial applications. The application of biochar as soil amendment reduces the chemical fertilizer demands. The continuous pyrolyzer was developed for production of bio-oil from crop residues. The developed system is suitable for production of bio-oil from woody mass (saw dust), agro residues (rice husk, groundnut shells and cotton stalk etc.), pellets and wood chips. The farmers will earn an extra income from selling crop residues. Managing paddy straw is a great challenge in northern states. Briquettes from paddy straw were prepared using portable briquetting machine and the performance was satisfactory. The machine can be used at farm site and utilization of briquettes as domestic fuel can reduce dependency on conventional fuel. Bio-methanation reactor with horizontal stirring arrangement was developed to produce biogas from paddy residues; cumulative biogas production was 266 litre/kg of paddy straw. Crop residues can be utilized to produce biogas as well as compost. The residue burning can be avoided thus reducing air pollution.

An electro-adsorption based water filtration device for treating arsenic and chromium contaminated water, was designed that can also be used for removal/deactivation of pathogenic bacteria. A solar powered 8.0 m long fishing boat for reservoirs and rivers with 6 knots speed, was developed.

Post-harvest management and value addition: A sugarcane rind removing equipment for juice making was developed where the potential stakeholders are juice vendors and juice bottling plants. A new turmeric polisher was developed, which is 100% waterproof, fungus and termite resistant and UV stabilized. A pilot plant for minimal processing of cut vegetables was developed. It is suitable for establishing an enterprise in peri-urban areas of vegetable production catchment. Process for ready to eat papaya puree (strained food), a complementary food supplement for babies and children, was developed. It is rich in vitamin C, calcium, magnesium and fibre. Eco-friendly and biodegradable dishware from banana fibres extracted from the pseudostem, was developed, which has sufficient strength for holding the food items and acceptable aesthetic look. Nano-lignocellulosic (NLC) biomass was extracted from the banana fibres and cotton stalks adding value to the farming by-produce. An elementary chlorine free (ECF) bleaching protocol was developed, which can be used for producing quality paper and whiter fabrics from banana fibres. An activated carbon based process was developed for removing the residual colour of the reactive dye effluent; and the treated water can be reused for dyeing. Banana pseudostem sap (BPS), an agro-residue, was used for flame retardant treatment of jute fabric. After application, the fabric was not catching flame and its limiting oxygen index (LOI) value improved notably. A better and user friendly technology for improved retting of jute was developed. Low calorie (12 Kcal/100 ml) aonla-fennel RTS drink and sugarcane juice blended with aonla juice were developed. Potato starch-based tableware having good strength, was developed. This work opens up new avenues for potato waste utilization. The procedure for extraction of curcumin, the active ingredient of turmeric, into the vegetable oils was standardized. Virgin coconut oil enriched with curcumin can be consumed for its medicinal and antioxidant activity. Iron fortification in milk and yogurt increased its bioavailability and reduced fat oxidation without sacrificing the sensory attributes and affecting shelf life of the product. To revalidate the effects of camel milk in autism disorder, 108 children suffering from autism were fed daily on an average 600 ml of camel milk/child for 3 months. A significant improvement was observed in children fed with camel milk. Several technologies, viz. whey jaljeera drink; DNA based method for differentiation of cow, buffalo, sheep, goat and camel milk; Arjuna herbal ghee; bajra lassi; strip based test for detection of hydrogen peroxide in milk, were transferred for commercialization. Yarn made from fine as well as coarser yak fibre in blending with jute fibre was used to produce high value apparels. Commercial exploitation of yak fibre would create an environment of economic manoeuvring to yak herders living at much harsh and cold climatic regions.

Cadalmin^{TM} Ate, a nutraceutical from seaweeds for treating hypothyroidism, was developed. Rapid detection kit 'CIFTest' to detect the presence of formaldehyde and ammonia in post-harvest fish, was developed. The kit is low cost but very important for human health.

Agricultural human resource development: The Education Division continued to strive for maintaining and upgrading quality and relevance of higher agricultural education under its scheme "Strengthening and Development of Higher Agricultural Education in India". Quality assurance of Agricultural Universities (AUs) was ensured through accreditation and ranking of AUs. Financial support was provided for strengthening, renovation and modernization of the structures pertaining to student and faculty amenities. Support for 29 new student hostels, 14 new examination halls, 62 smart classrooms enhanced student residential and teaching facilities in AUs. Twelve programmes were supported under Niche Area of Excellence including two new programmes one each at GADVASU and IVRI. Fifteen new Experiential Learning Modules were supported under student 'READY' component. HRD programmes/activities facilitated promotion and execution of ICAR sponsored schemes that include centralized admissions in UG/ PG 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 agriculture education; capacity building of faculty through summer-winter schools and Centre of Advanced Faculty training; National Professorial Chairs and National Fellow Scheme for promotion of excellence; Emeritus Scientist Scheme as a structural method of utilizing skill bank of the outstanding superannuated professionals. The improved teaching and learning facilities and capacity building of the faculty also enhanced the number of research publications in high impact journals out of PG research.

Agricultural economics and policy: Knowledge of agriculture-ecosystem interactions and trade-offs is essential for considering agriculture and ecosystems in a holistic manner and corrections of those processes, which contribute to negative environmental footprints. Once the role of ecosystem services is established, it is appropriate to pay to farmers and rural communities in lieu of ecosystem services provided by them. This requires development of an institutional mechanism. Its structure may differ depending on the nature of service, but an effective partnership of government, farmers and other stakeholders is necessary for fair distribution of payments. Rewards based on certification of farm practices on area basis or price support could be an option to begin with. Access to roads combined with access to information, affect producer prices strongly. These findings have important implications for agricultural policy. In the last decade, the compound growth rate of cumulative patents filed in agricultural sector in India was 12.5%, which was higher than the growth rate of global total (11%). India should also increase investment in R & D, reform economic policies and state support for patent filing to be globally competitive in agricultural sector.

The findings on water balance, water footprints and crop water productivity of major cereals showed that western dry region of the country is facing highest irrigation water deficit requiring immediate attention shift in cropping pattern towards less water requiring crops. The study advocates to incentivize farmers based water productivity of the crops in these regions. It can serve as a powerful advocacy tool that can support policy development, decision-making and for developing sustainable crop plans. The preliminary results showed that rural non-farm employment (RNFE) is a major contributor for reduction in poverty in rural areas. The calculated Sustainable Livelihood Security Index (SLSI), revealed that zones 4, 5, 7 and 8 of the country need immediate policy interventions to secure livelihoods. The calculated adaptive capacity index (ACI) revealed that Eastern Himalayan Region (EHR) has higher adaptive capacity, whereas Western Himalayan Region (WHR) the lowest. Both SLSI and ACI will help ascertain the current development status of the agro-climatic zones, *inter alia* prioritization of adaptation strategies, and policy interventions for augmenting livelihoods and resiliency of vulnerable regions.

Statistics and computer applications: Education Portal-ICAR (https://education.icar.gov.in) is a single window platform for providing vital education information/ announcements/ event schedules/e-learning resources from Agricultural Universities across the country to the rural youth in an easy and fast way. A software for prediction of herbicide resistant genes (http://webapp.cabgrid.res.in/ hrgpred/) was developed. Suitable sampling methodology for estimation of area and production of horticultural crops was developed, tested and validated. Suitable sampling methodology was developed for obtaining State level estimates of area and production based on reduced sample size.

Women empowerment: ICAR-Central Institute for Women in Agriculture (ICAR-CIWA) is the prime research institute mandated to carry out research exclusively on gender issues in agriculture. For engendering agricultural research and extension, technologies/ methodologies (547) were collected from different ICAR Institutes, SAUs, and AICRP on Home Science centres. Out of these, 138 technologies were found suitable for farm women. More than 100 different agriculture related problems of farm women were identified to create an expert system. A dynamic database on technologies for farm women was developed. Field level studies were taken up for identifying the gendered scope of doubling family income and an action plan was developed. Farm women knowledge groups (FWKGs) were formed under the Extension and Communication component to empower farm women on climate change.

Information, communication and publicity services: The Directorate of Knowledge Management in Agriculture is mandated for quick, effective and cost-

effective delivery of agricultural information to all the stakeholders in the agricultural sector. *The Indian Journal of Agricultural Sciences* and *The Indian Journal of Animal Sciences* monthly research journals of the Council are available in open-access mode (http://epubs.icar.org.in/ejournal). Trainings on 'Online article processing', 'Technical writing', 'Role of reviewer in quality research journals', 'Book writing' and 'Success Stories' were conducted. The Directorate has facilitated online access to 2,000 journals from a single subscription in more than 123 libraries under CeRA. The ICAR website was updated on regular basis, 1,375 new pages were created. DARE website received GIGW certification in 2018. E- Krishi Manch, ICAR facebook, ICAR twitter handle and YouTube Channel of ICAR helped in making the stakeholders aware about the ICAR activities. Agricultural Knowledge Management Unit (AKMU) of Indian Council of Agricultural Research undertakes management and maintenance of ICT infrastructure which includes Gigabit-speed wired and wireless network in premises of ICAR at Krishi Anusandhan Bhawan-1, Krishi Anusandhan Bhawan-2 and National Agricultural Science Centre Complex. An e-Publishing system developed and implemented in-house is used by readers, authors and research reviewers globally from 184 countries, 24×7, through Internet for accessing and publishing research in ICAR's research journals. The e-Publishing portal (http://epubs.icar.org.in/ejournal), presently has 40 research journals.

Technology assessment, demonstration and capacity development: A total of 3,354 technologies of various crops were assessed in 2,981 locations by KVKs through conducting of 24,976 trials on the farmers' field under different thematic areas. In livestock, 656 technology interventions were assessed across 842 locations covering 6,818 trials on animals under different thematic areas. Total 88 technological interventions were refined across 68 locations by laying out 442 trials in the farmers' fields under different thematic areas (cereals, pulses, oilseeds, fruits and vegetables). Demonstrations were conducted on 29,350 ha area in the country involving the major pulses. On national basis the yield advantage in pigeonpea was recorded the highest (56.80%), followed by field pea (39.51%). During the year, 26,481.25 ha area was covered with the demonstrations on oilseeds across all the zones in *kharif*, *rabi* and summer seasons. On national basis the yield advantage in oilseed crops was recorded highest in soybean (42.15 %), followed by linseed (40.43%). Farmers/ farm women, rural youth and extension personnel (14.98 lakh) were trained on various aspects through 50,934 training programmes. Training courses (6,262) for the skill development were organized for 1.64 lakh participants, out of which 59,557 (36.26%) were the young women. The KVKs organized 5.68 lakh extension programmes. Latest technologies related to agriculture and allied sectors were disseminated among 139.67 lakh participants.

During the year, 1.77 lakh q 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 19.98 lakh farmers. Planting materials (365.53 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 4.75 lakh farmers. Bio-agents (70.96 q), bio-pesticides (381.70 q), bio-fertilizers (12,307.17 q), vermicompost, mineral mixture etc., were produced and supplied to the extent of 264.74 q benefiting 12.13 lakh farmers. Poultry birds (chickens, quails, ducks and turkey) were provided to 26,199 farmers. A total of 154.91 lakh fish fingerlings were produced and supplied to 3,890 farmers.

Agricultural Technology Application Research Institutes (ATARIs) upgraded technical knowhow and skills of 13,715 participants from KVKs through 176 training programmes. Technology packages that have proven potential to impart resilience to crop and livestock production systems were demonstrated in 151 vulnerable districts by KVKs under the Technology Demonstration Component (TDC) of NICRA. The efforts of NICRA led to making of 26 villages as residue burning-free villages in Punjab and Haryana. Awareness among the farmers' and other stakeholders about the provision of Protection of Plant Varieties and Farmers' Right Act, 2001, led to application for registration of 3,101 farmers varieties. Farmer FIRST Programme was implemented at National level successfully in 52 institutes involving ICAR institutes and SAUs under jurisdiction of 11 ATARIs in a participatory approach. A total of 15,152 demonstrations were conducted covering 32,751 farm families under crop based modules. KVKs (60) belonging to three Zones (Zone-I, Ludhiana; Zone-II, Jodhpur; and Zone-III, Kanpur) implemented Crop Residue Management project. Demonstrations on *in-situ* crop residue management were laid out on 7,975 ha at 14,217 farmers' field. Mobile messages (175,941) were sent by KVKs which benefitted 612.95 lakh farmers on various aspects of agriculture, horticulture and animal husbandry, weather forecast, and pest and disease control.

At Pulses Seed-hubs, set-up at 97 KVKs, 40,077.37 q seeds of pigeon pea, black gram, green gram, lentil, chickpea, field pea and lathayrus, were produced. There are 475 static soil and water test laboratories available in KVKs. During the reporting period, 83,3107 soil samples were analysed; and 879,574 Soil Health Cards were distributed among the farmers.

Research for hills and tribal regions: Finger millet variety (VL Mandua 379), released for Uttarakhand hills and plains, yielded 18% more than the ruling variety, and is resistant to neck and finger blast. The newly developed crossbred pig variety Lumsniang had faster growth rate, early sexual maturity and higher

litter size at birth. A local red amaranthus variety, viz. Goa Tambdi Bhaji-1, was released for Goa; it is tolerant to rust and responds well to manures. A salt tolerant plant growth promoting bacterium (Goa Bio-1) for the paddy cultivation was developed. The product is eco-friendly, economically viable and sustainable in long term; showed yield improvement of 17% over the farmers' cultivation practice. Bio-formulation (Goa Bio-2) for plant health management of vegetable crops and black pepper, was developed, and its application reduced the incidence of bacterial wilt in brinjal, soil-borne diseases of chilli, foot rot of black pepper and mortality in mango nurseries. Fifty genotypes of chilli were collected from Andaman and Nicobar Islands, and some of these exhibited unique characteristics like purple colour (AC-15), small conical shape (AC-10), dark purple (AC-6) and dark green round (AC-1). First time rice varieties, viz. CARI Dhan 1 and CARI Dhan 5, were notified for Andaman and Nicobar Islands. *Eupatorium* and *Vitex trifolia* could be potent medicinal plants for the preparation of herbal egg sanitizers in the poultry hatchery to address the issue of health hazards by synthetic disinfectants. Planting material of black pepper (5,000), cinnamon (2,000), clove (1,000), dragon fruit (1,000), marigold (5,000), arecanut (5,000), ornamentals (500), coconut (500), minor fruit plants (500) and tubers (500 kg), were distributed to farmers.

Tribal sub-plan: Tribal welfare programmes were supported in 17 agricultural universities with financial support of ₹ 23.54 crore. Training programmes, workshops and demonstrations etc. were executed for capacity building and creating awareness among nearly 21 lakh tribal farmers. They were made aware about benefits of scientific housing of animals, adoption and spread of improved breeds of animals and poultry birds and health care of pig and poultry, production of silk yarn etc. Further to enhance the productivity, improved seeds of paddy (Pusa Sugandha-5), urd bean (IPU-94-1/PU-31) and wheat (Raj 4037/4082) and gram (Pratap-1/RSG-888), respectively, along with recommended fertilizers were distributed to farmers with package of practices. Under horticulture development, seedlings of pomegranate, lemon, mango, and jackfruit were distributed. Kisan Kalyan Abhiyan activities were organized to create awareness in scientific goat practices and other livestock at Raygada district of Odisha, having 55.99% of tribal population.

Organization and management: E-Governance division was established for smooth implementation and functioning of e-governance. The ERP solution for the ICAR was implemented in the institutes of ICAR for financial management, Pay Roll, HRMS, Project Management and Supply Chain Management. The digital office solution of NIC was also implemented in DARE and ICAR Hqrs. CPGRAMS (Centralized Public Grievance Redress and Monitoring System) was implemented in ICAR and regularly monitored. From April 2018 to till date, 3,267 tenders have been floated on CPP Portal and 299 tenders published on ePublish module of CPP Portal from ICAR Institutes. Institute Information Management System-IIMS portal was opened for all institutes to upload data. Krishi Vigyan Kendra Knowledge Network Portal has some new modules, viz. Module for DBT Schemes; Module for Krishi Kalyan Abhiyan (KKA); KVK Mobile App. Individual orders were issued in November 2018 to officers/employees of the council possessing proficiency in Hindi to do their cent percent administrative work in Hindi. At ICAR Hqrs, 16 sections were specified under rule 8(4) for doing their cent percent administrative work in Hindi.

Intellectual property and technology management: During the period under report, 33 new patent applications were filed pertaining to agriculture sciences. Thus the cumulative figure has now risen to 1,078 applications. Further, the IPO had granted 47 patents taking ICAR's cumulative number of granted patents to 259. To protect the plant varieties, 30 varieties (23 extant and 7 new) were granted registration certificates raising the cumulative figure of registered varieties to 830.

This year, 621 partnership agreements were firmed up with 362 public and private organizations and 38 entrepreneurs by 38 ICAR institutes. Out of these 621 partnerships, 64 were IP protected technologies, i.e. for Design/ Patents/ Trademark/Copyright/Plant Variety Protection etc. Under the Agri-business incubation (ABI) initiative, 25 ABI centers were supported/ established in various institutes. These ABI Centers were visited by 2,556 Technology Seekers/ Inventors/ Business People etc. The Council organized a two days Agri-Startup and Entrepreneurship Conclave—*Unleashing potential in agriculture for young agripreneures* (UPAYA). About 700 participants attended the Conclave. It provided a unique platform for bringing together agri-professional, business experts, researchers and Farm Producers Organizations (FPO) in a face to face mode, and at the same time country's finest mentors, angel investors, and venture capitalists also interacted. Through "Festival of Innovation and Entrepreneurship (FINE)", ICAR provided an excellent platform to its 20 Start-ups/Entrepreneurs/Innovators for building the linkages with potential stakeholders. The Grand Finale of Smart India Hackathon (SIH) 2018 for problem statements shortlisted by ICAR was organized.

The DARE/ICAR has upgraded the existing Quality Management Systems IS/ISO 9001-2008 to QMS IS/ ISO 9001-2015, which focused on customer satisfaction. To equip with knowledge about new standard and auditing system, a training programme on Awareness and Internal Audit Training on IS/ISO 9001:2015, was organized.

Technical coordination: Meetings of ICAR Regional Committees No. I, II, IV and V were held. The Regional

Committee Meetings, held once in every two years, provided an ideal platform for reviewing the status of agricultural research, education and extension in the mandated states and union territories. The Council provided financial support to 69 societies for the publication of Scientific Journals. In addition, Societies/ associations/universities were supported for holding National Seminars/ Symposia/Conferences (58) and International Seminars/Symposia/Conferences (21). MoUs (24) were signed with the Central/State Universities and other Departments to collaborate in conducting research through All India Coordinated Research Projects (AICRPs) / Revolving Fund Scheme/ and any other such schemes funded/ sanctioned by the Council.

Finance: The Revised Estimate of DARE/ICAR for 2017–18 was ₹ 6,992 crore. An Internal resources of ₹ 251.82 crore (including interest on loans and advances, income from Revolving Fund Schemes and interest on Short Term Deposits) was generated during the year 2017–18. The total allocation Budget Estimate for 2018–19 is ₹ 7,800 crore.

ICAR Awards 2017: The ICAR Awards for year 2017 were given in 17 different categories to 168 awardees. These comprise 116 scientists, 24 farmers, 3 institutes, 1 university, 2 AICRPs and 14 KVKs. It is heartening to note that out of the 116 scientists and 24 farmers, 23 were women scientists and 3 were women farmers.

Partnership and linkages: India is a donor member country to CGIAR as well as a voting member in CGIAR System Council and has assumed important role in CGIAR System as a permanent voting member. Work Plans were signed between ICAR and different CGIAR system like International Potato Centre, WorldFish, International Wheat and Maize Improvement Centre (CIMMYT), International Water Management Institute, and Bioversity International. ICAR-CABI Work Plan 2018–20 was signed under the Memorandum of Understanding for scientific and technical cooperation. The ICAR signed MoU and Workplans with University of Copenhagen, Denmark; Rwanda Agriculture and Animal Resources Development Board; Agricultural Research Council (ARC), South Africa; and Western Sydney University, Australia; University of Technology, Papua New Guinea; Ministry of Agriculture and Food Industry, Socialist Republic of Vietnam; and Ministry of Agricultural Development of Republic of Panama. Total 14 collaborative projects were approved during the year. Participation of DARE/ ICAR was confirmed in the various SAARC programmes and several trainings were conducted successfully in which Institutional charges were waived off for the SAARC Programmes. DARE hosted the 4th ASEAN India Ministerial meeting on Agriculture and Forestry during this year, which was attended by representatives from 10 ASEAN Countries and ASEAN Secretariat. Indian Agricultural Research Institute (IARI) played an important role in developing trained human resource for agricultural research in Afghanistan and helped establishing Afghan National Agricultural Sciences and Technology University (ANASTU) at Kandahar in Afghanistan under the bilateral cooperation programme between Afghanistan and India. Revised Post Graduate Handbook of Yezin Agricultural University (YAU) was released in Myanmar.

The Central Agricultural University, Imphal, was awarded the prestigious University of The Year in the 5th FICCI Higher Education Excellence Awards 2018 by the Federation of Indian Chambers of Commerce and Industry.

Supporting basic and strategic research: Water use efficiency and transpiration (diurnal and nocturnal) rate of 150 rice germplasm lines were analyzed. Genotypes with contrasting diurnal and nocturnal transpiration under well watered and moisture deficit stress condition were identified. A low correlation between leaf area and mean transpiration in rice germplasm suggested that large portion of genotypic variation in transpiration is controlled by physiological mechanisms, which is involved in stomatal regulation besides the leaf area. Wheat germplasm lines (183) and RILs of HD2967 × C306 cross (184) were phenotyped, and genotypes with higher WUE and grain yields were identified. Event selection trials of transgenic pigeon pea and chickpea were conducted to identify the best event each in pigeon pea and chickpea, based on trait efficacy (resistance to gram pod borer), expression of Bt protein at various stages and related agronomic characters including yield. Expression of the Bt gene was detected in all the positive progenies of the transgenic lines. Insect bioassay was conducted both in field condition and *in vitro* conditions and mortality of larvae was correlated with protein expression. Phosphite dehydrogenase showed herbicidal activity at higher concentration of 1,600 mM and above, indicating the potential of potassium phosphite as fungicidal and bactericidal compound for use in rice farming. Fourteen key defense genes were identified in the selected gene pyramided lines in rice. The examination of possible antagonism and their impact on manifestation of resistance revealed that there was no adverse effect of pyramiding of genes on the expression of resistance against the target pests. A low cost sensor was developed to sense ripening stages and nutritional quality of apples. Further a 'SMART FRUIT NOSE App' was developed, which could be used with existing Android phones for visualization of sensor response. To degrade lignin and cellulose, seven thermophilic fungi, four bacteria and two actinomycetes were isolated from municipal solid waste. These consortia of microbes enhanced the decomposition process as well as compost reached its maturity and stability within 21–30 days.

Strengthening the research system: In the combined examination for ARS 2016 (Prelims) and NET 2017

(I), 179 candidates were recommended for appointment under ARS in order of merit. Out of 179 recommended candidates, 36% were women candidates. A total of 59,960 candidates registered for NET (I)-2018 examination and only 7,771 candidates (17.28%) qualified the examination. Among 7,771 qualified candidates, 49% were female candidates and 61% were from rural areas. During the year, 219 proposals received from different institutes in 56 disciplines, were considered under CAS for promotion from senior scientists to the grade of principal scientists.

Training and capacity building: All ICAR-institutes/HQs developed the ATP for their scientists, technical, administrative and skilled support staff. Training programmes (242) for scientific staff for enhancing their competency were organized and 1,165 scientific staff of ICAR participated in these trainings. ICAR-Institutes also organized 83 training programmes for technical staff, in which 815 technical staff was trained. Impact assessment of all these training programmes revealed that the trainings impacted to a great extent.

With firm faith in the strength of accomplishments of the Council, I present these achievements to the policy planners, researchers and all stakeholders, and hope that these will help them in future actions for the improvement of Indian agricultural sector.

(T Mohapatra)
Secretary
Department of Agricultural Research and Education
and
Director General
Indian Council of Agricultural Research,
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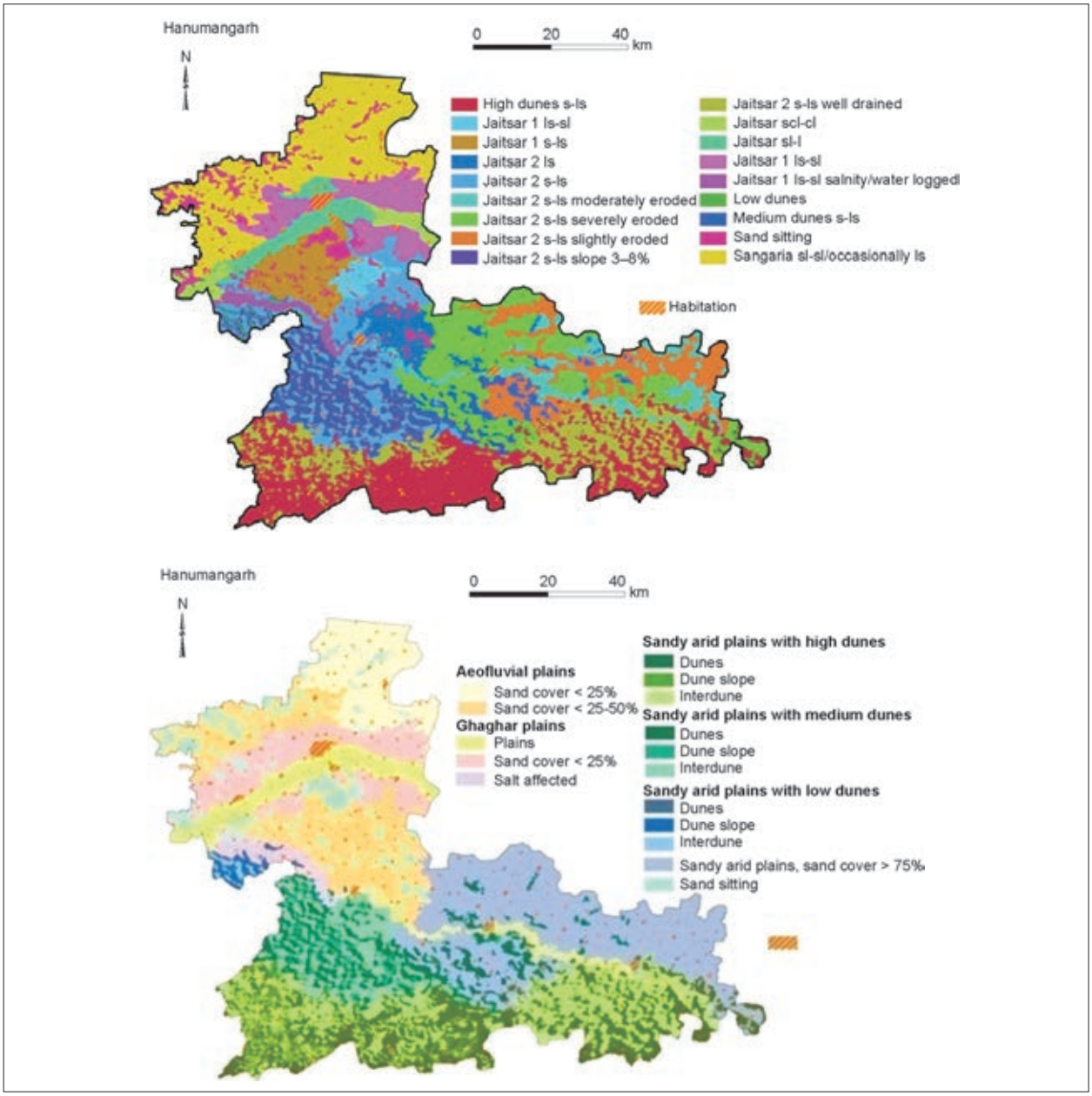
2. Soil and Water Productivity

Soil resource inventory and land use planning

Land resource inventory (LRI) on 1:10,000 scale: Soil maps at 1:10,000 scale were prepared for 62 different blocks covering 60 agro-ecological sub-regions (AESRs) of the country. Landscape Ecological Unit (LEU) consisting of landforms, land use and slope is taken as the base map for LRI instead of landforms alone. Contours at 10 m interval and drainage pattern are developed for delineation of slope and landforms using Cartosat digital elevation model. Other remote sensing data like IRS-LISS IV of 5.8 m resolution and those available in public domain are used for land use-land-cover (LULC) mapping. Landforms, slope and LULC maps are integrated for developing landscape ecological unit in GIS environment.

An automated method for delineation of landforms and landscape ecological units was developed using terrain attributes like, elevation, aspect, and contours and Sentinel data. The method is used for four districts namely Sriganganagar, Hanumangarh, Churu, and Bikaner of the desert ecosystem.

Global soil organic carbon stock map: The global soil carbon map consists of national SOC maps, developed as 1 km soil grids, covering a depth of



Soil (*top*) and landform (*bottom*) maps of Hanumangarh district, Rajasthan

0–30 cm by FAO in collaboration with ICAR-NBSS&LUP, Nagpur and ICAR-IISS, Bhopal. Around 2 lakh geo-referenced soil organic carbon stock data (SOC concentrations, bulk density and reference soil depth of 30 cm) were generated. Soils of north eastern states, Jammu and Kashmir, Uttarakhand and Himachal Pradesh are richer than the adjoining Indo-Gangetic plains. In the southern part of the country, west coast covering the states of Kerala, Karnataka and Maharashtra ran parallel to the north eastern states in SOC stock. Part of Tamil Nadu, Telangana and part of Karnataka adjoining to west coast are richer than the soils of remaining parts of these states. Central part of the country covering Maharashtra, Madhya Pradesh and Chhattisgarh are richer than their northern and southern counterparts. Parts of Rajasthan, Gujarat, Haryana and Punjab representing desert ecosystem of India are the lowest in SOC stock.

Soil erosion assessment and conservation planning: Total potential runoff volume for the period 2011 to 2015 was estimated using SCS CN method in Dhanora block, Seoni district, Madhya Pradesh. The average total potential runoff volume generated from the block is about 202.017 × 10^6 m^3 and average depth of runoff is 367 mm. On watershed basis, the average volume of runoff varies from 2009.83 × 10^3 m^3 (Sub watershed-VI) to 60560.3 × 10^3 m^3 (Sub watershed-II) and depth of runoff varies from 333 mm (Sub watershed-I) to 524 mm (Sub watershed-VIII).

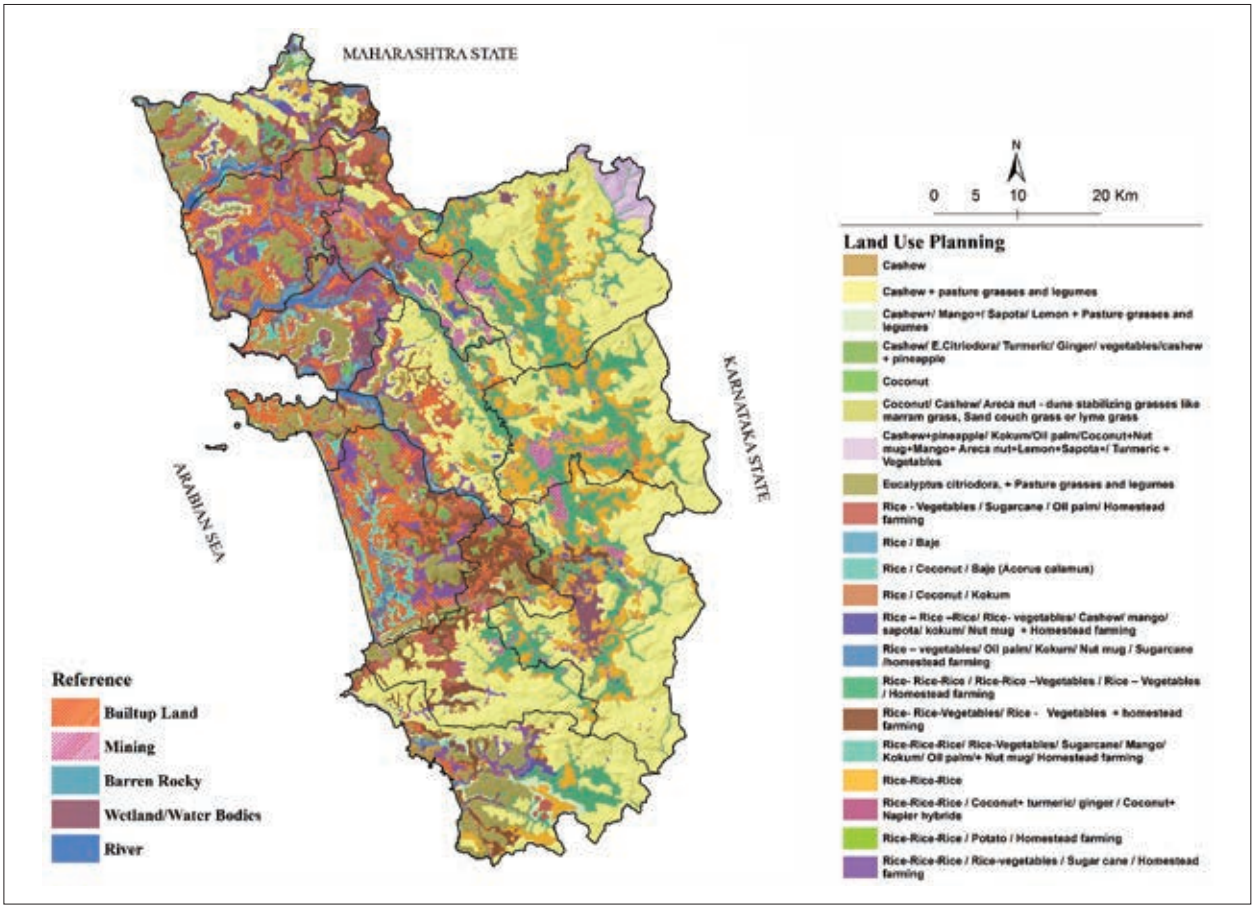
The drainage treatment for different watersheds of Sujala project, Karnataka has also been carried out in Harve 2 microwatershed of Chamarajnagar district.

Land Resource Information System of Goa (LRIS Goa) and Potential Crop Zone (PCZ): Based on the landforms, soil depth, slope, texture, drainage, nearness to sea, salinity and acidity, 27 land management units (LMU) were mapped for Goa. Suggested land use plan map of state indicated that cashew + pasture grasses and legumes occupy maximum area (32.6%) followed by rice–rice–rice/rice–rice–vegetables/rice–vegetables/homestead farming (10.9%) and rice–rice–rice (8.1%).

Android based cell phone applications on LRIS Goa and PCZ mapper were also developed for use by the stakeholders. LRIS Goa is capable of visualizing, disseminating, sharing and data mining of the land resources in a digital manner. PCZ mapper facilitates easy visualization, dissemination and sharing of database on crop suitability and potential crop zone of the country. The apps derive information from the Bhoomi Geoportal (http://nbsslup.in bhoomi; https://ncog.gov.in/SIS) and store information on land resources of the state for their easy access by users for agricultural development.

Soil and water productivity

Potential of NIR spectroscopy to evaluate soil quality in Vertisols of central India: Application of Visible (VIS)-near infrared (NIR) spectroscopy as a rapid, reliable diagnostic tool was assessed for

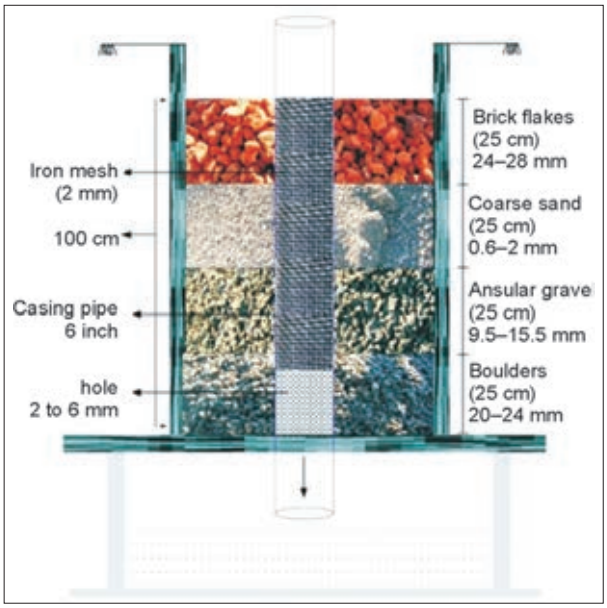


Land use plan for Goa

characterization of soil physical (sand, silt, clay, bulk density) and chemical properties (N, P, K, pH and EC) of black soils (Vertisols) of central India. The soil quality index (SQI) was computed using both spectrally derived indicator values and laboratory derived measurement following the methods of scoring, weighting factor and principal component analysis (PCA). The results indicated a significant and positive correlation between laboratory derived SQI and spectral derived SQI for the studied Vertisols of central India. Observed SQI ranges from 0.66 to 0.99 while Spectral SQI (SSQI) ranges from 0.68 to 0.98.

Improving water productivity and profit through drip irrigation: Drip irrigation (DI) was designed and used to enhance water productivity and profit in rice-based cropping sequence in an irrigated command of Odisha. Use of in-line DI system with 0.4 m emitter spacing, 2.1 litres/h emitter discharge and 1.0 m lateral-to-lateral distance in rice–capsicum–baby corn sequence enhanced productivity by 7.6 times higher than that of rice–rice system under surface irrigation (9.5 tonnes/ha/year). Further, the drip system in the cropping sequence generated higher profit (annual net return, ₹ 4.35 lakh/ha; benefit-cost ratio, 2.9) with 30% water saving resulting in 6 times higher water productivity (WP) compared with net return of ₹ 0.56 lakh/ha/yr with benefit-cost ratio of 1.6 and WP of 0.42 kg/m^3 under rice–rice cropping in the command area.

Development of groundwater recharge filters: Groundwater recharge filters were developed by Rahuri, and Ludhiana centres of AICRP on IWM. Filter developed by Rahuri centre consisted of a four-layer filter comprising Brick flakes (BF-I) of size 24.28 mm, Sand (SG-I) of size 0.6–2.0 mm, Angular Gravel (AG-I) of grade 9.5–15.5 mm and Pea Gravel (PG-I) of size 20–24 mm having thickness of each layer as 25 cm and total thickness of 100 cm. This filter was tested at three different locations in the command area of Musalwadi minor irrigation project canal. It showed



Filter to recharge groundwater through borewells (Rahuri)


Composite filter in operation (Ludhiana)

filtration efficiency of 84.49%, which can be considered as satisfactory performance with recharge capacity of 1,511,525 litres at research farm and farmers' field. Cost of the filter accordingly was ₹ 12,540 only. A composite filter developed by Ludhiana centre with material combination of 30 cm Brick flakes: 15 cm Gravel: 15 cm Coarse sand: 15 cm activated granular charcoal had highest silt removal efficiency of 72.7%, nitrate reduction by 25% and maximum filtration rate of 1.5 litres/s. An important fact about the filter is that in areas where soluble chemicals (e.g. nutrients like nitrate) are the critical pollutants in water, activated charcoal may prevent movement of these chemicals to underground soil layers and groundwater.

Drainage-cum-recharge well was designed and evaluated for rainwater, runoff water and greywater (wastewater) under north Bihar conditions by Pusa centre of AICRP on Irrigation Water Management. The filter combination, i.e. coloured gravel + sand + charcoal showed highest recharge rate of 2.6 litres/s and 79.3% reduction in turbidity.


Filter assembly of drainage-cum-recharge structure (Pusa)

Nutrient management

Mapping current status of Zn and B deficiency: Status of Zn and B deficiency in Indian soils were assessed and mapped based on nearly 2.04 lakh geo-referenced soil samples across the country covering 58 agro-ecological sub regions (AESRs). Zn deficiency status in soils of AESRs 1.2, 6.4, 14.1, 14.2 and 16.2 was recorded as less than 10% while soils of AESRs 7.3, 12.3, 14.2, 14.4, 15.1, 15.3, 16.3, 17.1, 18.3 and 19.1 were having 10–20% deficiency. The soils of these regions are mostly acidic in nature containing high organic carbon content. The highest (> 50% soils) Zn deficiency was reported in soils of middle (AESRs 4.4, 10.1, 10.2 and 10.4), western (AESRs 2.1 and 2.2) and southern (AESRs 8.1, 8.2, 8.3 and 18.1) parts of India. In general, the other AESRs falling in western India (AESRs 2.3, 5.1, 5.2, 6.1, 6.2 and 6.3) were having acute Zn deficiency as compared to north east, east and extreme northern parts of India. The soils of AESRs 4.1, 4.2, 7.1, 9.1, 11, 12.1, 12.2, 14.5, 18.4 and 19.2, were having 20–30% Zn deficiency.

Metagenomic studies of mangrove sediments

Mangrove areas are considered as repository of valuable microbes. Metagenomic DNA was isolated from soil samples of mangrove and non-mangrove ecosystem. In mangrove soil, *Pseudomonas, Alcanivorax, Desulfovibrio, Escherichia, Geobacter, Nitrosomonas, Paracoccus* and *Shewanella* showed greater abundance. In non-mangrove soil, *Dechloromonas, Deinococcus, Methylibium, Nitrobacter, Rhodoferax* were abundant. A significant correlation for relative abundance of probiotics bacteria between mangrove and non-mangrove samples was observed.

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

Synthesis of new potassic organo mineral fertilizer: Presently, requirement of potassic fertilizers are fully met out through import with a foreign exchange burden of about ₹ 20,000 cr/annum. India has huge deposits (87.12 million tonnes) of low grade potash bearing feldspar mineral in Rajasthan. Accordingly, a new method was developed to convert this mineral into organo-mineral fertilizer (OMF) by mixing it with chemically treated leonardite which is an oxidized form of lignite and found abundantly in the country (estimated reserves 2.05 billion tonnes). The response of pearl millet, wheat and mungbean to the potassium through this organo-mineral fertilizer (OMF) has been evaluated and found comparable to that of conventional potassium fertilizer—muriate of potash.

Halophilic plant growth promoters: Application of liquid bio-formulations 'Halo-Azo' and 'Halo-PSB' on growth and yield of wheat and rice under sodic soils (pH 9.4) were tested. In wheat, seed inoculation with halophilic nitrogen fixers (Halo-Azo, and Halo-Azsp) and P solubilizers (Halo-PSB) resulted in ~21% increase in plant height and ~17–25% increase in root length over control. Wheat grain yield increased by 14.2, 10.9 and 17.9% in Halo-Azo, Halo-PSB and Halo-Azsp treatments, respectively, over control. However, consortia of halophilic strains resulted in an increase of 21.8% in grain yield over control. In case of rice, grain and straw yields increased by 18.6 and 24.9% respectively in consortia treated pots over control.

Integrated nutrient management in sapota under agro-forestry system: Eight-year-old plants of sapota cv. Kalipatti were subjected to 17 treatment combinations consisting of inorganic fertilizers (1000:500:500 g NPK/plant), organic manures (vermicompost 10 kg and farmyard manure 50 kg/plant) and bio-fertilizers (*Azotobacter, Azospirillum* and PSB @ 250 g/plant). Integrated Nutrient Management package comprising 750:375:375 NPK + 50 kg FYM + 250 g *Azospirillum* + 250 g *Azotobacter*/ plant performed markedly better with an yield of 29.03 kg/plant and 4.54 tonnes/ha. The treatment recorded maximum net return of ₹ 58,575/ha with a B:C ratio of 1.82.

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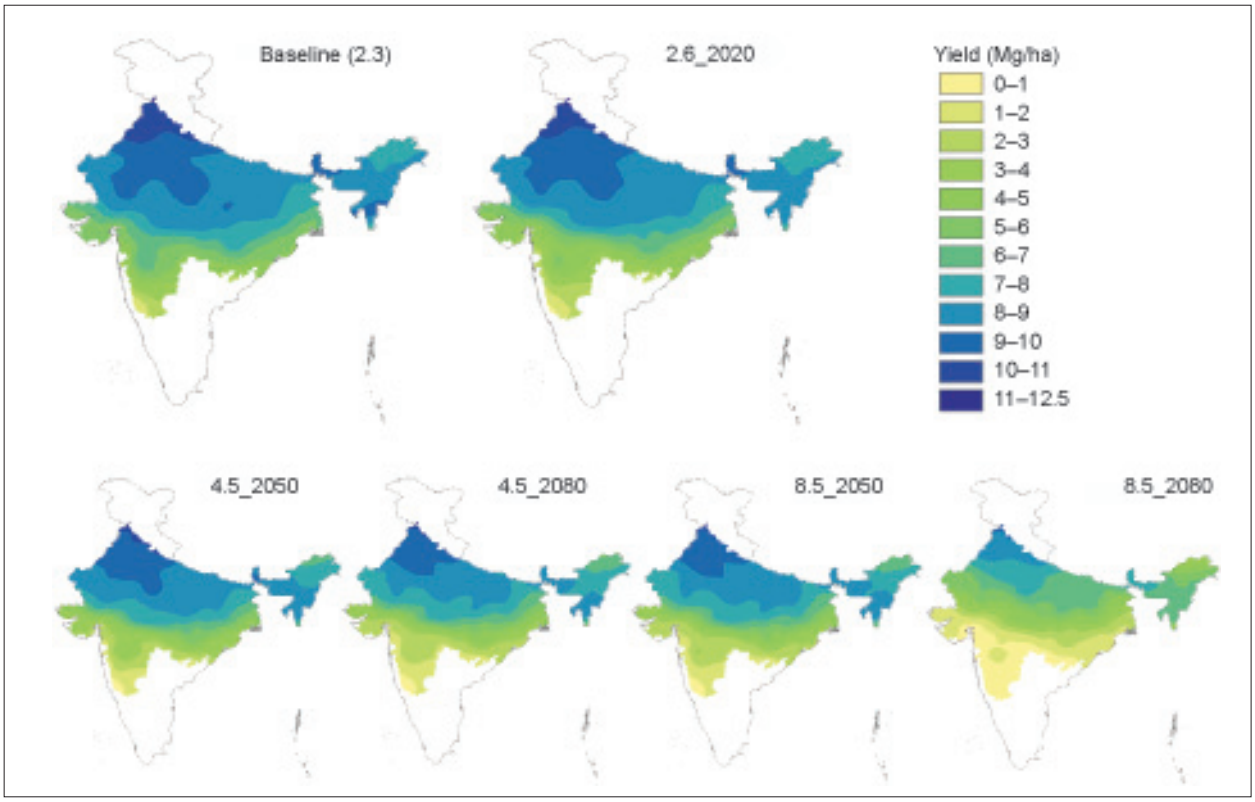
3. Climate Change and Resilient Agriculture

Impact of climate change on wheat and adaptation strategies: The yield potential of wheat was simulated under future climate scenarios of RCP 2.6, 4.5, 6 and 8.5 for 2020, 2050 and 2080 periods and compared with that of base line (1976–2005) using InfoCrop-wheat model. The results indicated that the climatic potential yield of wheat is projected to reduce in future climates with significant reduction in central India and in eastern parts. A gradual reduction in potential yield is likely in RCP 4.5 and above with maximum reduction in RCP 8.5. This calls for the need for developing heat tolerant varieties of wheat, specifically for central India as top priority. Further, the climate change impact on wheat yield under different management conditions is projected to have spatio-temporal variations for direction and magnitude of impact as well as with enhanced inter-annual variation. Adaptation strategies and adaptation gains were quantified for wheat crop using crop simulation (InfoCrop-wheat) analysis. The analysis indicated that adaptation gains have significant spatial and temporal variation.

Effect of CO_2 and temperature elevation on plant nutrition and water use in wheat: A field experiment in wheat crop (var. HI 1544) was conducted in the Open Top Chamber facility at the research farm of the Institute during *rabi* 2016–17 to study the effect of climate change parameters on plant growth, nutrient uptake and water use. The studied climate parameters at the required level were maintained through an automated control facility connected to data loggers. Results indicated that with recommended crop fertilization, elevation in atmospheric CO_2 concentration by about 150 ppm increased the grain yield by 12%, whereas increased temperature showed a decline in the yield by about 6%. The positive effect from CO_2 elevation showed a tendency of getting neutralized with rise in growing temperature by about 2.5°C.

Climate change impact on livestock: Life cycle of green house gas (GHG) emission from the dairy farms of Karnataka was assessed. Data were collected from the 69 farms located in eight different districts of Karnataka (41 small dairy farms, 18 medium dairy farms and 10 large dairy farms). The total GHG emission expressed as CO_2 eq/kg of fat protein corrected milk (FPCM) was low for the small dairy farms (0.58) as compared to medium (2.03) and large (1.66) dairy farms.

An inventory on annual enteric methane emission from Indian livestock was developed at the Institute. The estimate revealed that the Indian livestock is emitting 9.253 Tg enteric methane annually. Based



Impact of climate change on wheat and adaptation strategies

on the enteric methane emission from livestock, hotspots of the emissions were also identified for the immediate interventions. Uttar Pradesh is the largest enteric methane emitting state in the country.

Portable lamb incubators for cold stress: A low cost shelter was designed and fabricated using the globally available material for migrated sheep and goat in high altitude areas like Leh and Ladakh. This shelter maintains nearly 15°C in the incubator as compared to 5°–6°C in the ambient. Additionally felt jackets also provide comfort against falling winter temperatures at night as evidenced from lower levels of stress hormones like cortisol.

Portable lamb incubators for cold stress

Farming/cropping system

Integrated farming system model for irrigated areas of western Uttar Pradesh: A 0.70 ha integrated farming system model with 7 modules such as cropping systems (0.38 ha), horti-pasture (0.18 ha), agri-horti (0.12 ha), dairy (0.005 ha), vermicompost (0.005 ha), boundary plantation (0.01 ha) and secondary agriculture (value-addition) modules were developed and evaluated for marginal farm households of irrigated areas in western Uttar Pradesh wherein only crop (sugarcane–ratoon–wheat) + dairy (2 to 3 buffaloes/cows) system is practised by around 84% of total farm families depending mainly from the annual payment from sugar mills. Many a times, payment from sugar mills are delayed due to various reasons. Under the cropping system module, three systems namely cropping system for family nutrition [basmati rice–wheat + mustard/chickpea–green manure], soil health [*Sesbania* (seed)–chickpea–greengram] and income generation [okra–cauliflower–babycorn + cowpea] were found to meet the 7-member household demand of food, feed, and generation of income for the family and maintain soil health. The horti-pasture module with 5 fodder crops, viz. sorghum, pearlmillet, maize, cowpea and maize + cowpea in 5 strips (300 m^2 each) of kinnow plantation were evaluated and found that cultivation of maize + cowpea for fodder during *kharif* in 0.18 ha of kinnow plantation can supply green fodder to 1 cow and 1 buffalo for 195 days. Intercropping of fodder maize, sorghum, pearlmillet and cowpea in horti-pasture can supply fodder to two animals for 180 days, 135 days, 120 days and 75 days only, respectively in a year. Kinnow recorded 849 kg of fruits from 0.18 ha (27,416 kg/ha). The dairy unit with one buffalo (murrah) and one desi cow recorded net return of ₹ 34,780/year. Average daily dung production from dairy unit was 54 kg which works out to 19.7 tonnes/year. Recycling of dung and other wastes through vermicomposting resulted in meeting the 84% nutrient demand of the farming system. Planting of guava and close spaced karonda resulted in additional income besides partial protection from wild animals.

Secondary agriculture (value-addition) module of preparation of kinnow mandarin squash was integrated in the model by identifying the protocol. Economic analysis of value-addition to kinnow indicates that additional income of ₹ 0.28 lakh can be obtained from 0.18 ha by making kinnow mandarin squash. The

A Success Story

Drought proofing in South Karnataka

Nagenahalli village, Tumkur district falls under central dry agro-climatic zone of Karnataka with an average rainfall of 690 mm. The village is characterized by acute shortage of water, soil erosion and preponderance of wastelands. During 2017, about 539 mm rainfall was received and deficit rainfall of 23 and 55% was recorded in June and July, accompanied by long dry spells of 22 and 13 days in June and July respectively, significantly impacting sowing of *kharif* crops, plant establishment resulting in poor crop growth.

Intensive rainwater harvesting was taken up under NICRA involving construction of 81 new farm ponds, repair of 59 existing farm ponds, 34 check dams to harvest as much water as possible and provide access to water for every farmer in the village. Similarly, trench-cum-bunding was done on 80 ha involving 100 farmers' fields in uplands of the village resulted in minimising crop losses in uplands due to drought. To cope with early season drought, short duration drought tolerant finger millet (ML 365 and GPU 28) and drought tolerant pigeonpea (BRG 2 and BRG 4) was demonstrated in the village. These finger millet varieties were planted in about 159 ha involving 179 farmers' and drought tolerant pigeonpea (BRG 2 and BRG 4) are being adopted in 82 ha benefitting 148 farmers. Enhanced water availability resulted in increase in green fodder availability resulting in higher incomes from the livestock.

Drought proofing in South Karnataka

The water harvesting potential of 1,96,560 m^3 capacity was developed for life saving irrigation during dry spells. Thirty two open wells and 29 bore wells were recharged and area under irrigation was increased by 75 ha of the village out of the total cultivated area of 190 ha and contributed to increase in income. The yield of ragi (ML 365) was 38.5 q/ha compared to that of local ragi 29.5 q/ha. Yields were superior and farmers gained additional income of ₹ 13,500 from finger millet alone. Similarly, performance of pigeonpea BRG 2 (12.6 q/ha) was superior to the local variety of pigeonpea (10.2 q/ha) with an additional income of ₹ 10,440 under deficit rainfall.

Weed manager: A quick way to reach the farmer

A Mobile App on Weed Management named as "Weed Manager" was developed and placed in Google Play Store for wider accessibility. This App provides information on advanced weed management techniques/ technologies for the management of economically important weeds of major crops.

increase in net income due to value-addition was 2.17 times when 50% of produce is made as kinnow mandarin squash and 50% sold as fresh fruits. If 100% of produce is subjected to value-addition in the form of kinnow mandarin squash in the farming system, the net income increases by 3.32 times over net income obtained by selling fresh kinnow. The model having the components of cropping systems, agri-horticulture, dairy, mushroom, vermicompost, value-addition and boundary plantation was found to provide sustainable production (23 tonnes of rice equivalent yield) and income of ₹ 2.28 lakh with 595 man days of employment generation from 0.70 ha.

Integrated farming for rice-fallow system: A self-reliant farming system was developed in 1.5 ha area (representing a small-holder farm) based on multiple use of water for pisciculture, on-dyke horticulture, and field crops in *kharif* and *rabi*. Growing of paddy crop in wet season with *in-situ* sesbania green manuring (60 kg N/ha from 14.8 tonnes fresh biomass) and vermicompost (20 kg N from 3 tonnes vermicompost) resulted in 4.3 tonnes/ha rice grain yield and net return of ₹ 26,063/ha in *kharif* 2017. After harvesting rice, maize, food legume (blackgram), oilseeds (groundnut), vegetables (cabbage and cowpea) were grown. About 8 tonnes vermi-compost was produced using *Glyricidia* twigs, cow-dung, paddy straw and stubbles, maize stover and other bio-wastes. Irrigation water requirement was met from the harvested rain water (9,932 m^3) in the farm pond (3,894 m^2). The mean net return from these dry season field crops was ₹ 23,169/ha. Aquaculture in farm pond produced fish yield at 551 kg/ha with net return of ₹ 28,488/ha. Net income from lotus grown in farm pond was ₹ 5,000. On the dyke (4.5 m wide at top) of farm pond, two rows of banana were planted with plant to plant spacing of 2.5 m within a row. Between two rows of banana, one row of papaya was planted in diagonal pattern. A drip irrigation system costing ₹ 60,000 was installed for irrigating the dyke crops. Gross income per annum of the system was ₹ 72,780 with net return of ₹ 49,272 and the net income was ₹ 131,903 from 1.5 ha (₹ 87,935/ha). This is 6.3 times higher as compared to rice-fallow system and 6 times as compared to rice-*utera* blackgram system. Net water productivity of the farming system is ₹ 13.3/m.

Bio-intensive complimentary organic production systems: Bio-intensive complimentary organic production system practices comprising groundnut (cv. GPBD 4) + cotton (Sahana/DCH 32) in 2:1 inter-cropping with crop residue recycling through broad bed and furrow and conventional flat-bed method of planting resulted in higher net monetary returns and higher B:C ratio (₹ 58,757 to 64,183/ha and 2.67 to 2.87, respectively) compared to without crop residues (₹ 49,035 to 54,720/ha and 2.41 to 2.62, respectively) in Karnataka (Dharwad). Similarly, in Uttarakhand (Pantnagar), higher basmati rice grain equivalent yield was recorded under direct seeded rice + soybean–vegetable pea + mustard on furrow irrigated raised bed (FIRB) system (10,018 kg/ha) followed by direct seeded rice–chickpea–greengram (9,845 kg/ha) in FIRB. In Meghalaya (Umiam), rice variety Shahsarang-1 recorded the highest yield (4.47 tonnes/ha) in sunken beds under rice–lentil system.

Introduction of guinea grass or hedge lucerne as intercrops in sorghum + pigeonpea cropping systems in rainfed regions of Telangana resulted in higher system productivity and resource-use efficiency besides meeting the fodder needs of rainfed farmers.

It was observed that after 3rd year of planting, yield of guinea grass was 51.6 tonnes/ha of green fodder from 5 cuts, whereas hedge lucerne yielded 31.2 tonnes/ha green fodder from 5 cuts.

The highest gross returns of ₹ 1,18,054/ha were obtained with sorghum + pigeonpea/guinea grass, followed by sorghum + pigeonpea/hedge lucerne (₹ 1,12,766/ha). In both these systems, the perennial fodder component contributed significantly to the gross returns.

A Success Story

Improving resilience in flood prone area through submergence tolerant varieties

Dhubri district in Asom experiences a warm humid climate. Monsoon usually starts from June and continues up to early September. The district also experiences substantial amount of pre-monsoon rain starting from April. The average annual rainfall is about 2,233 mm. Flood is the major constraint affecting productivity of rice in the village Udmari. During 2017, the village experienced flood conditions during July and August.

Rice is the most important crop of Udmari village under Bilasipara sub-division of Dhubri district, Asom. Floods affect *kharif* rice during July–August and sometimes do not allow farmers to transplant rice seedlings in time resulting in very low yields. Flood tolerant varieties were demonstrated in the farmers' fields to popularize these situation specific rice varieties. The main characteristics of these varieties are: (*i*) Submergence tolerant varieties Jalashree and Jalkuwari can tolerate 12 to 15 days water submergence once seedlings are established; (*ii*) staggered planting variety Gitesh can be transplanted with 30 to 60 days-old seedlings; (*iii*) short duration varieties Luit and Kolong (105 days) can be transplanted up to last part of August and are also suitable for direct seeding with sprouted seeds if there is no time for nursery raising. These varieties are suitable for post-flood as well as pre-flood situations.

Adoption of these varieties resulted in about 50 to 60% higher grain yield than the existing varieties.

Agroforestry systems for sustainable crop yields and economics in rainfed areas: At AICRPDA Centre Bengaluru, amla + fingermillet agri-horti system gave significantly higher amla-equivalent yield (1,427 kg/ha), net returns (₹ 29,446/ha) and B:C ratio (2.07) compared to sole amla (879 kg/ha) and sole fingermillet (1,118 kg/ha). Similarly, among custard apple based agri-horti systems, custard apple + fodder maize system gave significantly higher custard apple equivalent yield (2,346 kg/ha), net returns (₹ 1,19,672/ha) and B:C ratio (6.67), followed by custard apple + fingermillet system (1,628 kg/ha) as compared to sole custard apple (724 kg/ha). At AICRPDA Centre Vijayapura, in tamarind based horti-pastoral system, crop geometry of 10 m × 6 m gave significantly higher tamarind fruit yield (610 kg/ha) and net returns (₹ 59,494/ha) than other treatments. Guinea grass produced significantly higher tamarind-equivalent yield (565 kg/ha) and net returns (₹ 55,410/ha) than signal grass.

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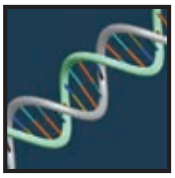


4. Genetic Resources

Crops

Germplasm augmentation, conservation and use: A total of 19 explorations were undertaken and 1,502 accessions were assembled comprising 1,063 cultivated and 439 wild accessions. Explorations were undertaken in 17 states/UTs (Andaman and Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Asom, Goa, Gujarat, Jammu and Kashmir, Karnataka, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Odisha, Rajasthan, Sikkim, Tripura and Uttarakhand). Emphasis was made on collecting germplasm from various diversity-rich, remote/tribal inhabited and disturbed areas, for instance from Great and Little Nicobar (A and N), Dibang Valley (Arunachal Pradesh), Kiphire (Nagaland), Saiha and Lunglei (Mizoram) and Cachar Hills (Asom). A natural population of wild okra, occurring in the Mahendragiri mountain range of Eastern Ghats was described as a new taxon *Abelmoschus angulosus* var. *mahendragiriensis*, owing to larger leaves, small sized petals, narrowly conical to oblong beaked capsules and reniform seeds with brown trichomes (in contrast to *A. angulosus* var. *purpureus*). During the period, 660 herbarium specimens were added to the National Herbarium of Cultivated Plants.

Germplasm conservation: A total of 5,775 accessions of orthodox seed species and 12,615 accessions of regenerated material were added to the National Genebank for long-term storage. Twenty three accessions of fruits, tubers, bulbs, clonally propagated, non-orthodox seeded and threatened/elite germplasm were added to the *in-vitro* Genebank, making the total collection of 1,855 accessions in the form of ~40,000 *in-vitro* cultures of 50 genera. In the Cryogenebank, 447 accessions including seeds (171), pollen (9) and genomic resources (267) of different crop species were successfully cryopreserved, making the total collection of 13,323 accessions.

Germplasm exchange: A total of 34,858 accessions were imported from 42 countries. Additionally, 16,959 entries (1,03,666 samples) of CGIAR trials/nurseries were imported. A total of 1,027 samples were exported including 100 samples each to Bolivia and Bangladesh; 827 samples of rice to Philippines and 27 samples of mungbean to AVRDC, Taiwan, under collaborative research projects. Promising introductions were: **Wheat:** Cultivar Wirtas with significant resistance to the most dangerous fungal pathogens combined with high protein content from Poland (EC 930686); Core set of wheat from Australia (EC 933715-933915); Heritage varieties with excellent grain quality from Canada, viz. Ladoga, Bishop, Marquis and Red fife (EC 946384-946387); Di-telocentric genetic stocks from Mexico (EC 949682-949712); Zip4-Ph mutant lines (EC 955298-955309) from UK. **Paddy:** Improved lines with submergence and bacterial blight tolerance (EC 956439-956453) from Nepal; Wild species (EC 955801-828) from Philippines. **Frenchbean:** Core collection from CIAT Columbia (EC 931101-EC 932597). **Safflower:** Salinity tolerant, resistant to *Phytophthora* rot and high yielding lines from USA (EC 938657-938712). **Wild species** of finger millet, banana and pigeon pea. **Rubber:** Promising clones (EC 929513-929533) from Ivory Coast. **Seabuckthorn:** Superior quality berries with good taste (EC 935319-935320) from Russia. **Siratia:** New introduction known for its fruit extract about 300 times sweeter than sugar, used as a natural sweetener in China for nearly a millennium due to its flavor and lesser food energy (230 kcal/g) compared to granulated sugar (387 kcal/g). It is also a traditional Chinese medicine (EC 938819). At IARI, New Delhi wheat genotype, HS 661 (HS 295*2/FLW 20//HS 295*2/FLW 13) developed through Bulk-Pedigree method of breeding was found to carry seedling resistance to brown, black and yellow rusts. Similarly, HS 628 (HS 240*2/FLW 20//HS 240*2/FLW 13) also found to carry rust resistance to yellow, stem and brown rusts except pathotype 77-8. HS 628 was tested positive for PSY1-E1 and Gb molecular markers, detecting the presence of *Sr25*/*Lr19*. The rust resistance present in HS 661 and HS 628 would prove novel sources for generating variability against new virulent pathotypes of rust diseases in wheat improvement program.

Variability in foxtail millet collected from Nagaland

Musa puspanjaliae from Dibang Valley, Arunachal Pradesh (fruiting bunch)

Abelmoschus angulosus var. *mahendragiriensis*

Germplasm characterization/evaluation: A total of 16,880 germplasm accessions were characterized for agro-morphological traits at New Delhi. Screening against biotic and abiotic stresses in different crops was done in 2,881 and 5,442 accessions, respectively. Biochemical evaluation of 2,936 accessions was undertaken in different crops for oil content, fatty acid profile, protein, sugar, minerals, amino acids, antioxidants and active principles. To strengthen the field genebank, a total of 34 perennial plant species have been established at Issapur farm. A total of 5,700 accessions were supplied for research use and crop improvement within the country. In addition, a total of 8,875 germplasm accessions of different crops maintained at various Institutes was also evaluated/ characterized and used in the breeding programmes. Lentil accessions, viz. EC 225495, EC 267710, EC 267635 and IC 567315 were early maturing and IC 240990 and IC 240976 were identified as with high biomass and number of pods in Jharkhand.

Plant quarantine: A total of 1,23,126 imported samples, including transgenic and trial materials were processed for quarantine clearance. Of 12,509 samples infested/infected with different pests, 1,087 samples were salvaged through physico-chemical methods and 1,876 samples were rejected due to fungal pathogens of quarantine importance. Important interceptions included—fungi, *Peronospora manshurica* in soybean from USA, *Colletotrichum capsici*, *Pestalotia macrotricha*, *Diplocladiella scaroides* and *Lasiodiplodia* sp. on bitter gourd from Thailand, *Bipolaris maydi* and *Lasiodiplodia* sp in maize from Thailand and *Pestalotia* sp. on maize from Zimbabwe, *Tilletia barclayana* in paddy from China and Brazil; insects, *Bruchus ervi* in lentil from Lebanon, *Plodia interpunctella* in maize from Thailand; viruses, *Broad bean stain virus* in pulses imported from USA, Colombia and Lebanon; *Broad bean true mosaic virus* in *P. vulgaris* from Colombia; *Cherry leaf roll virus* in *G. max* from AVRDC (Taiwan); nematodes, *Aphelenchoides besseyi* on *Oryza sativa* from China, Japan, the Philippines, USA and Vietnam and *Pratylenchus penetrans*, *Meloidogyne* spp. *Tylenchorhynchus claytoni* on *Hippophae rhamnoides* from Russia; and weeds; *Bromus secalinus*, *Echinochloa crus-pavonis* and *Polygonum cuspidatum*. A total of 2,028 samples were processed for export and eight Phytosanitary Certificates were issued.

Exotic weed species, *Bromus secalinus* (a), *Polygonum cuspidatum* (b), *Echinochloa crus-pavonis* (c) intercepted in imported germplasm

Plant germplasm registration: During the period under report, two meetings of Plant Germplasm Registration Committee (PGRC) were held and 110 genetic stocks comprising cereals and pseudocereals (45), millets (2), forages (3), grain legumes (4), vegetables (2), oilseeds (16), commercial crops (6), medicinal and aromatic plants and spices (20), fruit and nut (1), ornamental (6) and tubers (5) were registered.

Details of plant germplasm registered by PGRC during 2017–2018

Crop	National Id	INGR No	Novel unique features
Rice	IC0622805	17028	TGMS Line
Rice	IC0619320	17029	Tolerant to salinity stresses up to ECe 10.0 dS/m.
Rice	IC0619226	17066	Novel dual donor for resistance to both brown plant hoppers (BPH) and white backed plant hoppers (WBPH) in rice. Possesses resistance at vegetative and reproductive stages.
Rice	IC0619227	17067	Rich in zinc micronutrient. Tolerant to coastal salinity.
Rice	IC0639318	17068	Tolerant to alkalinity stresses up to pH 9.9.
Rice	IC0256801	17069	Resistant to BPH.
Rice	IC0626002	18001	Broad-spectrum resistance for leaf blast (Pi-54) and bacterial blight (Xa21 and xa13). Present in the elite genetic background of Improved Samba Mahsuri and 94.9% recurrent parent genome recovery. Moderate resistance for neck blast, sheath blight, sheath rot and brown spot besides blast resistance.
Rice	IC0626001	18002	Novel donor for resistance to BPH *Nilaparvata lugens* in rice. Possesses high resistance in vegetative and reproductive stages. Present in the elite background of popular commercial variety Swarna (MTU 7029).
Rice	IC0626284	18003	NH 686 tolerant to low P condition. Dark green leaves and grain yield of NH 686 was 6 fold more than N 22 under low P condition. Early duration, broad leaves and medium bold grains.
Wheat	IC0623528	17030	High tolerance to head scab.
Wheat	IC0623529	17031	Durum wheat genotype highly tolerant to head scab.
Wheat	IC0623451	17032	Resistant to stem leaf and stripe rusts, Karnal bunt and flag smut.
Wheat	IC0624127	17033	Low hardness index (soft endosperm).
Wheat	IC0624491	17034	Carrying *Lr13* as locally adapted differential for Indian pathotypes of wheat leaf rust.

Details of plant germplasm registered by PGRC during 2017–2018 (*Continued*)

Crop	National Id	INGR No	Novel unique features
Wheat	IC0624492	17035	Carrying *Lr18* as locally adapted differential for Indian pathotypes of wheat leaf rust.
Wheat	IC0624493	17036	Carrying *Lr19* as locally adapted differential for Indian pathotypes of wheat leaf rust.
Wheat	IC0624494	17037	Carrying *Lr26* as locally adapted differential for Indian pathotypes of wheat leaf rust.
Wheat	IC0624495	17038	Resistant to stem, leaf and stripe rusts, Karnal bunt and flag smut. High yield potential.
Wheat	IC0624496	17039	Early maturing and bold seeded germplasm for warmer areas of India.
Wheat	IC0624500	17040	Resistant to black and brown and rusts. Resistant to Ug99 pathotypes. Carries *Sr24/Lr24* and unutilized *Sr43*. Good agronomic background.
Wheat	IC0624501	17041	Resistant to black rust including ug99 pathotypes. It carries unexploited *Sr26* in the background of Raj 3765.
Wheat	IC0624649	17042	Resistant to black and brown rusts of wheat. Resistant to ug99 pathotypes. It carries *Sr32*, *Sr24/Lr24*. Derived from C77.19 (Sr32) accession and Indian variety HI 1500. Good agronomic background.
Wheat	IC0621835	17070	Resistance to brown rust carrying *Yr39*+ in the background of PBW 343.
Wheat	IC0625990	18004	Chlorophyll deficiency mutant.
Wheat	IC0624499	18005	High protein content with bold seeds, high manganese content.
Wheat	IC0624497	18006	Multiple disease and pest resistance (Stripe, leaf and leaf blight, Karnal bunt, flag smut, powdery mildew and shoot fly).
Wheat	IC0625998	18007	Highly resistant to yellow rust.
Wheat	IC0624570	18008	Spot Blotch resistance, Early Maturity.
Wheat	IC0625994	18009	Heat tolerance.
Wheat	IC0625997	18010	High sedimentation value. Grain hardness.
Wheat	EC531185	18011	Low DSI (drought susceptibility Index) <0.5 for 5–6 traits including yield/m^2. High and stable grain/spike under irrigated and non-irrigated conditions. Also showing the presence of genes associated with various drought responsive traits, viz. thylakoid membrane stability (Fv/Fm), grain filling duration (GYD), grain yield (GY) and gene maintaining low leaf temperature under drought stress condition.
Wheat	EC339604	18012	Resistant to prevailing leaf rust pathotypes. Presence of leaf rust resistance genes, viz. Lr22a, Lr46+, Lr67+ and additionally carries stripe rust resistance genes Yr5, Yr15 and Yr48.
Wheat	IC0252459	18013	Resistant to stripe rust pathotypes K (47S102), P (46S103), L (70S69), 13 (67S8), I (38S102), 46S119 and 78S84. Carries stripe rust resistance genes, viz. Yr5, Yr15 and Yr48 besides also carries leaf rust resistance genes Lr46+, Lr50 and Lr24/Sr24. Can be used as source for developing yellow rust resistant as well as multiple rust resistance wheat cultivars.
Wheat	IC0564121	18014	Highly resistant to spot blotch.
Wheat	IC0443669	18015	Highly resistant to spot blotch.
Wheat	C0626288	18016	Soft grain genotype (very low grain hardness index). Suitable for better biscuit making.
Wheat	IC0626289	18017	High grain protein content.
Wheat	IC0626290	18018	Loose smut resistance.
Barley	IC0624123	17043	Extra early heading hooded barley.
Barley	IC0624124	17044	Extra dwarf.
Barley	IC0624125	17045	Long spikes with more number of grains. Resistant to stripe rust.
Barley	IC0624126	17046	Resistant to spot blotch
Barley	IC0624535	18019	Highly resistant for stripe rust at seedling and adult plant stages.
Barley	IC0624536	18020	Resistant to spot blotch.
Barley	IC0626008	18021	Extra early heading. Short plant height.
Chickpea	IC0623452	17047	Fusarium wilt resistance.
Indian mustard	IC0622804	17048	Moricandia system based CMS line. Resistant to white rust disease.
Indian mustard	IC0624502	17051	High tolerance to salinity (ECe 12 dS/m) and alkalinity (pH 9.4).
Indian mustard	IC0598622	17077	White rust resistant.
Indian mustard	IC0598623	17078	White rust resistant.
Indian mustard	IC0626000	18031	Heat tolerant. Resistant to *Alternaria brassiceae.*
Indian mustard	IC0265495	18032	White rust resistant (PDI = 0) at three locations for two years and against DELHI isolate under artificial inoculation.
Indian mustard	IC0313380	18033	White rust resistant (PDI = 0) at three locations for two years and against DELHI isolate under artificial inoculation.

Details of plant germplasm registered by PGRC during 2017–2018 (*Continued*)

Crop	National Id	INGR No	Novel unique features
Castor	IC0374272	17049	Resistance to leafhopper (*Empoasca flavescens* (Fabr)).
Yellow sarson	IC0623820	17050	Potential parent for resynthesis of *B. juncea*.
Stevia	IC0624505	17052	Reb-A/Stevioside ratio =1.25; Rebaudioside-A content (%)=7.34; Stevioside content (%)=5.87;
Stevia	IC0624506	17053	Delayed flowering by 120 days. Prolonged vegetative phase. More number of harvests per year.
Rose-scented geranium	IC0624503	17054	Higher fresh foliage. High oil content (0.14–0.18%). High rhodinal content (66–75%).
Isabgol	IC0623443	17055	Extended bract mutant.
Ashwagandha	IC0623444	17056	Revolute rolled leaves.
Ashwagandha	IC0623445	17057	Yellow young leaves
Banana	IC0395101	17058	Inter-specific hybrid with intermediate characters flowers (Inflorescence) bright and semi erect. Intermediate height with broad leaves (can be used for leaf production).
Chrysanthemum	IC0623437	17059	Flower colour: 77.B, Purple group, Fan 2. Stellate ray florets (Cylindrical shape)
Chrysanthemum	IC0623438	17060	Flower colour: 162.D, Gray yellow group, Fan 4. Stellate ray florets (Cylindrical shape)
Potato	IC0623450	17061	Meiotic tetraploid (MT) with 2× genome from semi-cultivated species, *S. verrucosum* and other 2× from cultivated potato cv. K. Lalima. Highly resistant to late blight. Performs well under short and long day conditions
Potato	IC0623449	17062	Interspecific potato somatic hybrids produced by protoplast fusion between the dihaploid *Solanum tubersum* C-13 and the wild potato species *S. cardiophyllum*. Tetraploid and male fertile. Resistance to potato late blight disease introgressed from the wild *S. cardiophyllum*.
Potato	IC0623447	17063	Drought tolerant advanced potato hybrid. Good keeping quality. High tuber yield.
Potato	IC0623448	17064	Purple skin colored specialty advanced potato hybrid. Very good keeping quality. High tuber yield.
Potato	IC0623446	17065	Processing advanced hybrid. Excellent keeping quality. High tuber yield.
Sorghum	IC0621475	17071	Improved shoot fly resistance over the elite parent, 296B. Better level of resistance to grain moulds compared to 296B. Derivative to biparental mating involving two shoot fly resistant sources.
Jute	IC0621946	17072	Extremely dwarf mutant with around 1/10th plant height of wild type.
Jute	IC0621948	17073	Low lignin content of fiber (6.7%) at 120 days after sowing. Unique morphology having undulated stem, petiole and main leaf vein.
Jute	IC0621949	17074	Absolute absence of pre-mature flowering when sown in first week of February.
Jute	IC0558459	18023	Highly resistant to jute hairy caterpillar. Imparts non-preference and antibiosis mechanism of resistance against jute hairy caterpillar with less fecundity and adverse effect on insect biology. Contains significantly higher amount of phenol and less amount of sugar and protein as the basis of resistant against jute hairy caterpillar.
Jute	IC0621650	17075	High iron content in leaves (173.75 mg/kg fresh weight).
Blackgram	IC01572	17076	Resistant to Mungbean Yellow Mosaic Virus.
Senna	IC0610825	17079	Small size pod.
Senna	IC0610826	17080	Broad leaves. Broad pod shape.
Aromatic ginger	IC0624537	17081	High rhizome yields (10 tonnes/ha). Dry rhizome recovery. High essential oil.
Oil palm	IC0597686	17082	Slow vertical stem growth (low annual height increment of 15 cm per year). Early fruit maturity (4.5 months) with long and slender bunch stalk. High fruit set of 53.4% than other oleiferas (28% to 46%).
Oil palm	IC0597687	17083	Virescens fruit colour. Dura fruit forms.
Oil palm	IC0597688	17084	Long bunch stalk (53 cm).
Oil palm	IC0597689	17085	Sterile Pisifera palm. Virescens fruit.
Oil palm	IC0597690	17086	Dwarf palm (12 cm annual height increment). High fruit set (69.09%).
Oil palm	IC0597691	17087	Slow vertical stem growth (low annual height increment of 25 cm per year). Compact palm with tenera (thin shell thickness of 1.56 mm) fruit form.
Gladiolus	IC0621473	17088	Floret colour: (based on RHS color chart). Purple (78.A) middle. Red-purple (72.A) margin with Green Yellow (1.D) blotch. Floret type is open faced and floret placement is in double rows.

Details of plant germplasm registered by PGRC during 2017–2018 (*Continued*)

Crop	National Id	INGR No	Novel unique features
Gladiolus	IC0621474	17089	Floret colour: (based on RHS color chart). Purple violet (82.A) having purple (77.A) margin. Green-White (157.C) line on lower lip. Early flowering (61.54 days).
Gerbera	IC0621471	17090	Flower head colour: 68D, Red purple group (as per RHS colour chart). Double type flower head.
Gerbera	IC0621472	17091	Flower head colour: 50A, Red group (as per RHS colour chart). Double type flower head.
Sorghum	IC0568489	18022	Scented sorghum.
Guinea grass	IC0625987	18024	A novel cytotype (heptaploid) (2n=7x=56). Member of Ploidy series in guinea grass.
Guinea grass	IC0625988	18025	A novel cytotype (eleven-ploid) (2n=11x=88). Member of Ploidy series in guinea grass.
Pennisetum	IC0625989	18026	A novel hexaploid (6x) cytotype with 2n=54 chromosomes. Recovered through BIII hybridization of a 4× (2n=36) cytotype.
Blackgram	IC011613	18027	Resistant to mungbean yellow mosaic virus.
Blackgram	IC0485638	18028	Resistant to mungbean yellow mosaic virus.
Cucumber	IC0420405	18029	High carotenoid content. Orange flesh colour.
Cucumber	IC0257296	18030	Two female flowers per node. Earliness. Small fruit.
Linseed	IC096539	18034	Early maturity.
Sugarcane	IC0627273	18035	Moderately resistant to 4 pathotypes of red rot, 18.8% sucrose, Better ratoonability.
Opium poppy	IC0625991	18036	Rich in Thebaine content (>10%).
Malabar lemon grass	IC0625982	18037	High essential oil (0.80%). Methyle eugenol rich (>75%). High hebage yield (242.5 q/ha/year).
Galanga	IC0625983	18038	Higher essential oil yield (2.31%). Higher rhizome yield (6.75) tonnes/ha/year. Higher dry rhozome recovery (27.50%).
Malabar lemon grass	IC0625984	18039	High Elemicin content 70%. High herbage yield 24.26 tonnes/ ha/year.
Malabar lemon grass	IC0625985	18040	High essential oil (1.25%). High herbage yield (28.32 tonnes/ ha/year). Citral content (76%).
Patchouli	IC0625986	18041	High essential oil yield. High herbage yield (3,220 kg/year).
Sweet Basil	EC338785	18042	High methyl chavicol content (> 88.81±2.34%) in essential oil isolated from aerial parts.
Malaxis	IC0626004	18043	Yellow coloured flowers without any purple tinge. Yellowish green floral buds. Greenish basal sheath at the base of shoot.
Basil	IC0627270	18044	Number of PGs in leaf. Dry leaf recovery (23.10%). Essential oil contents (0.65%) in green herbage and leaves.
Basil	IC0627271	18045	Dwarf. Early to flower (27.75 days after transplanting).
Basil	IC0627272	18046	Upper leaf (adaxial surface) puckering. Light green leaf colour. Maximum number of PGs in mature leaf.

Identification of resistance source to neck and finger blast disease from finger millet: A total 225 hill collections of finger millet germplasm were evaluated against leaf, neck and finger blast disease under natural field conditions. Based on scoring pattern, it was observed that none of the germplasm was highly resistant to leaf blast disease. Neck blast incidence ranged from 0 to 86% and finger blast incidence from 0 to 40%. Entries VHC 3796, VHC 4085, VRB MF 1217, VL 324, VR MF 1516 and VL *Ragi* 149 were highly resistant to both neck and finger blast while moderately resistant to leaf blast. Twenty-one entries (VHC 3899, VHC 4168, VHC 3603, VHC 3637, VHC 4149, VHC 4167, VHC 4006, VHC 3641, VRS MF 859, VRB MF 1214, VHC 4134, VHC 3640, VRB MF 1575, VHC 4084, VHC 4136, VHC 4180, VHC 4087, VHC 3975, VRB MF 1817, VRB MF 1819 and VHC 3583) were highly resistant to neck blast and moderately resistant to leaf and finger blast. Twelve entries (VHC 3899, VHC 4103, VHC 3658, VHC 3757, VHC 3993, VHC 4074, VHC 3640, VHC 3900, VHC 4127, VHC 4200, VRB MF 1218 and VR MF 2233) were highly resistant to finger blast and moderately resistant leaf and neck blasts.

Development of DNA finger print: Population structure and genetic tree of 330 rice land races obtained from Uttarakhand (151), eastern Uttar Pradesh (71), Jharkhand (37) and West Bengal (23) were generated using 30 HvSSR markers. New genomic SSR markers (67) were generated in *Andrographis paniculata* and diversity study carried out in 42 accessions from different geographical regions. Seventy-seven samples of varietal material from public and private sector were DNA profiled during the period using Simple Sequence Repeat (SSR) markers. Eight genes having key roles in wheat nitrogen intake and metabolism have been predicted from analysis of wheat genome sequence data. A total of 5,818 plant genomic resources (Isolated plant genes, DNA, Libraries and others) from 41 species are being maintained in National Genomic Resource Repository at ICAR-NBPGR. Chromosomes in *Luffa* sp. were identified and characterized using karyotyping and FISH analysis. Six imported consignments of *Arabidopsis thaliana,* cotton, maize were tested to ensure absence of embryogenesis deactivator gene (terminator gene

technology) and a sample of papaya seeds (National Plant Quarantine Station, New Delhi) was tested for the confirmation of non-GM status, by employing PCR-based markers. Developed construct-specific assays which could facilitate rapid/on-site GM detection to test presence of commercialized *Bt* cotton events in the country.

Microbial genetic resources

National Agriculturally Important Microbial Culture Collection (NAIMCC) maintains microbial cultures of agricultural importance in India and is an affiliate member of World Data Centre for Microorganisms (WDCM). Currently, NAIMCC holds more than 6,500 AIMs including 2,500 bacteria (both actinomycetes and archaea), 3,809 fungi and 228 cyanobacteria. Several agriculturally important bacteria, fungi, actinomycetes and cyanobacteria belonging to various genera namely *Achromobacter, Acinetobacter*, *Bacillus*, *Brevibacillus*, *Enterobacter, Kluyvera, Kocuria, Lysinibacillus, Microbacterium, Micrococcus, Ochrobacterium, Paenibacillus, Pantoea, Planococcus, Pseudomonas, Raoutella, Stenotrophomonas, Streptomyces*, *Alternaria, Aspergillus, Coprinopsis, Fusarium, Irpex, Pseudogarobasidium, Schizophyllum, and Sclerotinia* were accessioned in NAIMCC. During the year 2017–18, 109 fungal cultures and 98 bacterial and actinomycetes cultures were added to MGR from 16 states and one union territory. NAIMCC has supplied more than 40 microbial cultures to different private and government institutions for research purposes.

Horticulture

During the reported period, 10 germplasms of ber, 2 of guava, 8 of acid lime and 27 of manila tamarind were collected. Eight genotypes of ber *viz.* HR Coll.-1, 3, 4, 8, 15, 16 and Chirawa Coll. 1 and 2 were collected from Hisar, Bhiwani, Mahendragarh and Rewari, Haryana and one genotype collected from Awadhpuri, Agra. Twenty five Manila tamarind genotypes from Panchmahal district of Gujarat and 2 genotypes (CHESM-26 and CHESM-27) from Vasad were collected. Twenty genotypes of Ocimum were collected from South and Little Andaman. A total of 105 new wild mushroom germplasm accessions were collected from different parts of the country.

Germplasm	Registration Number	Salient features
VMT 5-1	INGR17061	Late blight resistant, widely adapted meiotic tetraploid potato hybrid developed by unilateral sexual polyploidization (USP) scheme.
Crd-6	INGR17062	Late blight resistant, tetraploid and male fertile interspecific potato somatic hybrid produced by protoplast fusion between the dihaploid *Solanum tuberosum* C-13 and the wild potato species *S. cardiophyllum*.
MS/6-1947	INGR17063	Drought tolerant advanced potato hybrid possessing high tuber yield and good keeping quality.
MS/8-1565	INGR17064	Purple skin coloured specialty advanced potato hybrid having high tuber yield and very good keeping quality.
MP/6-39	INGR17065	Processing advanced hybrid with excellent keeping quality and high tuber yield.

Ninety-eight genotypes of vegetable cowpea, 45 genotypes of bush cowpea, 60 genotypes of pole type Indian bean, 40 genotypes of bush dolichos bean and 45 genotypes of cluster bean were evaluated for their growth and yield characters. Thirty genotypes of ivy gourd, 34 genotypes of drumstick were evaluated for their growth and yield parameters and genotypes of spine gourd were collected.

One late maturing, rain tolerant, red colour berry date palm germplasm (CIAH/DP/S-01) was identified and IC No. 0624544 was obtained from NBPGR, New Delhi. One elite male date palm (CIAH/DP/M-03) germplasm was also identified for more number of spathes (16-22), pollens production (640g/plant) and IC No. 624490 obtained. IC No 625644 of elite germplasm of cowpea (AHCP-1-1) and IC No. 0626391 (AHRM-1) and IC No. 0626392 (AHRM-2) of tinda (squash melon) were obtained from NBPGR, New Delhi.

Development of nutritionally rich potato clones: Registered five new genetic stocks with the NBPGR, New Delhi, and developed nutritionally rich potato clones.

Livestock

New registered breeds of indigenous farm animals: Breed Registration Committee approved the registration of nine new breeds of livestock and poultry, which includes one breed each of cattle, horse, pig, yak, geese, duck and chicken and two breeds of goat. First time indigenous breeds of yak, duck and geese were registered.

The total number of registered indigenous breeds in the country is 169: 41 cattle, 13 buffalo, 28 goat, 42 sheep, 7 horses and ponies, 9 camel, 7 pig, 1 donkey, 1 yak, 18 chicken, 1 duck and 1 geese.

Lakhimi cattle (Acc.No. INDIA_CATTLE_0200_LAKHIMI_03041): The Lakhimi cattle of Asom, distributed in the entire state are reared for milk and draught purposes by local people. The total population is about 79 lakh. Animals are small size, horned and have relatively short legs. Coat colour is mainly brown and grey. Hump is medium and backline slightly curved. Udder is small and bowel shaped. Bullocks are excellent draught animals for carting and ploughing especially the muddy paddy

IMAGEIDGP—Identification of individuals breeds

An image based system was developed for identification of individuals, breeds and diseases of pigs and goats. The objective of the project envisaged image-based identification of pigs and goat breeds as well as individuals. Different traits studied were ear contour, ear venation, iris, retina, muzzle imprint and picture of pigs; and ear contour, ear venation, iris, retina, tail and nostril imprint in goats. Auricular venation pattern and muzzle imprint in pig and iris image in goat can be used as a tool for individual identification. The image of ear for vein pattern was processed for segmentation followed by generation of auricular vein tree. Those vein trees were used for generating template database for recognition of pig. Branch points (up to secondary branching) of the ear venation pattern were considered in the analysis. The captured image of iris of goat was pre-processed for segmentation. The segmented iris was normalized and templates generated and stored along with the identification of goat in database for the purpose of animal recognition in future. For segmentation by HUE analysis, 800 pictures were captured for pig breeds, viz. Ghungroo, Large White Yorkshire, Hampshire and Duroc. Whole body cannot be represented by one colour owing to variation of colour of different parts of body. Hence, body colours of animals are represented by range of minimum and maximum HUE value. The segmentation method was able to classify the breeds of pigs and goats.

fields. Annual lactation milk yield ranges from 270 to 375 kg.

Salem black goat (Acc. No. INDIA_GOAT_1800_SALEMBLACK_06027): Salem black goats are reared by Vanniyar and Konguvellala Gounder communities for meat, skin and manure in Salem, Dharmapuri, Krishnagiri and Erode districts of Tamil Nadu. The estimated population is about 86,000. These goats are tall, lean and leggy; black; have medium ears, semi-pendulous with leaf-like appearance. Both males and females have medium size horns, curved upwards and backwards. In males, the neck is thick, broad and well placed. Early sexual maturity, multiple births and low mortality are the main features of this breed.

Sumi-Ne goat (Acc. No. INDIA_GOAT_1400_SUMINE_06028): The Sumi-Ne goat also known as Nagaland long hair goat, is reared by Sumi tribes of Nagaland in traditional open range system with almost zero input. The estimated population is about 4,500. This medium size goat is reared mainly for its silky fibre, which are used by local people for making traditional items of socio-cultural significance. The coat is white with black patches on head, neck and legs. Head straight; ears horizontal; and horns are pointed, small size and curved backwards. Beard is present.

Kachchhi-Sindhi horse (Acc. No. INDIA_HORSE_0417_KACHCHHISINDHI_07007): This indigenous horse breed is native to Kachchh district of Gujarat, and Jaisalmer and Barmer districts of Rajasthan. The total population is about 4,000. Unique features include Roman nose, appearance of face, ears curved at tips but not touching each other, 56 to 60 inch height, short back, short pastern bone length, broader hoof for better grip and docile temperament. Coat is mainly bay. Famous for its Rewal chal, as it performs with great speed and stamina covering a long distance. The horse possess excellent drought and heat tolerance capacity in arid and semi-arid region.

Zovawk pig (Acc. No. INDIA_PIG_2700_ZOVAWK_09007): Zovawk pig is distributed in Mizoram with an estimated population of about 39,000. It is reared by the Mizo community for pork and manure purposes. Animals are black with white spot on forehead, white patches on the belly and white boots. Erect ears, concave snout, pot belly, concave top line and long bristles on mid-line are characteristics of the Zovawk pig. Average body weight is 54 kg in males and 59 kg in females.

Arunachali yak (Acc.No. INDIA_YAK_2300_ARUNACHALI_16001): The native tract of Arunachali yak includes West Kameng and Tawang districts of Arunachal Pradesh. They are reared by the Monpa community for milk, meat, fibre, transportation and manure. The estimated population of the Arunachali yak is about 14,000. Predominantly black in colour, medium size with a compact body. Legs are short and stocky, horns are mostly curved, black and are bigger in males than females. The horizontal ear is a typical characteristic of Arunachali yak. Brisket, belly, ribs, lateral parts and legs are covered with long hair. Adult body weight ranges between 206 and 416 kg. Males are massive and aggressive. Milk production is about 1 kg/day.

Pati duck (Acc. No. INDIA_DUCK_0200_PATI_11001): Pati ducks are reared in backyard

production system in rural Asom. The estimated population is 18.21 lakh.

They are squat in posture, plumage is dark brown in drakes with a greyish black head; tail with black and white feathers. Ducks are solid brown. A white ring may or may not be present at the neck in both sexes. The bill, shank and feet are predominantly yellow. Pati ducks are used for meat, egg and ritual sacrifices. The average body weight is 1.58 kg.

Kashmir Anz geese (Acc.No. INDIA_GEESE_0700_KASHMIRANZ_18001): The native tract of Kashmir Anz geese is Srinagar, Bandipora, Ganderbal, Baramulla and Budgam districts of Jammu and Kashmir. The estimated population is nearly 13,000 birds. They are reared for meat, eggs, feathers, and as a hobby in areas located around the waterbodies. Colour of the plumage is cinnamon, white, and a mixture of cinnamon and white. Average adult body weight is 3.82 and 3.34 kg in male and female, respectively. The goose lays about 12 white-shelled eggs/year each weighing about 137 g. Kashmir Anz geese are hardy, disease resistant and foragers requiring minimum inputs for rearing.

Hansli chicken (Acc. No. INDIA_CHICKEN_1500_HANSLI_12018): Hansli chicken is reared in Mayurbhanj and Keonjhar districts of Odisha for game (fighting) and meat purposes. The estimated population is about 12,000. Birds are tall, slim, with a majestic look. Plumage is predominantly black. Males have golden yellow or red hackle and saddle feathers. Comb is pea type. Spur is present in males. Beak is small, strong and stout. Wattles are small and rudimentary, plenty of hackle feathers flow over the shoulder in males. Wings are medium to large and well folded. Average egg production is 67/year with an egg weight of 46 g. Average body weight is 3.8 kg in males and 2.5 kg in females.

Phenotypic characterization

Bidri and Nandidurga goat: Nandidurga goats are distributed in Chitradurga, Tumkur and Davangere districts of Karnataka. Total goat population of breeding tract is 6.6 lakh. The estimated population of Nandidurga goat is 178,000. Flocks are stationary and average flock size is 29.6 (12–93). Coat colour is white and eyelids are brown or black. Ears are leafy and pendulous. Milking is not done as these goats are reared for meat. Twining is common. Adult weight varies from 30 to 50 kg in males and 26 to 40 kg in females.

Nandidurga goat

Bidri goats are distributed in Bidar and Kalaburagi districts of Karnataka. There is uniformity and purity with an estimated population of 110,000. Average flock size is 74.3 (21–130), flocks are stationary. The coat colour, muzzle, eyelids and hooves are black with pendulous ears. Goats are reared for meat only and the adult weight varies from 31 to 47 kg in males, and 24 to 40 kg in females; and twinning is common.

Bidri

Chitarangi sheep: Chitarangi sheep was surveyed in Fazilka, Muktsar districts of Punjab, and Sri Ganga Nagar district of Rajasthan. It is a carpet wool type sheep population. Chitarangi is medium to large in size. Coat is white with tan patches around the eyes, muzzle and on the ear. Serrations of different shape and depth are available on distal end of ear pinna. Average annual greasy wool production is 1.5 to 2 kg. To genetically characterize Chitarangi sheep, 237 distinct alleles were identified across the 24 markers. The mean F_{IS} (within population inbreeding estimates) was 0.096 in the population, indicating a deficiency in the number of heterozygotes.

Chitarangi ram

Chitarangi ewe

Ladakhi donkeys: The Ladakhi donkey population is about 5,000 in the district of Leh, and is reared by Buddhist communities mostly in rural areas. It is used primarily as a pack animal for transportation of manure/fuel-wood/fodder/construction/trekking-camping materials by local people, food-logistics supply by Indian Army, and secondarily for manure. Animals are of medium size and docile. Coat colour varies from light to dark brown and black with light colour or white belly. White mark around muzzle and mouth and white ring around eyes are observed in most of the animals irrespective of sex. The hair coat is medium and curly, and dense on lateral sides of the body. Nasal bone is straight to slightly concave. Forehead


Male Ladakhi donkey


Female Ladakhi donkey

is flat to convex. In females, age at first breeding is 3.5–4.0 years and first foaling is 4.5–5.5 years. Major season of breeding and foaling is March–June. Herd size is 1–6 donkeys per household. As for uniqueness, the Ladakhi donkey has the ability to easily cross small ridges (Bonchangs) and can travel 15–20 km in 5–6 hr with 40–50 kg load in high terrain.

Genetic characterization

Genomic profiles of chicken lines: Expression of fatty acid synthase (FASN) and acetyl-CoA carboxylase A (ACACA) genes were analyzed during the ontogenic and post-hatch juvenile period in broiler, layer and indigenous native (Ghagus) chicken lines. Chicken hepatocyte culture was established and shRNA molecules were designed, synthesized and tested for silencing FASN and ACACA genes under cell culture system. A transgenic vector (DPREGG1 vector) was prepared and used for expressing the green fluorescent protein (GFP) in chicken oviductal cells *in-vitro*. The exons of Tapasin and TAP2 genes were found to be polymorphic with 21 haplogroups in Tapasin and 10 haplogroups in TAP2 gene exons. Nab (Natural antibody) titres to rabbit RBCs and specific antibody titres to Newcastle disease virus (NDV) were determined at various ages in Ghagus, Nicobari and White Leghorn (WL) chickens. NAb titres at 20 weeks of age were significantly associated with the survivability of birds up to 72 weeks of age in Ghagus. There was higher genetic variability in indigenous breeds compared to WL at MHC. Genetic polymorphism in the coding sequence of MDA5, LGP2, TLR3, TLR1LA, and B-NK genes through SSCP was carried out in Ghagus, Nicobari and WL breeds indicating polymorphic nature of genes with the presence of non-synonymous types of mutation. The lipogenic genes, stearoyl Co A desaturase and fatty acyl synthase were expressed higher in liver and brain of PD-3 and Nicobari chickens in summer. The receptors for hormones, leptin, ghrelin and GH were downregulated and adverse effects of high ambient temperatures on plasma leptin, histomorphology of intestine and performance of Nicobari chicken were reduced with fermented yeast culture supplementation in the diet.

Transcriptome analysis of Zanskar: Transcriptome analysis of Zanskar PBMCs during endurance exercise at high altitude was generated to identify differentially expressed genes before and after endurance exercise at high altitude. A total of 646 genes were found to be differentially expressed in Zanskar ponies during exercise. Ribosomal protein genes were among the top up-regulated genes. Several immune related genes were also found to be up-regulated in animals after trial. Increased expression of CXCL16 and CCL5 after trial treatment indicated strong inflammatory response in horses during stress conditions. Data suggested significant induction of hypoxia inducible factor 1A (*HIF-1A*). The anti-inflammatory superoxide dismutase 1 (*SOD1*) also showed increased expression in T1 and T2 groups after exercise.

Diversity analysis of Indian buffalo population: Genotyping by sequencing (GBS) data generated in 17 buffalo populations (625 animals) was utilized to estimate linkage disequilibrium. Total 23,306 SNPs were genotyped. Genetic distance block of 20–25 kb was found for riverine buffaloes and 25–50 kb for the swamp buffaloes. Number of SNPs ~150,000 for riverine and 120,000 for swamp buffaloes, was determined for an association mapping. SNPs (23,306) were analyzed for identification of admixture among 17 buffalo breeds/populations. There was high degree of admixture for most of the buffalo populations of the country except Chilika, Mehsana, Toda, Asom and Manipuri. The buffaloes of Manipuri and Asom are primarily swamp buffaloes. Although the sampling was done purely on phenotypic characteristics, still there are few animals that are crosses of riverine and swamp buffaloes. Spatial genetic analysis allowed the grouping of all the populations into 11 groups, largely by region-wise. The first group consists of swamp buffaloes of North East region of Asom and Manipur, the second group of Chilika buffaloes, the third group of Murrah and Nili Ravi buffaloes, the fourth group of Surti, Mehsana, Nagpuri and Banni buffaloes; Kerala buffaloes, Toda and Kalasthi buffaloes forming separate clusters or groups, Tarai and Bhadawari forming two separate groups, rest of the Uttar Pradesh buffaloes formed two groups.

Detection of 2',5'-oligoadenylate synthetase 1 (OAS1) protein: The OAS1 protein expression at bovine PBMC was assessed at day 18 post AI in pregnant and non-pregnant animals. Higher expression of OAS1 protein in nulliparous pregnant animals in comparison to open animals was observed but the difference was not prominent. The western blotting technique and further quantification of the levels of protein revealed that the level of OAS1 protein in nulliparous pregnant animals was higher than the non-pregnant animals.

Characterization of Vrindavani cattle using high throughput SNP Bead Chip

Admixture levels in Vrindavani cattle were estimated for the first time using Bovine 50K SNP Bead Chip, and the inheritance of Holstein Friesian, Jersey, Brown Swiss and Haryana was ascertained to be 42.16, 22.39, 10.67 and 24.78%, respectively. Thus giving the evidence of optimum applicability of Bovine 50K SNP Bead Chip for admixture studies in Vrindavani cattle. This approach can estimate the breed purity/composition of any unknown/purebred/ non-descript cattle population in near future.

Association of OAS1 genotypes with milk production traits: Genetic variants in the exonic regions of OAS1 gene were identified and sequenced for associating with milk production traits in 250 cows comprising 168 Frieswal and 82 Sahiwal cattle. The genotypes of exon 6 fragments 1 of OAS1 gene had a significant association with milk production traits, whereas, genotypes identified in exon 2 and exon 5 did not reveal any association in both Frieswal and Sahiwal populations.

Expression of fertility associated genes in cattle: Study on correlation of different semen quality parameters with expression profiles of genes like AKAP4, PRM1 and CAT showed positive correlation with both acrosome integrity and post-thaw motility in Frieswal bull semen. The AKAP4 had significant correlation with both semen quality parameters. PRM1 showed high correlation with PTM at 1% level. Other genes, viz. CLU, TPN1, TPN2 and MnSOD showed positive correlation with PTM of which the MnSOD showed correlation at 1% level. Acrosome integrity was also correlated with the expression profiles of SOD and PKM2.

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

Modulating thermo regulatory response: Characterized bovine HSP90AA1 IRES sequence was subjected for structural prediction and generation of interactome model between the predicted bovine IRES with human 40S subunit ribosomal protein 5 (RPS5) and ribosomal translational initiation factor (TIF). Spectrophotometric readings revealed that the concentration of *in-vitro* synthesized eventually increased. Transfected MDBK cells revealed the AcGFP expression under the control of bovine Hsp90AA1. However, the GFP expression under the control of native IRES (53%) was slightly higher than the Hsp90AA1 IRES (47%). Further confirmation was made through immune fluorescent assay, which also localized the GFP gene expression under the control of Hsp90AA1 IRES element.

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

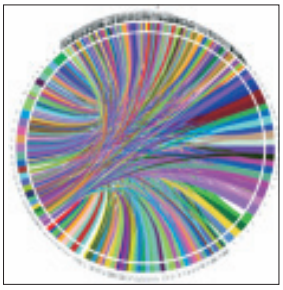
Identification of functional internal ribosomal entry sites (IRES): A putative IRES was identified in bovine heat shock protein gene for the first time, which was showed to be functional. The identified bovine heat shock protein IRES was used to develop an artificial expression cassettes for simultaneous translation of two gene from the same reading frame. An Indian patent has been filed with application number 201711042562 dated 28/11/2017.

***Ex-situ* conservation of AnGR:** Germplasm repository at National Gene Bank, ICAR-NBAGR, Karnal has been strengthened by preserving diversified form of germplasm (semen, embryos, DNA, epididymal sperms and somatic cells). Total 23,975 semen doses of 8 cattle breeds and 400 somatic cell doses each of Katchi camel and Marwari horse were added for cryopreservation. Manipuri horse and Kutchi camel fibroblast cell lines were generated from skin explants for somatic cell banking. Ear marginal tissues of Manipuri horse and Kutchi camel were utilized for establishment of cell lines. Primary culture was established using explants culture technique using fibroblast specific media. The cells were cryopreserved from third to sixth passage.

Fisheries

Genetic stock assessment of chocolate mahseer: Chocolate mahseer (*Neolissochilus hexagonolepis*) a commercially important food and game fish, is restricted to North East region of India particularly in the Brahmaputra river basin. However, due to rapidly declining natural population, it is ranked as threatened species. The population genetic structure and genetic diversity of *N. hexagonolepis* was studied from nine geographically-isolated populations in the drainages of Asom, Arunachal Pradesh and Meghalaya. Thirty-three distinct haplotypes were identified from concatenated gene analysis. Most of the populations showed high polymorphisms, parsimony and haplotype diversity, indicating genetically healthy stocks in the wild. The pattern of haplotype network and phylogenetic tree revealed six major groups. The present finding would be beneficial for sustainable management, stock-specific strategies for breeding and conservation of the wild population of *N. hexagonolepis*.

Decoding complete genomes of hilsa, rohu and magur fishes: Sequenced, assembled and annotated the whole genomes of commercially important indigenous fishes hilsa (*Tenualosa ilisha*), rohu (*Labeo rohita*) and magur (*Clarias magur*). In hilsa draft



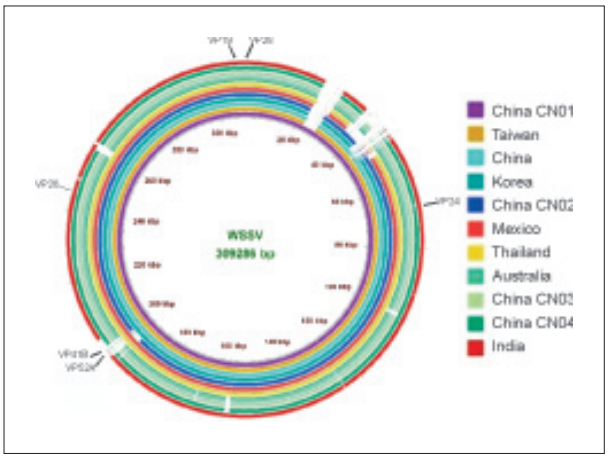
Synteny analysis showing the mapping of *T. ilisha* genome (660 sequences) against *Danio rerio* (25), *Salmo salar* (29) and *Cyprinus carpio* (50)

genome with 95% coverage, genes, which were identified include genes for growth, lipid metabolism, immune function and osmoregulatory genes which are

essential for enduring extreme environmental stress faced during the spawning migration by fish. Rohu genome with 95% coverage had over 40,000 genes and functional role of around 25,000 genes was annotated. Magur genome assembly with 93% coverage had over 51,000 genes and nearly 35,000 genes were analysed for functional roles. These analyses would pave way for finding genes of important traits, such as, growth, disease resistance, etc.

Sequencing genome of oomycete pathogen: Draft genome of oomycete (*Aphanomyces invadans*), known to cause epizootic ulcerative syndrome (EUS), was fully sequenced with 87% coverage. Of about 18,000 genes predicted, 636 genes were identified to be secretory in nature. EUS is one of the most destructive diseases of freshwater and brackishwater fishes. Genome sequencing would help in identification of virulence factors and thereby useful in developing novel strategies for disease management.

Complete genome sequencing of white spot syndrome virus (WSSV): White spot syndrome virus



(WSSV) is a pathogen of shrimps causing major economic losses to the aquaculture industry. Complete genome of an Indian isolate of WSSV obtained from *Penaeus vannamei* was decoded. The genome has 280,591 bp with 442 predicted coding genes. ❑

5. Crop Improvement

During 2018, total 372 varieties pertaining to cereals, oilseeds, commercial crops etc., were developed.

Cereals

High-yielding varieties/hybrids of cereals (200) comprising 94 of rice, 27 of wheat, five of barley, 26 of maize, 15 of pearl millet and sorghum, and 18 of nutri-cereals were released for cultivation in different agro-ecologies of the country during 2018. Description of selected released varieties/hybrids of cereals is given below.

List of released varieties/hybrids of cereals

Variety	Area of adoption	Salient features
Rice		
Daksha (KMP-175)	Karnataka	Suitable for recurring drought and rainfed condition, aerobic rice, yield: 45 to 50 q/ha, maturity:110–115 days, tolerant to sheath blight and sheath rot
JR 81	Madhya Pradesh	Suitable for irrigated conditions, yield: 55–60 q/ha, long slender grains, maturity: 120–125 days
Improved Chinnor	Madhya Pradesh	Suitable for irrigated conditions, yield: 30–32 q/ha, medium slender aromatic rice, maturity: 150–155 days
Improved Jeera Shankar	Madhya Pradesh	Suitable for irrigated conditions, yield: 30–32 q/ha, aromatic short bold rice, maturity: 140 days
Mahisagar (IET 22100)	Gujarat	Suitable for irrigated mid early conditions, yield: 50–55 q/ha, medium slender grains, maturity: 115–120 days
CN 1272-55-105 (IET-19886)	West Bengal, Bihar, Odisha, Andhra Pradesh, Karnataka, and Maharashtra	Suitable for irrigated long duration condition, yield: 54 q/ha, maturity 145–150 days
CO 52	Tamil Nadu	Suitable for irrigated condition as transplanted rice, yield: 61.91 q/ha, medium slender grains, maturity: 135 days, resistant to brown plant hoppers and leaf hopper
JRB 1 (IET 23422)	Madhya Pradesh	Suitable for irrigated early condition, yield: 45.25–71.40 q/ha, short bold grains, maturity: 115 days
GNRH-1 (NVSR-H-1003) hybrid	Gujarat	Suitable for transplanted rice growing areas, yield: 50.77 q/ha, first rice hybrid of Gujarat, long slender grains, maturity: 110–115 days, tolerant to insect pests
GNR-5 (NVSR-6137)	Gujarat	Suitable for salt-affected rice growing areas of Gujarat, yield: 57.91 q/ha, long slender grain, maturity: 125 days, salinity tolerant, tolerant to brown plant hopper (BPH)
CO 43 Sub-1 (IET 25676)	Tamil Nadu, Andhra Pradesh, Odisha, Karnataka	Suitable for irrigated lowland ecosystems during *rabi*, developed through Marker Assisted Backcross Breeding (MABB), yield: 40.44 q/ha, short bold grains, maturity: 135–140 days, tolerant to flash flooding/ submergence up to 2 weeks
27P37 PR 14101 (IET 24844) Hybrid	Chhattisgarh, Madhya Pradesh and Maharashtra	Suitable for irrigated conditions, yield: 60–65 q/ha, high-yieldings hybrid with long-bold grain, maturity: 125–130 days

Variety	Area of adoption	Salient features
28S41PR 14109 (IET 24891) Hybrid	Uttar Pradesh, Odisha, West Bengal, Jharkhand, Maharashtra, MP, Chhattisgarh, Telangana, AP, Karnataka and TN	Suitable for irrigated conditions, yield: 60 q/ha, maturity: 134–138 days, resistant to bacterial leaf blight, tolerant to leaf blast.
28P67 PR 14105 (IET 24879) Hybrid	UP, Bihar, Jharkhand, Odisha, WB, Chhattisgarh and Maharashtra	Suitable for irrigated conditions, yield: 65 q/ha, long bold grain maturity: 130–135 days, tolerant to neck blast and brown spot.
DRR Dhan 47 (IET 23356)	Telangana, AP, Karnataka, Kerala and Puducherry	Suitable for irrigated/transplanted and low fertility ecology, yield: 50 q/ha, long bold grain, maturity: 110–115 days, lodging resistant, drought tolerant and shattering tolerant, resistant to blast.
DRR Dhan 48 (IET 24555	AP, Telangana, TN, Karnataka and Kerala	Suitable for irrigated/transplanted production ecology, yield: 50–55 q/ha, high zinc line with BLB resistance maturity:135–140 days, lodging resistant, fertilizer responsive, non-shattering.
DRR Dhan 49 (IET 24557)	Gujarat, Maharashtra and Kerala	Suitable for irrigated/transplanted and medium fertility ecology, yield: 50–55 q/ha, high zinc line (25.2 ppm) with BLB resistance, maturity: 125–130 days, lodging resistant, shattering tolerant, fertilizer responsive.
DRR Dhan 50 (IET 25671)	AP, Telangana, TN, Karnataka, Bihar, Odisha, Chhattisgarh, UP and MP	Suitable for irrigated/transplanted and rainfed low land and drought prone areas, yield: 58.6 q/ha (normal), 37.5 q/ha (drought), 25.3 q/ha (submergence), medium slender grains, maturity: 140–145 days, lodging resistant, drought tolerant, submergence tolerant.
DRR Dhan 51 (IET 25484)	UP, Gujarat, Telangana and Chhattisgarh	Suitable for irrigated rice ecosystem, developed by Marker Assisted Backcross Breeding (MABB), yield: 45–50 q/ha, short bold rice, maturity: 135–140 days, non-lodging, responsive to fertilizer application, resistant to blast.
CAU-RI (IET 23544)	Manipur and Meghalaya	Suitable for rainfed direct seeded/transplanted upland hill and terrace condition, yield: 55–65 q/ha (normal cultivation) and 23.95 q/ha in upland condition, maturity: 130–135 days, moderately tolerant to drought.
Him Palam Lal Dhan-1 (HPR 2795)	Himachal Pradesh, Meghalaya and Manipur	Suitable for low elevated hills under rainfed ecology for direct sowing, yield: 35 q/ha, maturity: 120–124 days, drought tolerant, tolerant to blast, resistant to leaf and neck blast under natural epiphytotic conditions in low elevated hills.
Punjab Basmati-4 (RYT 3404) (IET-25399)	Punjab	Suitable for low land irrigated rice ecosystem, yield: 43.28 q/ha, developed by Marker Assisted Backcross Breeding (MABB), scented grains, maturity: 145 days, this genotype is resistant to all the 10 pathotypes of bacterial blight pathogen prevalent in Punjab.
Punjab Basmati-5 (RYT 3432) (IET-26153)	Punjab	Suitable for low land irrigated rice ecosystem, yield: 37.08 q/ha, developed by Marker Assisted Backcross Breeding (MABB), long-slender aromatic rice, maturity: 137–140 days, this genotype is resistant to all the 10 pathotypes of bacterial blight pathogen prevalent in Punjab.
PR-126 (RYT 3379) (IET-24721)	Punjab	Suitable for irrigated mid-early rice ecosystem, yield:76.18 q/ha, maturity: 123 days, this genotype is resistant to 7 of the 10 pathotypes of bacterial blight pathogen known in Punjab.
MDU.6 (IET-23994)	Tamil Nadu	Suitable for irrigated early condition, yield: 61.18 q/ha, long slender rice, maturity: 115–120 days, non-shattering.

Variety	Area of adoption	Salient features
PDKV Kisan (SKL 22-39-31-25-31-34)	Eastern Vidarbha Zone of Maharashtra	Suitable for irrigated and assured rainfall during *kharif* season in transplanted condition, yield: 40–42 q/ha, medium slender grains, maturity: 130–135 days, resistant to leaf blast, bacterial leaf blight (BLB) and gall midge biotype 4.
CNRH 102 (IET 22913)	West Bengal	Suitable for irrigated/ rainfed condition, yield: 50–60 q/ha, medium slender grains, maturity: 125 days, resistant to lodging and tolerant to shattering.
Ranjit Sub-1	Asom	Suitable for lowland rice ecology, yield: 55 q/ha, medium slender grains, maturity: 145–150 days, can tolerate up to 12 days complete submergence. Non-lodging, non-shattering.
Bahadur Sub-1	Asom	Suitable for lowland rice ecology, yield: 60 q/ha, medium bold grains, maturity: 145–150 days, can tolerate up to 12 days complete submergence, non-lodging, non-shattering.
CSR 46 (CSR 2K 262)	Uttar Pradesh	Suitable for alkalinity/sodicity condition, yield: 6 to 6.5 tonnes/ha under non-stress soil conditions and 3.5 to 5 tonnes/ha in salt-affected soils, maturity: 125–135 days, long slender grains, tolerant to alkalinity (pH 9.8–10)/ sodicity.
Gobinda (OR 2324-8) IET 21009	Odisha	Suitable for rainfed and irrigated shallow medium land, yield: 40 q/ha, maturity: 135 days.
Hasanta (OR 2328-5) IET 21477	Odisha	Suitable for rainfed and irrigated shallow lowland, yield: 39.5 q/ha, maturity: 145 days, tolerant to sheath rot.
Ashutosh (OR 2331-14) IET 21341	Odisha	Suitable for rainfed shallow and semi-deep lowland, yield: 40 q/ha, maturity: 150 days.
Tripura Chikan Dhan	Tripura	Suitable for irrigated and favourable rainfed shallow lowland and in *boro* season, yield: 56–58 q/ha in *boro* season under irrigated conditions, very fine grain variety, maturity: 120–125 days.
Tripura Sarat	Tripura	Suitable for irrigated and favourable rainfed shallow lowland in *boro* season, yield: 58–60 q/ha in *boro* season, maturity: 120–125 days.
Tripura Nirog	Tripura	Suitable for irrigated and favourable rainfed shallow lowland and in *kharif* as well as *boro* season, yield: 58–60 q/ha, maturity: 125–128 days.
Tripura Hakuchuk 2	Tripura	Suitable for transplanted lowland as well as direct seeded upland, yield: 55.4 q/ha, under transplanted and 33 q/ha under direct seeded upland, maturity: 100–105 days in transplanted and 90–95 days in direct seeded, drought tolerant.
Tripura Khara 2	Tripura	Suitable for rainfed, drought prone lowlands, variety performed very well under moderate to severe drought stress, yield: 56–58 q/ha under normal condition, maturity: 115–120 days, drought tolerant.
Tripura Khara 1	Tripura	Suitable for rainfed drought prone lowlands, the variety performed very well under moderate to severe drought stress, yield: 56–58 q/ha under normal condition, maturity: 115–120 days, drought tolerant.
Tripura Hakuchuk 1	Tripura	Suitable for transplanted lowland as well as direct seeded upland, yield: 55.4 q/ha in 100 days under transplanted conditions. 33 q/ha under direct seeded upland, maturity: 100–105 days in transplanted and 90–95 days in direct seeded, drought tolerant.

Variety	Area of adoption	Salient features
Tripura Jala 1	Tripura	Suitable for water stagnant lowlands, semi deep water condition, yield: 50–55 q/ha, very good for making high quality puffed rice, maturity: 145–150 days.
Tripura Aush	Tripura	Suitable for transplanting in August (spring/ summer), yield: 50–54 q/ha, maturity: 100–105 days, drought tolerant.
VNR-2228 (IET 24951) VNR 218	Punjab, Haryana, Uttarakhand, MP, Rajasthan, Chhattisgarh and Maharashtra	Suitable for transplanted condition in irrigated and rainfed ecologies in *kharif* season, yield: 63.72 q/ha, mid-early duration hybrid, maturity: 125–130 days, resistant to lodging.
VNR-2111 PLUS (IET 24075) (VNR 212)	Punjab, Haryana, Uttarakhand, WB, Odisha, Bihar, UP, Jharkhand, MP, Chhattisgarh and Maharashtra	Suitable for irrigated and rainfed ecologies in *kharif* in transplanted condition, yield: 63q/ha, maturity: 115–120 days, tolerant to terminal water stress.
VNR-216 (IET 25287)	Chhattisgarh, Maharashtra and Gujarat, WB	Suitable for irrigated and rainfed ecologies in *kharif*, long duration hybrid, yield: 59 q/ha, short bold grains, maturity: 140–145 days, tolerance to lodging, BPH and BLB, high tolerance to lodging under high winds.
Gujarat Anand Rice-14 (GAR-14) (IET-24619)	Western region of Maharashtra and Gujarat for *kharif*	Suitable for irrigated transplanted growing area of *kharif* seasons, aromatic short grain, yield: 51.08 q/ha, aromatic short slender rice, maturity: 137–140 days, resistant to neck blast.
ADT 52 (IET 25521) AD 13121	Central Zone of Chhattisgarh and Maharashtra	Suitable for irrigated rice ecosystem (*kharif*), yield:49 q/ha, maturity: 140–150 days, moderately resistant to leaf blast, neck blast, sheath rot grain discoloration and RTD.
CSR 60 (IET 25378) (CSR 2013 MI-10)	Uttar Pradesh, Puducherry	Suitable for high fertility, transplanted and *kharif* condition, yield: 34 q/ha, long slender grains, maturity: 120–130 days, resistant to lodging, shattering and suitable to high alkaline irrigated conditions.
CSR 56 (IET 24537)	UP and Haryana	Suitable for irrigated, alkaline, high fertility, transplanted and *kharif* condition, yield: 35 q/ha, long bold grains, maturity: 120–130 days, resistant to leaf blast, blight, brown spot, glume discoloration diseases, stem borer, leaf folder and white backed plant hopper
YNP 9761(IET 24338)	Chattisgarh, WB, Bihar and Odisha	Suitable for *kharif* irrigated areas, mid-early, yield: 62 q/ha, maturity: 135–140 days, moderately resistant to leaf blast, sheath blight and brown spot.
Bina Dhan 17 GSR (SAGCand) (IET 24460)	WB, Asom and Tripura	Suitable for irrigated mid-early conditions, yield: 55–60 q/ha, long slender, maturity: 115–120 days, Resistant to BLB, sheath blight.
BRRI Dhan 69 (WTR 1) (IET 24461)	WB, Asom and Tripura	Suitable for Boro cultivation, yield: 55–60 q/ha, medium bold seeds, maturity: 145–155 days, resistant to blast, BLB, sheath blight and stem borer, tolerant to cold in vegetative phase.
BRRI Dhan 75 (Hua 565) (IET 24459)	WB, Asom and Tripura	Suitable for irrigated condition, yield: 45–50 q/ha, long bold, maturity: 110–120 days, moderate resistance to blast, BLB, sheath blight, stem borer, BPH, GLH.
Pusa Samba 1850 (IET 25480) (Pusa 1850-27)	Chattisgarh and Odisha	Suitable for irrigated, high fertility and *kharif* season, maturity: 140–145 days, yield: 47.70 q/ha, it is a MAS derived rice variety, highly resistant to blast.

Variety	Area of adoption	Salient features
ADT 51 (AD 09367) (IET 23617)	Tamil Nadu	Suitable for semi-dry and transplanted cultivation in samba season (August sowing) in Cauvery delta districts of Tamil Nadu, for both direct seeding (Semidry) and transplanting, yield: 65.33 q/ha, medium slender grains, maturity: 150–160 days, resistant to blast, yellow stem borer and leaf folder.
KHP-13 (Bharath) (IET 21479)	Karnataka	Suitable for lowland situations of Hill Zone of Karnataka, yield: 50 to 55 q/ha, medium slender grains, maturity: 165–170 days, non-lodging and blast tolerant.
KKP 5	Karnataka	Suitable for irrigated area of southern Karnataka, yield: 80–85 q/ha, high yielding, medium slender grain, maturity: 130–135 days, resistant/tolerance to blast, BLB and BPH.
Pradeep (IET 20923) (OR 2327-23)	Odisha	Suitable for rainfed and irrigated medium lands, yield: 50 q/ha, long slender, maturity: 125–135 days, moderately resistant to leaf blast, sheath blight, sheath rot and whorl maggot.
Pratibha (IET 21582) (OR 2172-7)	Odisha	Suitable for rainfed and irrigated medium lands, yield: 52 q/ha, long slender, maturity: 120–130 days, resistant to leaf blast, brown spot and sheath rot.
Gomati Dhan (TRC-2005-1) (TRC-05-8-4-42-8-3-7) (IET 21512)	South Tripura, West Tripura and Dhalai districts of Tripura	Suitable for rainfed shallow lowland and irrigated land in *kharif*, yield: 58–60 q/ha, medium slender grain with very good cooking quality, completely free from chalkiness, maturity: 130–135 days.
Khowai (TRC 2005-3) (TRC 05-2-6-4-39-3-6)(IET 21564)	South Tripura, West Tripura and Dhalai districts of Tripura	Suitable for rainfed shallow lowland in *kharif* and irrigated land in *boro* season, yield: 54–56 q/ha, maturity: 130–135 days.
Wheat		
KRL 283	Uttar Pradesh	Suitable for timely sown, irrigated conditions salt affected soils of UP. yield: 20.9 q/ha, maturity: 134–144 days, resistant to leaf blight, karnal bunt and hill bunt.
DBW 168	Maharashtra and Karnataka	Suitable for timely sown, irrigated conditions, yield: 47.46 q/ha, maturity: 95–141 days (Avg. 115 days), resistant to brown and black rusts.
DBW 173	Punjab, Haryana, Delhi, Rajasthan (excluding Kota and Udaipur division), Western UP (except Jhansi division), Jammu and Kathua district of J and K, Paonta Valley and Una district of HP and Tarai region of Uttarakhand	Suitable for irrigated, late sown conditions, yield: 47.2 q/ha, heat tolerant, high protein (12.5%), high Fe (40.7 ppm) and Zn (33.1 ppm), maturity: 106–138 days (Avg. 122 days), resistant to yellow and brown rusts.
UAS 375	Maharashtra and Karnataka	Suitable for timely sown, rainfed conditions, yield: 21.4 q/ha, high protein (13.8%), maturity: 97–117 (Avg. 103) days, resistant to brown and black rusts and Karnal bunt.
Pusa Wheat 1612 (HI 1612)	Eastern UP, Bihar, Jharkhand, WB (excluding hills), Odisha, Asom and plains of other North Eastern States	Suitable for timely sown, restricted irrigated conditions of NEPZ, yield: 37.6 q/ha, high protein content (11.5%), maturity: 113–144 (Avg. 125) days, tolerant to heat stress, resistant to stripe, leaf rusts, leaf blight and loose smut.
MACS 4028 (d)	Maharashtra and Karnataka	Suitable for rainfed, low fertility, timely sown conditions in Peninsular zone, yield: 19.3 q/ha, high protein (14.7%), iron (46.1 ppm) and zinc (40.3 ppm), maturity: 99–105 (102) days, resistant against stem and leaf rusts, foliar aphids, root aphids and brown wheat mite.

Variety	Area of adoption	Salient features
Pusa Wheat 8777 (HI 8777)	Maharashtra and Karnataka	Suitable for rainfed timely sown conditions in Peninsular zone, yield: 18.5 q/ha, high levels of essential micronutrients like iron and zinc etc. maturity:105–110 (108) days, tolerant to heat stress, stem rust, leaf rust, Karnal bunt, loose smut, flag smut and foot rot.
HUW 669 (Malviya 669)	Uttar Pradesh	Suitable to late sown, rainfed/limited irrigation condition, yield: 24.1 q/ha, maturity: 130–140 days, drought tolerant, resistant to all the three rusts, leaf blight, lodging, having fertilizer responsiveness.
Chhattisgarh Genhu 3 (CG 1013)	Chhattisgarh	Suitable for irrigated timely sown conditions, yield: 33.37 q/ha, high hectolitre weight 78.1 kg/litre, maturity: 119 days, resistance to brown rust.
UAS 334	Karnataka	Suitable for irrigated timely sown conditions, yield: 49.1 q/ha, good protein (13.3%) and zinc (43.1 ppm) content, maturity: 100–107 days, resistance to stem and leaf rust.
AAI-W9 (SHIATS-w9)	Uttar Pradesh	Suitable for irrigated late sown conditions, yield: 36–40 q/ha, maturity: 110 days, resistant to lodging, tolerant to higher terminal temperature (38°–40°C) of March/April, resistant to all the rust/diseases, viz. stripe rust, leaf rust, stem rust as well as smut, leaf blight and kernel bunt in field condition.
AAI-W10 (SHIATS-w9)	Uttar Pradesh	Suitable for timely sowing (15–30 November) under irrigated conditions, yield: 45–50 q/ha, maturity: 120 days, resistant to lodging, tolerant to higher terminal temperature (35°–40°C) of March/April, resistant to all the three rust, viz. stripe rust, leaf rust, stem rust as well as smut, leaf blight in field condition.
Barley		
K-1055 (Prakhar)	Uttar Pradesh	Suitable for irrigated timely sown condition, yield: 38.07 q/ha, maturity: 116–145 days (Avg. 132 days), tolerant to lodging and shattering, responsive to fertilizers, resistant to yellow, brown and black rusts and foliar blight.
Central Barley DWRB 137	Madhya Pradesh, Gujarat, Kota and Udaipur division of Rajasthan, UP, Bihar, Jharkhand, WB (excluding hills), Odisha, Asom and plains of NE states	Suitable for irrigated, timely sown condition in CZ and NEPZ, yield: 42.49 q/ha, maturity: 113–119 days (Avg. 115 days), lodging resistant, resistant to yellow, brown and stripe rust.
RD 2899	MP, Gujarat, Chhattisgarh, Kota and Udaipur division of Rajasthan, Jhansi division of UP	Suitable for timely sown irrigated conditions, yield: 42.19 q/ha, high yielding, feed barley variety, maturity: 110–120 days, rust resistant.
RD 2907	Punjab, Haryana, Delhi, Rajasthan, Western UP, Parts of J&K and HP	Suitable for timely sown irrigated, saline in alkaline area of NWPZ and NEPZ, yield: 35.54 q/ha, high yielding, feed barley variety, maturity: 119–130 days, rust resistance.
Maize		
Gujarat Anand White Maize Hybrid-2 (GAWMH 2)	Gujarat	Suitable for middle Gujarat Agro climatic Zone-III under rainfed *kharif* conditions, yield: 39 q/ha, fulfils food and nutrition security in tribal belt where white maize is preferred, maturity: 80–85 days, tolerant to stem borer (*Chilo partellus*).
Shaktiman-5(MHQPM 09-08) Hybrid	UP, Bihar, Jharkhand, WB, Odisha and Chhattisgarh in both *kharif* and *rabi*	Suitable for rainfed, *kharif*, yield: 105 q/ha. 9.4% protein, high lysine and tryptophan (0.6% of total protein), maturity: 100 days, tolerant to TLB and MLB.

Variety	Area of adoption	Salient features
CP 999 Hybrid	Karnataka, TN, Telangana and Maharashtra	Suitable for *rabi* under irrigated, high fertility and good management condition, yield: 85 q/ha, maturity: 107–109 days, moderately resistant against LIR/ *S. inferens* under field condition and major insects of *rabi*.
CP 838 Hybrid	Punjab, Haryana, UP, Plain Uttrakhand, Bihar, Jharkhand, WB, Odisha, Karnataka, TN, Telangana, AP, Maharashtra, Rajasthan, Gujarat	Suitable for *rabi* under irrigated, high fertility and good management condition, yield: 87–112 q/ha, maturity:105–110 days, highly resistant to major *rabi* insect *S. inferens* under natural field condition.
MH 9344 (DMH 192) Hybrid	Karnataka, Maharashtra, Andhra Pradesh, Tamil Nadu and Telangana	Suitable for irrigated, *kharif* conditions, yield: 91 q/ha, high plant density, performed exceedingly well under different spacing and fertilizer doses, maturity: 115–120 days, tolerant to moisture stress, highly responsive to high fertilizer and resistant to common rust and charcol rust.
ADV-756 (ADV 0990296) Hybrid	Karnataka, Maharashtra, AP, TN, Telangana, Rajasthan, Gujarat, MP and Chhattisgarh	Suitable for irrigated and rainfed areas, yield: 71–93 q/ha, the hybrid shows better response to higher plant density and higher fertilizer dosage, maturity: 110–115 days, multiple disease resistance, resistant to *Curvularia* leaf spot (CLS).
HTMH 5108 Hybrid	Karnataka, Maharashtra, AP, TN and Telangana	Suitable for rainfed and irrigated ecology, yield: 97.21 q/ha, good response to high density, maturity: 112–114 days, resistant to lodging.
HTMH 5109 (HT 51412616) Hybrid	Karnataka, Telangana, AP, TN and Maharashtra	Suitable for irrigated, high and medium fertility soils, yield: 25 q/ha, good performance under moisture stress conditions, maturity: 118–120 days, grains tolerant to stored grain insect-pests.
Top Class (KMH 1411) Hybrid	Bihar, Jharkhand, WB, Odisha and Eastern UP	Suitable for early sown, irrigated *rabi* conditions with medium to high fertility soil, yield: 91.45 q/ha, responsive to inputs, maturity: 136–152 days (Avg. 146) days, non-lodging.
GK 3150 Hybrid	Rajasthan, Gujarat, Chhattisgarh and MP	Suitable for *rabi*, both high and low fertility conditions, yield: 95 q/ha, maturity: 124–132 (Avg. 130) days, tolerant to lodging, highly responsive to fertilizer. Resistant to *Sesamia inferens* (2.0).
GK 3155 Hybrid	Bihar, Jharkhand, Odisha, UP and for WB in *rabi*	Suitable for *rabi* under normal and high density planting, yield: 91 q/ha, fertilizer responsive, maturity: 145–150 days, tolerant to lodging, resistant to *Sesamia inferens* (3.4).
LG 34.05 (BL 900) Hybrid	UP, Bihar, Jharkhand, WB, Odisha, Maharashtra, Telangana, AP, Karnataka, TN, MP, Chhattisgarh, Gujarat, Rajasthan	Suitable for *rabi* in both high and low fertility conditions, yield:110–120 q/ha, medium, resistant to SDM, BLSB and C rust.
LG 34.04 (BL 147) Hybrid	UP, Bihar, Jharkhand, West Bengal and Odisha	Suitable for *rabi* in both high and low fertility conditions, yield: 91 q/ha, maturity: 110–120 days, resistant to C rust, TLB, SDM and BLSB.
JKMH 4222 (Hybrid)	Rajasthan, MP, Chhattisgarh, Gujarat	Suitable for both rainfed and irrigated condition of rainy and, in all types well drained soils, tolerant to rainfed and moisture stress condition, yield: 59.64 q/ha, maturity: 82–85 days, high level resistance to important diseases, i.e. *Fusarium* stalk rot, Rajasthan downy mildew, *Curvularia* leaf spot, tolerant to *Chilo partellus*.
DMRH 1305	J&K, HP, Uttarakhand (Hill region), Sikkim, Meghalaya, Asom, Tripura, Nagaland, Manipur and Arunachal Pradesh	Suitable for irrigated condition of rainy season, yield: 60 q/ha, maturity: 93 days, high level resistance to Curvularia leaf spot, tolerant to *Chilo partellus.*

Variety	Area of adoption	Salient features
IMHB 1532	Punjab, Haryana, Delhi, Uttarakhand, UP (NWPZ) and Rajasthan, Gujarat, MP and Chhattisgarh (CWZ)	Suitable for irrigated condition of rainy season, yield: 20 q/ha dehusked baby corn, maturity: 50–52 days, resistant to *Curvularia* leaf spot.
IMHB 1539	J&K, HP, Uttarakhand (Hill region), Meghalaya, Sikkim, Asom, Tripura, Nagaland, Manipur and AP	Suitable for irrigated condition of rainy season, yield: 13 q/ha dehusked baby corn, moderately resistance response to multiple disease, viz. MLB, TLB, C. Rot and BLSB and tolerant to *Chilo partellu.*
Pusa Super Sweet Corn 1 (ASKH4)	J & K, HP, Uttarakhand (Hill region), Meghalaya, Sikkim, Asom, Tripura, Nagaland, Manipur and AP (North Eastern Hill Region), Punjab, Haryana, Delhi, Uttarakhand (Plain), UP (Eastern and Western region), Bihar, Jharkhand, Odisha, WB, Maharashtra, Karnataka, AP, Telangana and TN	Suitable for irrigated condition of rainy season, yield: 75–98 q/ha dehusked cob, maturity: 78 days, resistance to Curvularia leaf spot.
MAH-14-5 Hybrid	Karnataka	Suitable for irrigated and rainfed conditions during *kharif* season, yield: 90–120 q/ha, maturity: 110–120 days, tolerant to Fusarium stalk rot, TLB and DM and drought.
Pearl millet		
AHB 1200 Fe (MH 2072 (AHB 1200) hybrid	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Maharashtra, Telangana, AP and TN	Suitable for rainfed condition of *kharif*, yield: grain yield 31.7 q/ha, fodder yield 70 q/ha, biofortified [high iron (77 ppm) and zinc (39 ppm)], bold grain, maturity: 78 days, highly responsive to fertiliser, drought tolerant but in stress require protective life saving irrigation. Resistant to major disease such as downey mildew and tolerant stem borer.
PB 1705 (MH 2008) Hybrid	Rajasthan, Gujarat, Haryana, Punjab, Delhi, MP and UP	Suitable for low to medium rainfall (rainfed), low to high fertility soil during *kharif*, dual purpose hybrid, yield: grain 36.4 q/ha and fodder 88 q/ha, responsive to fertilizers, suitable for early and late sowing conditions, high iron (49 ppm) and zinc (32 ppm). maturity: 79 days, lodging tolerant, moisture stress tolerant, resistant to DM, blast, rust, smut and ergot, tolerant to shoot fly, stem borer and drought.
HHB 299 (MH 2076)	Rajasthan, Haryana, Gujarat, Punjab, Delhi, Maharashtra and TN	Suitable for *kharif* with high grain and dry fodder yield potential, yield: grain yield 32.74 q/ha, dry fodder yield 73 q/ha, biofortified [high iron (73 ppm) and zinc (41 ppm)], dual pupose fertilizer responsive hybrid, maturity: 81 days, resistant to major diseases such as downey mildew, smut etc. major insect pests such as shoot fly, stem borer, grey weevil, leaf roller, *Helicoverpa* etc.
Central Pearl Millet Hybrid RHB 223 (MH 1998) (RHB 223)	Rajasthan, Gujarat and Haryana	Dual purpose hybrid with grain yield 29.69 q/ha and dry fodder yield 55 q/ha, fertilizer responsive, maturity: 71 days, highly resistant to downey mildew, blast and resistant to smut, major insect pests such as shoot fly, stem borer and grey weevil.
GK 1116 (MH 1974) hybrid	Rajasthan	Suitable for rainfed conditions during *kharif* and of Rajasthan state in both low and high fertility conditions, dual purpose hybrid, grain yield 32.75 q/ha and dry fodder yield 70.7 q/ha, highly responsive to fertilizers and suitable for both early and late planting, maturity: 81 days, tolerant to downey mildew, rust, smut, ergot and stem borer.
BHB-1202 (Bikaner Hybrid Bajra-1202) (MH 1831)	Rajasthan	Suitable for early and late planting under rainfed conditions in *kharif* and of arid region of Rajasthan, dual purpose hybrid, grain yield 17.76 q/ha and dry fodder yield 28 q/ha, maturity: 76 days, highly resistance to downy mildew, blast and major pests, tolerant to water stress, resistant to lodging.

Variety	Area of adoption	Salient features
Pusa 1201 (MH 1849)	NCT Delhi	Suitable for rainfed, *kharif* and for both high and low fertility conditions, dual purpose hybrid, grain yield 28.10 q/ha and dry fodder yield 72 q/ha, highly responsive to fertilizers, maturity: 79 days, highly resistance to downy mildew, smut, rust, stem borer, leaf roller, *Helicoverpa* and grey weevil.
Raj Bajra-1(RBB-1)	Rajasthan	Suitable for rainfed and irrigated conditions, grain yield 12–25 q/ha and green fodder yield 350–700 q/ha, 9.33% crude protein in green fodder on dry matter basis, maturity: 85 days, resistant to leaf spot disease, downy mildew and general insect pests.
MP 7878 (MH2155)	Gujarat, MP, Rajasthan, UP, Haryana, Punjab and Delhi	Suitable for *kharif*, dual purpose stay green hybrid, grain yield 41.81 q/ha, dry fodder yield 106 q/ha, maturity: 86 days, highly resistant to downy mildew, blast and smut.
PA 9072 (MH 2082) (PB 1756)	Western Rajasthan, drier Parts of Gurarat and Haryana	Dual purpose, early maturing, grain yield 27 q/ha, dry fodder yield 47 q/ha, maturity: 75 days, resistant to downy mildew, blast, smut, ergot, shoot fly and stem borer, tolerant to moisture stress and lodging.
PB 1720 (MH 2107)	Rajasthan, Gujarat, Haryana, Punjab, Delhi, UP, MP	Suitable for early/ late sowing, low to medium rainfall (rainfed), low to high fertility soil conditions during *kharif*, grain yield 33.4 q/ha, dry fodder yield 79 q/ha, maturity: 79–81 days, tolerant to shoot fly, stem borer, responsive to fertilizers, lodging tolerant.
Sorghum		
BJV 44 (SPV 2034)	Karnataka	Suitable for *rabi*, it is high grain and fodder yielding variety of *rabi* sorghum with grain yield 22–25 q/ha and fodder yield 50–60 q/ha, maturity: 120–123 days, it is moderately tolerant to charcoal rot, shoot fly and aphids and suitable for deep soils with adequate moisture situations.
AKJ 1 (Flaking variety)	Karnataka	Suitable for *rabi* sorghum growing areas of Karnataka, grain yield 12–15 q/ha and fodder yield 40–45 q/ha, having excellent flaking quality with additional benefit of presence of significantly high polyphenols, maturity: 120–123 days, high resistance to rice weevil.
KMJ 1 (Popping variety)	Karnataka	Suitable for *rabi* sorghum growing areas of Karnataka, grain rabi sorghum variety suitable for popping purpose (making pops or *aralu*) with good popping yield (75 kg per quintal of seeds), yield: 9–10 q/ha (grain) and 30–35 q/ha (fodder), maturity: 120–125 days, higher resistance to rice weevil.
SMJ 1 (Hurda variety)	Karnataka	Suitable for r*abi* sorghum growing areas of Karnataka, grain *rabi* sorghum variety suitable for making hurda/seethani/belasi (tender roasted grains) of good quality very soft sweet, with additional benefit of presence of high micronutrients (iron and zinc) and high polyphenols, the variety yields fresh hurda grains of 7.5 to 8.5 q/ha, dried hurda grains of 4.5 to 5.5 q/ha and matured grains of 7–8 q/ha, maturity: 120–125 days.
SR 2917 (GNJ-1)	Gujarat	Suitable for *kharif* sorghum growing area of Gujarat, yield: 34 q/ha, maturity: 114 days, resistant to grain mold with less incidence of ergot disease and stem borer.
CSH 36F (Dairy Green) (SPH 1752) DFSH 109) Hybrid	Punjab, Haryana, UP, Uttarakhand, Rajasthan and Gujarat	Suitable for irrigated, medium to high soil fertility condition under normal sowing, green fodder yield 642 q/ha, dry fodder yield 169 q/ha, protein 11.4 q/ha, digestible dry matter 77.5 q/ha, maturity: 115–120 days, tolerant to lodging and fertilizer responsive, resistant to grey leaf spot, tolerant to shoot fly dead hearts and stem borer dead hearts.

Variety	Area of adoption	Salient features
CSH 38 (HTJH 3301) (SPH 1779) Hybrid	TN, Gujarat, Telangana, Maharashtra, Karnataka, AP, MP, Rajasthan	Suitable for rainfed *kharif* with protective irrigation, grain sorghum hybrid, grain yield 45.57 q/ha, fodder yield 139.83 q/ha, maturity: 106 days, shoot fly and grain mold tolerant, non-lodging.
CSH 37 (HTJH 3208) (SPH 1778) Hybrid	TN, Gujarat, Telangana, Maharashtra, Karnataka, AP, MP, Rajasthan	Suitable for rainfed *kharif* with protective irrigation, grain sorghum hybrid, grain yield 46.83 q/ha, fodder yield 145.32 q/ha, maturity: 104–114 days, tolerant to downy mildew and grain mold under natural conditions, non-lodging, fertilizer responsive.
K 12	Tamil Nadu	Suitable for rainfed situation and also perform well during summer irrigated condition, yield: 31.0 q/ha, maturity: 95 days, non-lodging, non shattering
SPV 2217	Karnataka	Suitable for *rabi* and for deep soils of Karnataka, grain yield 15–18 q/ha, fodder yield 65–70 q/ha, bold and round grains with lustrous bright colour, stay green, maturity:124 days, tolerant to lodging and charcoal rot disease.
CSV 34 (SPV 2307)	Maharashtra, Karnataka, Madhya Pradesh and Gujarat	Suitable for timely sown rainfed conditions of *kharif*, grain yield 45 q/ha; stover yield 129 q/ha, grain protein 10.39%, starch 62.54%, maturity: 110–112 days, tolerant to grain mold, *Fusarium* and zonate leaf spot, tolerant to shoot fly, dead aphid hearts stem borer, non-lodging, non-shattering
Finger millet		
GPU 66	Karnataka	Suitable for late *kharif*, yield: 35–40 q/ha, green plant parts with narrow leaves, maturity: 112–115 days, resistant to neck and finger blast.
Vakula (PPR 2700)	Karnataka	Suitable for late *kharif*, yield: 25–30 q/ha, semi-dwarf plants, maturity: 105–110 days, resistant to leaf blast and tolerant to drought.
DHFM-78-3	Karnataka	Suitable for cultivation in Agro-climatic Zone-3 and 8 of Karnataka, yield: 30–35 q/ha, suitable for contingency planting, maturity: 115–120 days, resistant to finger and neck blast.
VL Mandua 379 (VL 379)	Uttarakhand, Bihar, Jharkhand and MP	Suitable for rainfed *kharif* ecology, fertilizer responsive, yield: 31–35 q/ha, maturity: 107–109 days, resistance to neck and finger blast, tolerant to ear head caterpillar incidence.
Chhattisgarh Ragi-2 (BR 36)	Chhattisgarh	Withstand better under water stress conditions, yield: 34–36 q/ha, responsive to nitrogen fertilizer, maturity: 115–118 days, non-lodging, tolerant to stem borer and other major pests.
Surya Nandi (SiA-3088)	Karnataka	Suitable for all foxtail millet growing areas of the country, yield: 20–25 q/ha, suitable for double cropping, maturity: 70–75 days, non-lodging
DHFt-109-3	Karnataka	Suitable for cultivation in agro-climatic Zone-3 and 8 of Karnataka, yield: 26–29 q/ha, suitable for contingency planting, maturity: 86–88 days.
Little millet		
DHML-36-3	Karnataka	Suitable for Karnataka, yield: 14–16 q/ha, late maturity (95–100 days).
GNV-3	Gujarat	Suitable for dry land/hilly/tribal region, yield: 28–29 q/ha, bold seeded multi-tillering little millet variety, has good nutritional properties particularly high minerals, crude fiber, calcium, phosphorus, iron and magnesium, maturity: 110–115 days, non-lodging, resistant to leaf, neck and panicle blast disease as well as to grain smut and sheath blight.

Variety	Area of adoption	Salient features
Proso millet		
DHPM 2769	Karnataka	Suitable for cultivation in Agro-climatic Zone-3 and 8 of Karnataka, yield: 23–25 q/ha, suitable for contingency planting, maturity: 70–72 days.
Barnyard millet		
MDU 1	TN	Suitable for *kharif*, *rabi* and summer. yield: 15–17 q/ha, maturity: 95–100 days, non-shattering
DHBM 93-2	Karnataka	Suitable for cultivation in agro-climatic Zone-3 and 8 of Karnataka, yield: 25–27 q/ha, suitable for contingency planting, maturity: 86–88 days

Oilseeds

Forty-nine high yielding oilseeds varieties comprising seven each of rapeseed–mustard and linseed, 11 of groundnut, 10 of soybean, four of sesame, three each of safflower and sunflower and four of castor were released for different agro-ecological regions. Description of selected improved released varieties/ hybrids is given below.

Improved released varieties/hybrids of oilseeds

Variety	Area of adoption	Salient features
Indian mustard		
RH 725	Jammu, Punjab, Haryana, Delhi and Northern Rajasthan	Suitable for timely sowing and rainfed conditions in *rabi*, yield: 20.02 q/ha, maturity: 141 days, moderately resistant to *Alternaria* leaf blight, white rust and aphid infestation.
CS 60 (CS2800-1-2-3-5-1)	Haryana, Punjab, Uttar Pradesh and Rajasthan	Suitable for timely sown, salt-affected soil and water conditions of *rabi*, yield: 18 q/ha, maturity: 134 days, resistant to *Alternaria* blight, WR, PM, DM, stag head and SR.
Toria		
Tapeshwari (TK 06-1)	Uttar Pradesh	Suitable for rainfed, irrigated areas and recommended for extra early sowing, i.e. mid September, yield: 13.5–14 q/ha, maturity: 90–95 days, tolerant to drought and fog, being extra early maturity, it escapes diseases especially *Alternaria* blight, aphid and white rust.
Tripura Toria 1 (TRC T-1-1-5-1/ IC 615573)	Tripura	Suitable for rainfed upland and lowland after *kharif*, yield: 8–9 q/ha, perform well under residual moisture after *kharif* rice, also as utera crop, maturity: 86 days, resistant to lodging, exhibits very low incidence of white rust, *Sclerotinia* rot, bacterial stem rot and aphid.
Brown sarson		
HPBS-1	Himachal Pradesh	Suitable for rainfed farming in late September–October in low and mid hills of Himachal Pradesh, yield: 10 to 12 q/ ha, maturity: 147 days, moderately resistant to white rust.
Groundnut		
GJG 33 (Gujarat Junagadh Groundnut 33)	Andhra Pradesh, Telangana and Tamil Nadu	Suitable for timely sown, *rabi*-summer conditions, kernel yield: 20.4 q/ha, high oil (51%), maturity: 113 days, tolerant to stem rot, collar rot, dry root rot; foliar fungal (rust, early leaf spot) and peanut bud necrosis diseases (PBND). Tolerant to *Helicoverpa* and *Spodoptera* leaf damage.
ICGV 93468 (Avtar)	Uttar Pradesh	Suitable for irrigated, summer season, yield: kernel yield 16.9 q/ha, high oil (51%), maturity: 85–95 days, tolerant to PBND and jassids.
Nitya Haritha (TCGS 1157)	Zone III (Maharashtra and Madhya Pradesh)	Suitable for rainfed/ supplementary irrigated kharif conditions, timely sown, kernel yield: 18 q/ha, maturity: 105–110 days, tolerant to rust, late leaf spot and PBND.

Variety	Area of adoption	Salient features
DH 232	Karnataka	Suitable for *kharif*, kernel yield: 14.8–23.4 q/ha, oil content (46.9%), maturity: 105–110 days, tolerant to rust, and late leaf spot diseases.
DH 245	Karnataka	Suitable for *kharif*, kernel yield: 14.8–23.4 q/ha, oil content (45.9%), maturity: 105–108 days, tolerant to rust, late leaf spot diseases.
Soybean		
Jawahar Soybean 20-98 (JS 20-98)	MP, Bundelkhand region of UP, Rajasthan, Gujarat, Marathwad and Vidarbha region of Maharashtra.	Suitable for medium to high rainfall normal sowing conditions, yield: 20.9 q/ha, maturity: 99 days, resistant to charcoal rot and YMV disease.
Chhattisgarh Soybean-1 (CG SOYA-1)	Chhattisgarh	Suitable for soybean growing areas of Chhattisgarh, yield: 21.3 q/ha, maturity: 104 days, resistant to Indian bud blight, *Myrothecium* leaf spot and bacterial pustule disease.
Kota Soya 1 (RKS 113)	Asom, WB, Jharkhand, Chhattisgarh and North Eastern States	Suitable for rainfed condition under assured rainfall in *kharif*, yield: 18.8 q/ha, maturity: 102 days, resistant to YMV disease, good germinability and tolerant to pod shattering.
DSb. 23 (DSb 23-2)	Karnataka, TN, Telangana, AP, and Southern Maharashtra	Suitable for rainfed and irrigated conditions, yield: 24.4 q/ha, maturity: 95 days, highly resistant to soybean rust caused.
KS 103	Southern Maharashtra, AP Karnataka, Telangana, TN	Suitable for irrigated and rainfed *kharif*, yield: 25.4 q/ha, maturity: 92 days, resistance to field rust and pest complex.
MAUS 612	Maharashtra and Southern India.	Suitable for assured rainfall of 700 to 1000 mm with medium to heavy soil, yield: 25.3 q/ha, maturity: 91 days, moderately resistant to charcoal rot.
Basara (ASb-22)	Telangana	Suitable for rainfed *kharif*, yield: 26.6 q/ha, maturity: 105–115 days.
NRC 127	MP, Rajasthan, Bundelkhand region of UP, Gujarat, Marathwada and Vidarbha region of Maharashtra	Suitable for rainfed, normal sowing time, yield: 18.1 q/ha, maturity: 102 days, shown promising resistance against pod borer, Lepidopteran defoliators and pest complex.
Linseed		
Jawahar Linseed Sagar 95 (JLS 95) (SLS 95)	Bundelkhand part of UP, Rajasthan, MP and Central Peninsular India	Suitable for rainfed farming, yield: 10.1 q/ha. maturity: 113–133 days, resistant to rust and moderately resistant to wilt.
Utera Alsi (RLC-143)	Chhattisgarh, Odisha, MP, Bihar, Jharkhand and Asom	Suitable for moisture stress *rabi*, i.e. rice based relay cropping ecosystem, yield: 5.7 q/ha, maturity: 118 days, moderately resistant to linseed bud fly.
Sabour Tisi-1(BAUP-101)	Uttar Pradesh excluding Bundelkhand, Bihar, Jharkhand, West Bengal and Asom	Suitable for timely sown under utera/rainfed/high/low fertility condition during *rabi* season, yield: 6.86 q/ha, maturity: 120–122 days, moderately resistant to *Alernaria* blight and budfly.
Varsha Alsi (RLC 148)	Rajasthan, MP, Bundelkhand region of UP, Odisha, Maharashtra, Chhattisgarh and Karnataka	Suitable for rainfed cultivation, yield: 10.33 q/ha, maturity: 114 days, moderately resistant to powdery mildew and bud fly.
Him Palam Alsi-2 (KL-263)	Himachal Pradesh, Haryana and J&K	Suitable for cultivation in irrigated areas, yield: 16.89 q/ha, resistant to rust, moderately resistant to powdery mildew and bud fly.
Sesame		
VRI 3	Tamil Nadu	Suitable for irrigated tracts of *rabi* and summer seasons, yield: 8.5–9.5 q/ha, maturity: 75–80 days, moderately resistant to *Macrophomina* disease, capsule borer pest in all the stages of the crop.

Variety	Area of adoption	Salient features
Tripura Siping Borok (TRC Til 1-8-1-1)	Tripura	Suitable for both summer as well as late *kharif*, yield: 13–14 q/ha, maturity: 83 days, tolerant to *Phytopthora* blight.
Suprava (CUMS 17)	WB, Odisha, Maharashtra, Chattisgarh, Telangana, TN and Karnataka	Suitable for irrigated, summer crop, superior performance under timely, early and late sown conditions with very low reductions in seed yield and other agronomic parameters, yield: 9–12 q/ha, oil content 48–50%, maturity: 88–92 days, highly resistant to diseases like root rot, phyllody and powdery mildew, suitable for high heat and drought situation.
Sunflower		
DSFH 3 Hybrid	Karnataka	Suitable for *rabi*, yield: 18–20 q/ha, seed has a high oil content of 38–39%, maturity: 95–98 days.
LSFH 171 Hybrid	Maharashtra, Karnataka, TN, AP, Telangana, Odisha, Bihar and West Bengal	This hybrid is resistant to downy mildew, yield: 18–20 q/ha, maturity: 95–100 days
COH 3	TN	Suitable for both *kharif* and *rabi*, yield: *kharif* 16.13 q/ha, *rabi* 18.22 q/ha, maturity: 90–95 days
Safflower		
NARI 96 hybrid	Maharashtra, Telangana, AP, MP, Chhattisgarh and Rajasthan	Suitable for early and timely sowing irrigated conditions, yield: 20.23 q/ha, oil yield 6.74 q/ha, maturity:116–165 days, non-lodging, non-shattering, and fertilizer responsive, tolerant to safflower wilt (*Fusarium oxysporum*) and moderately tolerant to aphids.
DSH 185	Safflower growing areas of India for both rainfed and irrigated situations	Suitable for rainfed and irrigated ecology, yield: 21 q/ha (irrigated), 14.3 q/ha (rainfed), maturity: 121 days (rainfed), 139 days (irrigated), non-shattering, spiny and fertilizer responsive, resistant to wilt and moderately resistant to *Fusarium* wilt and aphid infestation.
Purna (PBNS 86)	Maharashtra	Suitable for both rainfed and irrigared condition, yield: 18–20 q/ha (irrigated), 10–12 q/ha (rainfed), oil content 30%, maturity: 135 days, moderately tolerant to wilt, *Alternaria* and aphids.
Castor		
GCH 8 (SHB 896)	All castor growing states of the Country	Suitable for irrigated as well as rainfed conditions, yield: oil yield 1,718 kg/ha, seed yield (rainfed) 1895 kg/ha, irrigated 3,588 kg/ha, oil content 48.6%, maturity: 96–126 days, resistant to *Fusarium* wilt and root rot.
Gujarat Castor Hybrid 9 (GCH-) (JHB 1018)	Gujarat	This variety contains high ricinoleic acid (90.23%), yield: 37.8 q/ha, maturity: 180–210 days, resistance to *Fusarium* wilt and *Macrophomina* root rot.

Pulses

Forty-seven high-yielding varieties of pulses comprising five of chickpea, eight of mungbean, six of urdbean, eight of pigeonpea, five each of lentil, fieldpea and cowpea, one each of rajmash, clusterbean, mothbean and two of Indian bean were released for different agro-ecological regions. Description of selected improved released varieties/ hybrids is given below.

Improved released varieties/hybrids of pulses

Variety	Area of adoption	Salient features
Chickpea		
Pusa 3043 (BG 3043)	Bihar, Jharkhand, West Bengal, Asom and Eastern Uttar Pradesh	Suitable for timely sown, *rabi*, irrigated condition in the North East Plain Zone, yield: 16 q/ha, grain protein content 21.1%, maturity: 130 days, capable of escaping terminal drought and heat stresses, moderately resistant to *Fusarium* wilt and tolerant to dry root rot, collar rot, stunt, *Ascochyta* blight and *Botrytis* grey mold.

Variety	Area of adoption	Salient features
Awadh (GNG-2207)	Asom, WB, Jharkhand, Bihar, Eastern UP, Manipur	Suitable for timely sown irrigated conditions of *rabi* season, yield: 16–17 q/ha, maturity: 99–145 days, moderately resistant to *Fusarium* wilt.
Phule Vikrant (Phule G 0405)	Maharashtra, West Madhya Pradesh, Gujarat and South Rajasthan	Suitable for optimum sown irrigated condition, yield: 20–21 q/ha, maturity: 110 days, moderately resistant to *Fusarium* wilt.
BGD 111-1	Karnataka	Yield: 16–17 q/ha, *desi* type, maturity: 95 days, moderately resistant to *Fusarium* wilt and tolerant to dry root rot.
Mungbean		
Arun (KM 2328)	UP	Suitable for summer season, timely sown condition, yield: 8–11 q/ha, protein 25.2%. maturity: 60–62 days, resistant against MYMV, *Cercospora* leaf spot, WB, MB and anthracnose.
Pusa 1431	Delhi and adjoining areas of Haryana, Rajasthan and UP	Suitable for early plantings after harvest of mustard and potato in spring season, yield: 13–14 q/ha, maturity: 56–66 days, resistant against MYMV, *Cercospora* leaf spots (CLS), anthracnose, web blight and urdbean leaf crinkles (ULCV), resistant to bruchids.
Gujarat Anand Mung Bean-5) (GAM-5)	Gujarat	Suitable for Gujarat, summer season under irrigated condition, yield: 8.11 q/ha, bold seeded, maturity: 60–65 days, highly resistant to Yellow Mosaic Virus (YMV).
Tripura Moong-1	Tripura	Suitable for *kharif*, yield: 10–11 q/ha, early maturing, medium bold seed, moderately resistant to MYMV, CLS, *Anthracnose* and resistant to powdery mildew.
GM-6 (NMK-15-12)	Gujarat	Suitable for *kharif* and summer season cultivation in Gujarat state, yield: 950–1050 kg/ha, early maturing, highly resistant to MYMV, resistant to *Anthracnose*, powdery mildew and whitefly.
Varsha (IPM 2K 14-9)	UP	Suitable for *kharif*, yield: 10–11 q/ha, maturity: 70–75 days, resistant to MYMV and CLS.
Kanika (IPM 302-2)	UP	Suitable for *kharif* and spring seasons, yield: 10–12 q/ha, maturity: 70 days, highly resistant to MYMV and CLS.
Urdbean/Blackgram		
Mukundra Urd-2 (KPU 405)	Rajasthan, Haryana, Punjab, plains of HP and Uttarakhand	Suitable for spring season in NWPZ, yield: 9.42 q/ha, resistant to MYMV.
ADT 6	TN	Suitable for rice fallow conditions (December–January), yield: 7.41 q/ha, maturity: 65–70 days, moderately resistant to leaf crinkle virus, powdery mildew and less pod borer damage.
Blackgram KKM 1 (COBG 643/VBN 3)	TN	Suitable for irrigated (*kharif*) and rice fallow conditions, yield: 6.07 q/ha, maturity: 65–70 days, tolerant to root knot nematode, moderately resistant to YMV.
VBN 8 (VBG 09-005)	AP, TN, Karnataka and Odisha	Suitable for summer, irrigated condition, yield: 13.29 q/ha, bold seeded with 21.9% protein and 7.5% arabinose, suitable for idli and vada preparation, maturity: 65–75 days, resistant to yellow mosaic virus, leaf crinkle virus, leaf curl virus, stem necrosis; free from powdery mildew and *Cercospora* leaf spot and moderately resistant to root rot.
Tripura Maskalai	Tripura	Suitable for *kharif*, yield: 11–12 q/ha, maturity: 75–80 days, moderately resistant to MYMV, CLS, Anthracnose and resistant to powdery mildew.

Variety	Area of adoption	Salient features
Pigeonopea/Red gram		
GRG 811 (Dharamaraj)	Karnataka	Suitable for deep black cotton soil, maturity: 170 days, drought resistant, resistant to wilt and sterility mosaic disease.
CO 8	TN	Suitable for rainfed/irrigated condition, yield: 13.14 q/ha, maturity:170–180 days, resistant to sterility mosaic disease and root rot, moderately resistant to *Helicoverpa* and *Maruca*.
GNP-2 (BP-06-33)	Gujarat	Suitable for *kharif* in south and north Gujarat, yield: 12.55 q/ha, this is the first dual purpose (grain and vegetable) variety of the Gujarat state, medium maturity, moderately tolerant for pod fly, pod borer and moderately resistant to wilt and SMD.
Pusa Arhar 16 (PADT 16)	NCR Delhi	Suitable for sole cropping, irrigated condition, yield: 20.2 q/ha, maturity: 120 days, resistant to lodging, disease incidence not experienced, suitable for growing of mustard/wheat/potato after its harvest.
Gujarat Tur 103 (GT 103)	Gujarat	Seeds of the variety are bold and attractive, yield: 15 q/ha, medium maturity: resistant to wilt and insect pest.
BRG 3	Karnataka	This variety is resistant to wilt and SMD diseases, yield: 18–20 q/ha, maturity: 160–170 days.
Lentil		
L 4727	MP, Maharashtra, Chhattisgarh and parts of Rajasthan	Suitable for *rabi*, rainfed conditions, yield: 11.4–14.4 q/ha, protein content 26.47%, maturity: 93–120 days, moderately resistant to wilt and exhibits lower pest incidence.
Kota Masoor 2(RKL 14-20)	MP, Maharashtra, Chhattisgarh and parts of Rajasthan	Suitable for rainfed, normal sown, *rabi* cultivation, yield: 12.13 q/ha, maturity: 100 days, tolerant to drought and high temperature, moderately resistant to wilt and very less incidence of pod borer and aphids.
IPL 220	Eastern UP, Bihar, Asom and WB	Suitable for rainfed, *rabi*, yield: 13.78 q/ha, biofortified variety having high concentration of Fe, Zn and Se, Maturity:121 days, resistant to major diseases including rust, *Fusarium* wilt and *Stemphylium* blight.
Field pea		
Pant Pea 250	Punjab, Haryana, Northern Rajasthan, Western UP and Uttarakhand	Suitable for both rainfed and irrigated situation of *rabi*, yield: 16.88 q/ha, protein 29.84%, maturity: 124 days, resistant against powdery mildew and moderately resistant to rust, *Ascochyta* blight and root rot diseases, tolerant to pod borer.
Pant Pea 243	MP, Chhattisgarh, Maharashtra and parts of Rajasthan	Suitable for both rainfed and irrigated situation of *rabi*, yield: 19.48 q/ha, protein 27.33%, maturity: 109 days, resistant to powdery mildew and moderately resistant to rust, *Ascochyta* blight and root rot diseases, tolerant to pod borer.
Central Field pea IPFD 2014-2	MP, Chhattisgarh, Maharashtra and parts of Rajasthan	Suitable for both rainfed and irrigated situation of *rabi*, yield: 22.7 q/ha, maturity: 102 days, resistant to powdery mildew and moderately resistant to pod borer, aphid and leaf miner.
TRCP-9	Tripura and other states of northern hilly zone	Suitable for both rainfed and irrigated situation of *rabi*, yield: 17–18 q/ha, protein content: 20.89%, maturity: 93–95 days, multiple disease resistance to powdery mildew and rust, good tolerance to pod borer and stem fly.

Variety	Area of adoption	Salient features
Cowpea		
Karan Chanwla 1 (CPD 119)	Rajasthan	Suitable for rainfed/irrigated condition, yield: 7.99 q/ha, maturity: 70 days, tolerant to moisture stress, non-shattering, resistant to moderately resistant against mosaic, necrosis, root rot and CLS, low incidence of pod borer, aphids and leaf hopper.
GC 6 (GC 521)	Gujarat	Suitable for summer cowpea growing area of north Gujarat, yield: 10.77 q/ha, early maturity, lesser infestation for root rot, YMV, leaf curl, leaf hopper and whitefly etc.
TC-901	Gujarat, Rajasthan, MP, WB, Maharashtra and Uttarakhand	Suitable for summer season under timely sown condition with minimal irrigation, yield: 10.21 to 13.53 q/ha, high fodder yield (49.54 q/ha), maturity: 69–75 days, resistant to whitefly and tolerant to spotted pod borer.
KBC-9	AP, Karnataka, Kerala, TN and some part of the Odisha	Suitable for rainfed /irrigated condition, suitable for *in-situ* green manure/fodder after harvest, yield: 12–13.5 q/ha, maturity: 80–85 days, resistant to dry root rot and collar rot, moderately resistant to yellow mosaic virus.
VBN 3 (VCP 0 9-013)	TN	Yield: 10.13 q/ha under rainfed condition, contains 25.22% protein, maturity: 75–80 days, resistant to Bean Common Mosaic Virus, rust and anthracnose diseases, pod borers, viz. *Maruca vitrata, H. armigera* and pod bug.
Rajmash/ French bean		
Kota Rajmash 1 (RKR 1033)	Gujarat, Maharashtra, and Southern Rajasthan	Suitable for *rabi* in irrigated and high fertility condition, yield: 16.78 q/ha, maturity: 101 days, lodging resistant, non-shattering and responsive to fertilizer and irrigation, resistant to angular leaf spot and *Anthracnose* and tolerance to wilt, BCMV and *Alternaria* leaf spot, less incidence of aphids, whitefly and pod borer.
Moth bean		
RMO 2251 (MARUDHAR) RMO 225-1-6-3)	Rajasthan, Haryana, Gujrat, Punjab	In this variety, fodder remains green up to maturity, yield: 5–6 q/ ha, maturity: 63–67 days, good resistance against sucking pests like jassid and white fly, average incidence of YMV and moderately resistant to leaf crinkle virus in field condition.
Indian bean		
GNIB-22 (NIBD-14-01)	Gujarat	Suitable for late *kharif* to late *rabi* season cultivation in south Gujarat, yield: 43–50 q/ha, extra early maturity, suitable as intercrop in sugarcane, pigeonpea, highly resistant to MYMV and *anthracnose*, moderately resistant to aphid and pod borer.
Cluster bean		
Karan Guar 1 (RGr 12-1)	Rajasthan	Suitable for *kharif*, yield: 10.58 q/ha, maturity: 87 days, drought tolerant, lodging and shattering resistant, moderately resistant to bacterial blight, *Alternaria* blight, *Alternaria* leaf spot and root rot, minimum incidence of jassids/leaf fly observed.

Commercial crops

Forty-seven high-yielding varieties of commercial crops including 23 of cotton, two each of jute and kenaf, one each of mesta and sunhemp, and 18 of sugarcane were released for different agro-ecological regions.

Description of selected improved released varieties/ hybrids is given below.

Improved released varieties/hybrids of commercial crops

Variety	Area of adoption	Salient features
Cotton		
Gujarat Anand Deshi Cotton-2 (GADC-2)	Gujarat	Suitable for desi cotton growing areas of north-west agro-climatic zone V and Bhal and Coastal Zone VIII, yield :16.4 q/ha, it has recorded 45.4% ginning out turn, 24.2 mm 2.5% span length, 4.88 micronaire value and 19.3 g/tex tenacity (ICC mode).

Variety	Area of adoption	Salient features
Cotton CO 15 (TCH 1705)	Tamil Nadu, Andhra Pradesh and Karnataka under irrigated condition	Suitable for winter irrigated ecology, high density planting system, yield: 28.07 q/ha, maturity: 150 days, moderately resistance to jassids and *Alternaria* leaf spot, tolerant to leaf hopper.
BGDS 1063 (IC No.624101) UASR-COT-I	Gujarat, Maharashtra, Odisha, MP, AP, Telangana, Karnataka, TN	Suitable for irrigated (South Zone) and rainfed conditions (Central Zone), yield: 22.71 q/ha, maturity: 165–170 days, moderately resistant to *Alternaria* leaf spot, rust diseases, moderately tolerant to leaf hoppers.
SVPR 6 (TSH 04/115)	Andhra Pradesh, Telangana, Karnataka and TN	Suitable for irrigated areas of medium to high fertile soil of south zone states, yield: 25.3 q/ha, maturity:150–155 days, moderately resistant to bacterial leaf blight and *Alternaria* leaf spot, moderately resistant to leafhopper and white fly.
Nirmal-433 (NACH-433) hybrid	Maharashtra, MP, Odisha and Gujarat	Suitable for desi cotton growing area of Central Zone under rainfed/irrigated condition, suitable for timely sown rainfed conditions, yield: 22–30 q/ha, maturity: 160–165 days, non-lodging, drought tolerant, highly tolerant to bacterial leaf blight, *Alternaria* leaf spot/blight, grey mildew, *Myrothecium* leaf spot and leaf blight, highly tolerant to jassids and moderately tolerant to bollworm.
Cotton CO 16 (TCH 1777)	Gujarat, Maharashtra and MP	Suitable for winter irrigated ecology of central zone, yield: 20.36 q/ha, maturity:150 days, moderately tolerant to bacterial blight, grey mildew and leaf hopper.
Raj Vijay Kapas 67 (RVK 67) IH 67 (HR)	MP	Suitable for irrigated *rabi,* yield: 16–17 q/ha, maturity: 150 days, tolerant to jassids, aphids, bollworms; drought tolerant.
Suchitra (Central Cotton CCH 12-2)	Gujarat, Maharashtra, MP, Odisha	Suitable for irrigated conditions during *kharif,* yield: 17.67 q/ha, maturity: 150–160 days, moderately tolerant to jassids
Subiksha (CCH 4474)	AP, Karnataka and TN	Suitable for irrigated tracts during *kharif* under closer spacing, yield: 15.42 q/ha (normal spacing); 37.43 q/ha (closer spacing), maturity: 150 days, resistant to BLB and rust, tolerant to jassids and whitefly.
Phule Suman (RHH-1007)	Maharashtra, Madhya Pradesh and Gujarat	Suitable for irrigated, timely sown condition, yield: 23.06 q/ha, maturity: 160–170 days, resistant to aphids, thrips and whitefly while tolerant to jassids, leaf hopper and bollworms, highly responsive to fertilizer.
HS 292	AP, Telangana, TN and Karnataka	Suitable for irrigated areas, time for sowing from July–August, yield: 23.16 q/ha, maturity: 160–170 days, moderately resistant to lodging and shattering and responsive to fertilizers, moderately tolerant to biotic and abiotic stresses.
Gujarat Junagarh Cotton 102 (GJHV- 516)	Maharashtra, Gujarat and Madhya Pradesh	Suitable for irrigated and high fertility *kharif* ecology, yield: 19.55 q/ha, maturity: 170–200 days, resistant to BLB, Jassids.
Phule JLA 0603 (JLA 0603)	TN, Karnataka and AP	Suitable for rainfed conditions, yield: 15.15 q/ha, maturity: 160–180 days, moderately resistant to sucking pests and bollworms, resistant to jassids, BLB.
GN Cot.Hy-32 (GISV 267)	Gujarat	Suitable for cotton growing irrigated areas, yield: 22.01 q/ha, maturity: 160–185 days, moderately resistant to disease free for bacterial leaf blight (BLB), *Alterneria* leaf spot (ALS).

Variety	Area of adoption	Salient features
GN Cot.Hy 26 (GVHB 170)	Gujarat	Suitable for cotton growing rainfed areas, yield: 16.40 q/ha, maturity: 180–190 days, disease free for wilt and *Alternaria* leaf spot and resistant to bacteria blight, lower population of sucking pests.
GN Cot.Hy 29 (GBab 106)	Gujarat	Suitable for cotton growing rainfed areas, yield: 14.93 q/ha, maturity: 160–170 days, showed disease free reaction against wilt, sternaria leaf spot and bacteria blight, recorded below ETL population of sucking pests (Thrips, whitefly, jassids and mealy bug).
Jute		
Shweta (BCCC-1)	WB, Asom, Bihar and Odisha	Suitable for rainfed mid and high land where jute is cultivated followed by transplanted paddy, low and high fertility, yield: 27.5 q/ha, maturity: 120 days, tolerance to stem rot disease and insect pests like semilooper and Bihar Hairy Caterpillar.
NJ 7010 (Rani)	WB, Asom, Tripura, Odisha, Bihar and UP	Suitable for both rainfed and irrigated situation, pre-*kharif* (mid-March to mid-July), yield: 30.92 q/ha, maturity: 120–125 days, less susceptible to stem rot disease and Bihar Hairy Caterpillar.
Mesta		
JRR-17 (Ayush) (JRR-2012-1)	Odisha, Maharashtra, AP, Bihar and North eastern states	Suitable for adapted to rainfed HS mesta growing belt of the country, yield: 26.35 q/ha, finer fibre, maturity: 130–135 days, tolerant to foot and stem rot disease and insects like spiral borer, mesta mealy bug
Kenaf		
JBMP 3 (Priya) (JRK-2011-1)	AP, Maharashtra, WB, Odisha, Bihar and North eastern states especially Tripura	Suitable for adapted to rainfed, mesta growing belt of the country, yield: 26 q/ha, maturity: 120–130 days, resistant to Yellow Vein Mosaic disease.
Sugarcane		
CoVC 99463	Karnataka	Suitable for moisture stress conditions, yield: 60–70 tonnes/acre (1,483–1,730 q/ha), high yielding (70–80 tonnes/acre), high tillering, better quality, suitable for wide row planting, good ratooner, drought tolerant and good for jaggery making, maturity: midlate.
CoLK 09204 (Ikshu 3)	Punjab, Haryana, Uttarakhand, Rajasthan and Central and Western parts of UP	Suitable for irrigated and waterlogged condition, cane yield: 82.8 tonnes/ha and CCS yield: 9.30 tonnes/ha, a mid-late clone, non-lodging, non-flowering, better ratooning and nutrient responsive, maturity: mid-late (11–12 months), resistant to moderately resistant for red rot and smut.
CoPb 94 (CoPb 10181)	North West Zone comprising Punjab, Haryana, Rajasthan, Uttarakhand and Western and Eastern UP	Suitable for normal irrigated condition, sub-tropical climate, spring planting with recommended dose of fertilizers, yield: 84.87 tonnes/ha, high yielding, high sugared, mid-late maturing, maturity: mid-late (11–12 months), red rot resistant.
UP 09453	Eastern UP, Bihar, WB and Asom	Suitable for irrigated, normal fertility level, tolerant to stress. yield: 74.74 tonnes/ha, sucrose (%) in juice (17.90), CCS (8.76 tonnes/ha) and Pol (%) in cane (13.23), maturity: early, MR to major diseases and LS to major pests.
Sri Mukhi (CoA 11321)	AP	Suitable for assured irrigated, limited irrigated, late planted, rainfed, waterlogged and red rot prone areas. yield: 111.31 tonnes/ha, CCS (13.59 tonnes/ha), sucrose (%) in juice (17.16) and Pol (%) in cane (13.73), maturity: early, resistant to red rot, susceptible to smut and wilt, least susceptible to early shoot borer scale insect and highly susceptible to inter nodal borer.

Variety	Area of adoption	Salient features
Ikshu 4 CoLk 11206	Punjab, Haryana, Uttarakhand, Rajasthan, central and western parts of UP	Suitable for irrigated planting, yield: 91.50 tonnes/ha, high yielding and mid-late maturing commercial variety, good performance under moisture stress condition, maturity: mid-late, resistant to moderately resistant reaction to red rot and smut at all test centres.
Ikshu 5 CoLk 11203	Punjab, Haryana, Uttarakhand, Rajasthan, Central and Western parts of UP	Suitable for irrigated planting, high yielding, red rot resistant commercial variety, yield: 81.97 tonnes/ha, CCS (10.52 tonnes/ha), Sucrose (%) in juice (18.41) and Pol (%) in cane (13.44), maturity: mid-late, resistant to moderately resistant reaction to red rot and smut at majority of the centres, less susceptible to the main insect pests at most of the locations.
CO 06022 (06 Co 022)	Ecological conditions of TN and Puducherry	Suitable for normal conditions of Peninsular Zone as well as drought prone areas, yield: 105.23 tonnes/ha. CCS (13.76 tonnes/ha), sucrose (%) in juice (18.88), maturity: 10 months (300 days), early, moderately resistant to prevalent pathotype/races of red rot.
Bahubali (VCF 0517)	Karnataka	Suitable for irrigated areas of southern Karnataka, yield: 200–225 tonnes/ha, good ratoonability, deep rooting with moderate lodging, maturity: mid-late (12–14 months), resistant to foliar disease, less susceptible to leaf mite and internode borer.
Charchika (CoOr 10346)	Odisha	Suitable for non-lodging, well suited to irrigated uplands and medium lands, could also be grown in rice land with proper water management, yield: 100 tonnes/ha, maturity: mid-late (360 days), tolerant to waterlodging and moisture stress.

Forage and other crops

Twenty-nine high-yielding varieties/hybrids of forage crops comprising seven each of forage sorghum and oats, two of marvel grass, three of Anjan grass, two of berseem, and one each of napier bajra hybrid, Dhaman grass, forage cowpea, Aparajita, forage Sewan Grass, ricebean, lucerne and Kalingda were released for cultivation in different agro-ecologies. Description of selected released varieties/hybrids is given below.

Released varieties/hybrids of forage and other crops

Variety	Area of adoption	Salient features
Forage sorghum		
Gujarat Anand Forage Sorghum 11 (GAFS 11) Gujarat	Gujarat	Suitable for cultivation in the middle Gujarat, Bhal and North-West Zone under rainfed conditions, green fodder yield (GFY): 400 q/ha (single cut), it showed higher green forage, tall stature with non-lodging thin stem. In its reaction to anthracnose, zonate leaf spot and leaf blight diseases it was found comparable with checks.
Gujarat Anand Forage Sorghum 12 (GAFS 12) Gujarat	Gujarat	Suitable for rainfed, middle Gujarat, green fodder yield: 300 q/ha, and dry matter yield: 101 q/ha, tall and non-lodging, maturity:68–76 days.
Fodder Sorghum CO 31 (TNFS 0952) TN	TN	Suitable for multi cut, tolerant to mild drought, non-lodging, nonshattering, green fodder yield: 1920 q/ha.
CSV 35F (SPV 2317) (UTFS 85)	Delhi, Gujarat, Rajasthan, Uttarakhand, Haryana, UP, Punjab, MP, Maharashtra, TN, Karnataka	Suitable for cultivation during rainfed *kharif* season, high yielding, and single cut forage sorghum variety with good nutritional quality and good seed yielding ability, maturity: 120–125 days

Variety	Area of adoption	Salient features
CSH 40F (SPV 1797) (UTFSH 2)	Delhi, Gujarat, Rajasthan, Uttarakhand, Haryana, UP, Punjab, MP, Maharashtra, TN, Karnataka	Suitable for green and dry fodder production under rainfed/irrigated (if required) condition, in medium to high fertile soils during *kharif*, maturity: 72–75 days (flowering), 110–120 days (hard dough stage), tolerant to major shoot pests, viz. Shoot fly and stem borer under natural field conditions.
Napier bajra hybrid		
PBN 342 **(**Hybrid)	Punjab, Haryana, Rajasthan, Odisha, Asom, TN and Karnataka	It is an irrigated crop, yield: green fodder yield 940 q/ha, it is F_1 hybrid but clonally propagated through stem cuttings or rooted slips, non-seed setting, maturity: perennial, gives good production up to 4 years of planting, tolerant to major diseases and pest.
Marvel Grass		
Phule Marvel-1 (Marvel 90-4)	Maharashtra, Madhya Pradesh, UP and Gujarat	It is a perennial, rainfed grass of grassland and pasture land, can be cultivated as *kharif* crop, yield: green fodder yield 368.5 q/ha, dry matter yield 100.4 q/ha, higher crude protein yield 5 q/ha, maturity: 60–65 days, resistant to leaf blight, sucking pest and defoliants not observed throughout the year.
Bundel Marvel Grass 2013-2 (JHD 2013-2)	Punjab and Rajasthan	Suitable for cultivation during *kharif* for multicut system under rainfed and irrigated condition, yield: average green fodder yield 442.2 q/ha, average dry matter yield 153.1 q/ha, 7–8% protein, medium late, resistant to leaf blight, no major pest incidence observed.
Anjan grass		
Phule Madras Anjan 1 (RCC 10-6)	Punjab, Rajasthan, Gujarat, UP, Maharashtra,	It is rainfed (perennial) multi-cut crop variety, green fodder yield: 397.7 q/ha, dry matter yield: 111.6 q/h, and crude protein yield: 7.8 q/ha, good fodder quality, maturity: 50–55 days, resistant to leaf blight, tolerant to sucking pests and diseases.
CAZRI Anjan-358 (CAZRI 358)	Rajasthan	It is rainfed, *kharif* multicut crop variety, GFY 84.1 q/ha, average DMY 20 q/ha, crude protein 5–6%, maturity: perennial crop, highly drought tolerant, no major disease and pest infestation.
CAZRI Anjan 2178 (CAZRI 2178)	Rajasthan	It is rainfed *kharif* crop variety, GFY 108.4 q/ha, average DMY 38.4 q/ha, crude protein 5–6%, maturity: perennial crop, no major disease and pest infestation.
Dhaman grass (Anjan grass)		
Bikaneri Dhaman (RCCB 2)	Rajasthan	It is perennial rainfed *kharif* crop variety, yield: 150 q/ha (GFY), 35 q/ ha (DMY) under rainfed condition with irrigation, 5–6 cuttings of green fodder can be taken in one year, 6–7% protein, maturity: perennial, seed set in November after cessation of monsoon, no major disease or pest infestation.
Aparajita		
JGCT 2013-3 (Titli)	Maharashtra, Rajasthan, Punjab, Haryana, South UP, MP and Gujarat	It is a rainfed perennial legume, rich in crude protein content (20%), suitable for pastures, grasslands, yield: GFY: 250 q/ha, DFY: 61 q/ha, maturity: perennial, no major infestation of disease and pest.
Berseem		
Bundel Berseem Single Cut 1 (JBSC 1)	Maharashtra, Rajasthan, Punjab, Haryana, UP and MP	It is a single cut short duration forage variety grown under irrigated condition during *rabi* season, GFY: 153 q/ha, DMY: 60.0 q/ha, CPY potential 8.2 q/ha, average per day productivity is 1.8 q/ha, 18% CP, tolerant to major biotic stress.
Fodder cowpea		
CO 9 TN	Tamil Nadu	Suitable for irrigated condition throughout year, GFY: 250 q/ha, DMY 45 q/ha, seed yield: 8 q/ha, higher protein content (21.56%), reduced fibre portions

Variety	Area of adoption	Salient features
		confer increased digestibility, palatability and intake rate, maturity: shorter in duration (50–55 days); suited for intercropping with sorghum and maize, moderate field tolerant to drought, moderately resistant to yellow mosaic virus and resistant to major pests.
Forage sewan grass		
CAZRI Sewan 1 (CAZRI 30-5)	Rajasthan	It is a rainfed *kharif* perennial crop variety, GFY 156.8 q/ha and DMY 57.1 q/ha, 6–7% crude protein, maturity: perennial, highly drought tolerant, no major disease and pest infestation.
Oats		
Central Oat OS 403	Asom, Manipur, Odisha, WB, Eastern UP, Bihar, Jharkhand, Telangana, AP, Karnataka, TN, Haryana, Punjab, Uttarakhand and Rajasthan	Suitable for timely sown, normal fertility and irrigated conditions in *rabi*, yield: GFY 454.3–533.8 q/ha, DMY 92.0–108 q/ha, and seed yield 18.1–20.5 q/ha, 9–10% CP, moderately resistant to *Helminthosporium* leaf blight.
OL 1802-1 (Single cut)	Punjab, Haryana, Rajasthan, Uttrakhand	Suitable for timely sown, normal fertility, irrigated conditions in *rabi*, GFY: 530.1 q/ha, DMY: 97.3 q/ha, 9–10% CP.
OL 1769-1 (Single cut)	Western UP, Gujarat, Maharashtra, Madhya Pradesh, Chhattisgarh	Suitable for timely sown, normal fertility and irrigated conditions *rabi*, GFY: 487.8 q/ha, DMY: 102 q/ha, late maturing (157 days), moderately resistant to *Helminthosporium* leaf blight.
OL 1760 (Single cut)	TN, Telangana and AP	Suitable for timely sown, normal fertility and irrigated conditions *rabi*, GFY: 355 q/ha, seed yield: 10.5 q/ha, better nutritional quality in terms of CP and IVDMD, maturity: medium, moderately resistant to *Helminthosporium* leaf blight.
Bundel Jai 20122 (JHO 2012-2)	Telangana, AP, Karnataka and TN	Suitable for timely sown, normal fertility and irrigated conditions *rabi* season, GFY 354 q/ha, DMY: 80 q/ha, 10% CP, maturity medium (110 days).
Kilingada seed		
CAZRI Kalingada 1 (CAZJK 13-2) (Water Melon)	Arid zone of Rajasthan and Gujarat Rainfed	Suitable for rainfed *kharif*, seed yield: 3.5–4.5 q/ha, fruit yield: 125–150 q/ha, oil content: 28–30%, maturity: 90–95 days, suitable for low rainfall areas (< 300 mm), no serious disease and insect pest noticed.

Public sector Bt cotton varieties released

Twenty-one Bt cotton cultures containing the deregulated MON 531 event of *Cry 1 Ac* gene were evaluated at 18 locations across ICAR-CICR (Nagpur, Coimbatore and Sirsa) and SAUs of cotton growing states during 2016–17. Based on the agronomic performance, Cry toxin expression, reaction to sucking pests diseases and fibre quality parameters, eight were

ICAR-CICR Rajat Bt

ICAR-CICR Bt 14 (CPT 2)

Variety	Yield (kg/ha)	Fibre length (mm)	Fibre strength (g/tex)	Micronaire	State/Zone Recommended
ICAR-CICR Bt 6 (RS 2013)	3046	26.1	26.6	4.6	Haryana (I)
ICAR-CICR GJHV 374 Bt	2577	28.2	26.8	4.4	Maharashtra (R)
ICAR-CICR PKV 081 Bt	2743	28.5	27.9	3.9	Maharashtra (R)
ICAR-CICR Rajat Bt	2660	26.8	26.1	4.5	Maharashtra (R)
ICAR-CICR Suraj Bt	2407	29.1	26.0	4.3	Central Zone
ICAR-CICR Bt 14 (CPT-2)	3066	28.1	25.4	4.8	Maharashtra (R)
ICAR-CICR Bt 9 (SRI 1)	3109	25.7	25.5	4.4	Maharashtra (R)

I, Irrigated; R, rainfed

approved and released for commercialization. Seven of them were developed by ICAR-CICR and one (PAU-1) Bt was developed by PAU, Ludhiana.

Varieties developed through marker assisted selection: Seven varieties of rice, viz. CO 43 Sub-1 (IET 25676), DRR Dhan 51 (IET 25484), Punjab Basmati-4 (RYT 3404) (IET-25399), Punjab Basmati-5 (RYT 3432) (IET-26153), Ranjit Sub-1, Bahadur Sub-1, Pusa Samba 1850 (IET 25480) (Pusa 1850-27) have been developed by using the modern molecular tools. These varieties have resistance/tolerance to various biotic (blast and bacterial blight) and abiotic (flood/sub-mergence) stresses which has introgressed through marker assisted backcross breeding.

Quality enhancement

Biofortified varieties developed: Eight biofortified varieties of various crops including rice, wheat, maize, pearl millet and lentil have been released and notified during 2018. DRR Dhan 48 (IET 24555) and DRR Dhan 49 (IET 24557) are high zinc (25.2 ppm) rice varieties. Three wheat varieties, viz. MACS 4028 (d) [high protein (14.7%), iron (46.1 ppm) and zinc (40.3 ppm)], Pusa Wheat 8777 (HI 8777) [Iron (48.7 ppm), zinc (43.6 ppm)] and UAS-334 [high protein (13.3%) and zinc (43.1 ppm)] have also been released. Two pearl millet hybrids, viz. AHB 1200 Fe (MH 2072) (AHB 1200) hybrid [high iron (77 ppm) and zinc (39 ppm)] and HHB 299 (MH 2076) [high iron (73 ppm) and zinc (41 ppm)] and lentil variety IPL 220 with high concentration of Fe, Zn and Se have been released and notified.

Micro level tests for quality traits in wheat: Micro level tests were developed for gluten strength and yellow pigment content. These tests are very useful in predicting the quality in early segregating generations when small quantity of materials is available and short time is left in between next sowing. These methods are rapid; require relatively small amounts of grain, wheat meal, or flour; and provide information that can be used to improve the end use quality potential of breeding material.

Processing quality of nutrient rich pearl millet: To simulate model for optimizing the biochemical conditions associated with low rancidity. To identify superior varieties/hybrids with better processing quality based on the simulated model. Mapping the micronutrient concentration in diverse population of pearl millet grains. Characterizing the effect of Fe/Zn on storability of pearl millet flour. Whole transcriptome sequencing of pearl millet hybrid Pusa 1201 for the identification of genes associated with rancidity. Characterizing the genes associated with Fe/Zn transporter in pearl millet for enhancing the micronutrient density in pearl millet flour.

Association mapping for favorable alleles for grain Fe and Zn: A set of 96 diverse germplasm lines of lentil (*Lens culinaris* subsp *culinaris*) were evaluated at three different locations in India to examine the variation in iron (Fe) and zinc (Zn) concentrations and identify simple sequence repeat (SSR) markers that associate with the genetic variation. The genetic variation among genotypes of the association mapping (AM) panel was characterized using a genetic distance-based and a general model-based clustering method. The model-based analysis identified six subpopulations, which satisfactorily explained the genetic structure of the AM panel. AM analysis identified three SSRs (PBALC 13, PBALC 206 and GLLC 563) associated with grain Fe concentration explaining 9% to 11% of phenotypic variation and four SSRs (PBALC 353, SSR 317±1, PLC 62, and PBALC 217) were associated with grain Zn concentration explaining 14% to 21% of phenotypic variation. These identified SSRs exhibited consistent performance across locations. These candidate SSRs can be used in marker-assisted genetic improvement for developing Fe and Zn fortified lentil varieties. Favourable alleles and promising genotypes can be utilized for lentil biofortification.

Genome/gene editing for multiple stress tolerance and yield enhancement in crop

Molecular mapping of QTLs for aluminium tolerance: Major quantitative trait loci (QTLs) identified for Al resistance using simple sequence repeat (SSR) markers in F2 and F3 mapping populations derived from contrasting parents. Phenotypic response to Al was measured on the bases of root re-growth (RRG), fluorescent signals and Al contents in hydroponic assay. Two major QTLs were identified using 7 trait linked markers, one each for fluorescent signals and RRG mapped on linkage group (LG) 1 under Al stress condition in F2 mapping population of cross BM 4 × L 4602. One major QTL (qAlt_fs) was localised in between PLC_88 and PBA_LC_373, covering 25.9 cM with adjacent marker PLC_88 at a distance of 0.4 cM. Another major QTL (qAlt_rrg) for RRG was in the marker interval of PBA_LC_1247

and PLC_51, covering a distance of 45.7 cM with nearest marker PBA_LC_1247 at a distance of 21.2 cM. Similarly, in F3 families of BM 4 × L 4602 and BM 4 × L 7903, LG-1 was extended to 277.9 and 230.9 cM respectively, having 4 newly developed genic-SSR (g-SSR) markers.

STS markers for erucic acid content: Two STS markers based on the *FAE1.1* and *FAE1.2* promoter sequence polymorphism were developed for erucic acid content in *Brassica juncea*. These markers are completely co-segregating with the erucic acid content.

Mapping of genomic regions for seed coat permeability: In order to map the genomic regions for seed coat permeability, a RIL population ($F_{2:6}$) developed from a cross between a wild type soybean (impermeable seed coat) and a cultivated variety (permeable seed coat) were used. A set of 207 polymorphic SSR markers were used for genotyping the 204 RILs. The seeds of the RILs were soaked in water for 6 h for phenotyping. Permeability of the seed coat showed wider variations. Through composite interval mapping, 5 QTL were mapped for the trait; however a QTL on Chr.2 alone explained 62.92% of the phenotypic variations indicating it to be a major QTL or a gene. Other 4 QTL had phenotypic effect in the range of 5.93–10.33%. The QTL were validated in an unrelated F_2 population.

QTL identification for stem-rot resistance in groundnut: RIL mapping population was developed by using CS 8 × TG 37A cross and used for QTL mapping for stem-rot resistance. Total 13 main-effect QTLs (M-QTLs) for various plant architecture and disease-related traits were identified using QTL cartographer with LOD score ranging from 3.07 to 5.39 and phenotypic variance explained (PVE %) ranging from 4.91 to 10.34%. The QTL-cluster of 5.2 Mb harbouring six QTLs (3 main effect QTLs and 3 environment effect QTLs) for stem-rot resistance explaining up to ~18% PVE was physically located in a 5.2 Mb genomic region (1.8 cM on genetic map) on pseudomolecule B04. This QTL cluster harboured 170 genes including LRR (leucine rich repeats) zinc finger motifs and ERFs (ethylene responsive factors) and 11 uncharacterized/unknown proteins. Leucine rich repeats are most conserved gene family among plant genomes.

Molecular marker assay for high oleic trait in safflower: A cost-effective molecular marker assay for high oleic trait in safflower is developed. This marker can be used in large scale for marker assisted breeding to develop high oleic safflower cultivars. This high oleic varieties has distinct economic advantage because of diversified uses.

Genome editing: RNA-guided genome editing based on CRISPR-Cas9 has been standardized in rice mega variety MTU1010. Mutations in Drought and Salt Tolerant (DST) gene was induced by using genome editing in MTU1010. Further work on editing genes for yield and stress tolerance is in progress in MTU 1010 and black rice *Chakhao amubi*.

Genome editing in soybean for regulating phytate-flux: Editing/mutagenesis of the terminal step enzyme – Inositol pentakisphosphate-2-kinase using sgRNAs complementary to *GmIPk1 was* targetted. The constructs were validated using a novel *Agrobacterium*-mediated Disc Assay for Transient Expression (AGRODATE) method on agroinfitration of soybean leaf discs. PCR analysis of mutagenized *GmIPK1* in transient mutants by sequencing revealed 90% deletions and 10% insertion in the randomly sequenced clones. HPLC-PDA analysis for phytate levels in the mutants revealed 6–7 fold reduction compared to the control.

Novel heat-shock factor (*TaHSFA6e*) in wheat: A transcription factor of 1100 bp was identified from HD 2985 (thermotolerant) wheat cultivar based on its transcriptome data. The heat shock factor was named as *TaHSFA6e* and it was submitted to NCBI GenBank (KU 291394). Homology analysis of the *TaHSFA6e* cloned from thermotolerant and thermosensitive (HD 2329) wheat cultivars showed ~2% variation at nucleotide level.

Epigenetics of gene expression and stress memory in plants: Role of epigenetic changes in regulation of gene expression was investigated. Cytosine methylation level of *IFS1* and *IFS2*, coding for two isoforms of the isoflavone synthase, was investigated in the developing seeds (at 65 days after flowering) of two contrasting genotypes (NRC 37—high isoflavone accumulation, and NRC 7—low isoflavone accumulation) of soybean. NRC 37 showed high level (85% and 20.51%) of cytosine methylation in coding region of the genes, while it was extremely low (2.5% and 7.89%) in case of NRC 7. The higher isoflavone content in NRC 37 could be correlated with hypermethylation of the coding region of the genes in soybean. Similarly, a significant increase in the genome-wide cytosine-methylation was observed in drought-tolerant rice genotype (Nagina 22), but hypomethylation was observed in drought-sensitive genotype (IR 64) under the stress. Moreover, a part of the increased methylation (~25%) was retained in the drought-tolerant genotype even after withdrawal of the stress, which might serve as stress-memory.

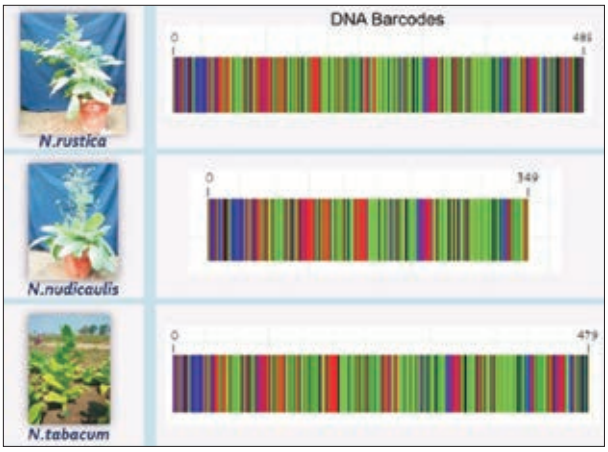
Overexpression of abscisic acid receptors for cold and drought tolerance: Plant stress hormone abscisic acid (ABA) is synthesized under stress. It regulates physiological processes through protein modification and gene expression to confer abiotic stress tolerance. The hormone is perceived by ABA receptors (ABARs). Rice genome encodes at least 10 functional ABARs. ABAR11 gene was cloned from drought tolerant rice cv. Nagina 22 and was overexpressed in rice cv. MTU1010. *OsABAR11* overexpressing transgenic plants showed higher membrane stability, chlorophyll stability, less senescence, and significantly higher survival under cold stress. *OsABAR11* transgenics lose less water in Excised Leaf Water Loss (ELWL) assay and produced more roots under drought stress as compared with NT plants. Similarly, overexpression of *ABAR2* gene in *Arabidopsis* conferred cold stress tolerance. Transgenic

rice cv. MTU1010 overexpressing *ABAR2* gene showed enhanced drought tolerance under greenhouse conditions. These results showed that *ABAR2* and *ABAR11* genes are useful for improving drought and cold tolerance in rice.

Overexpression of *AtICE1* gene for multiple stress tolerance to rice: Transgenic rice overexpressing *AtICE1* (*Inducer of CBF Expression 1*) gene from stress inducible *RD29A* promoter was developed. Pot experiment with transgenic rice plants under greenhouse conditions showed that transgenic plants maintained better tissue water status, photosynthetic pigment and cell membrane membrane stability and thus better survival yield under cold, drought and NaCl stresses. Scanning electron microscopic studies showed that *AtICE1* transgenic rice plants have higher stomatal density and smaller stomatal size through regulation of rice genes for stomatal development. This shows that *AtICE1* is useful for enhancing multiple stress tolerance in rice.

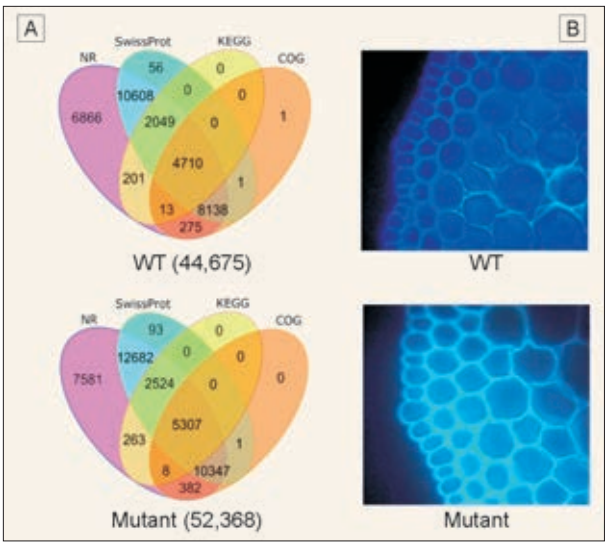
Diversity of chitinase genes from chitinolytic *Bacillus* spp.: A sample of 15 isolates out of 83 was studied for chitinase gene characteristics by sequence comparison of target region. Sequence homology study using entire GenBank database by BLASTN search revealed that 10 isolates were 78 to 80% identical to *chiA* gene from *Paenibacillus* sp. FPU7 (Accession no. AB683959). Two isolates (UKCH17 and UKCH77) showed 99% identity to a variety of *B. licheniformis* chitinases and with variable identity (88 to 95%) to other *Bacillus* species (*B. paralicheniformis, B. circulans, B. pumilus, B. subtilis* etc) chitinases. Interestingly, three isolates (UKCH19, UKCH20 and UKCH44) showed 89 to 90% similarity with *B. circulans* chitinase. Multiple sequence alignment of obtained nucleotide sequences showed 40 and 16 single nucleotide polymorphisms (SNPs) in *Paenibacillus* (UKCH19, UKCH20 and UKCH44) and *circulans* group chitinases, respectively. The *licheniformis* sequences (UKCH17 and UKCH77) were identical. Multiple sequence alignment of deduced primary structure (approximately 120 amino acids) showed eight conserved, 19 semiconserved, 22 non-conserved amino acids substitutions between all 15 sequences covering the three groups. The *circulans* group reported only one semi-conserved amino acid substitution (A to S) despite of observed 16 SNPs, whereas, the *Paenibacillus* group reported two conserved (especially in UKCH68), eight semi-conserved and one non-conserved substitution.

DNA barcoding of wild *Nicotiana* species: DNA barcoding is a taxonomic tool that utilises a short genetic marker in an organism's DNA to identify it as belonging to a particular species. Among the barcode loci identified for plant species, by the Consortium for the Barcode of Life (CBOL), two plastid genes, viz. intergenic space region of trnH-PsbA and hypothetical chloroplast open reading frame 1 (ycf1) were found to be polymorphic among *Nicotiana* species accessions and hence, selected for bar coding. Accordingly, the trnH-PsbA and ycf1 regions of diverse *Nicotiana* species from 13 different sections of sub genus *rustica*, *tabacum* and *petunioide* were amplified and sequenced. The resultant amplicon sequences were annotated and used for developing species specific DNA barcodes for 24 *Nicotiana* species. These barcodes can be used for species identification, purity testing and flagging of new *Nicotiana* species from an unknown sample in a rapid, repeatable, and reliable fashion.



DNA barcodes of selective *Nicotiana* species

Generation of high-quality hypocotyl transcriptomes: Jute is one of the fastest growing crop plants. The rate of hypocotyl development in jute is much faster than the dicot model plant *Arabidopsis thaliana* or monocot rice. An investigation was taken up to understand the genetic basis of hypocotyl development through transcriptome analysis of a hypocotyl-defect mutant of *Corchorus capsularis* and its wild type JRC 212. A total of 10.1 and 8.3 Gbp of Illumina paired-end raw sequence data for the WT and mutant jute hypocotyl transcriptomes, respectively were generated with an average read length of 97 bp. After filtering the raw data, 48,507,660 and 39,986,065 clean reads were obtained. Three different

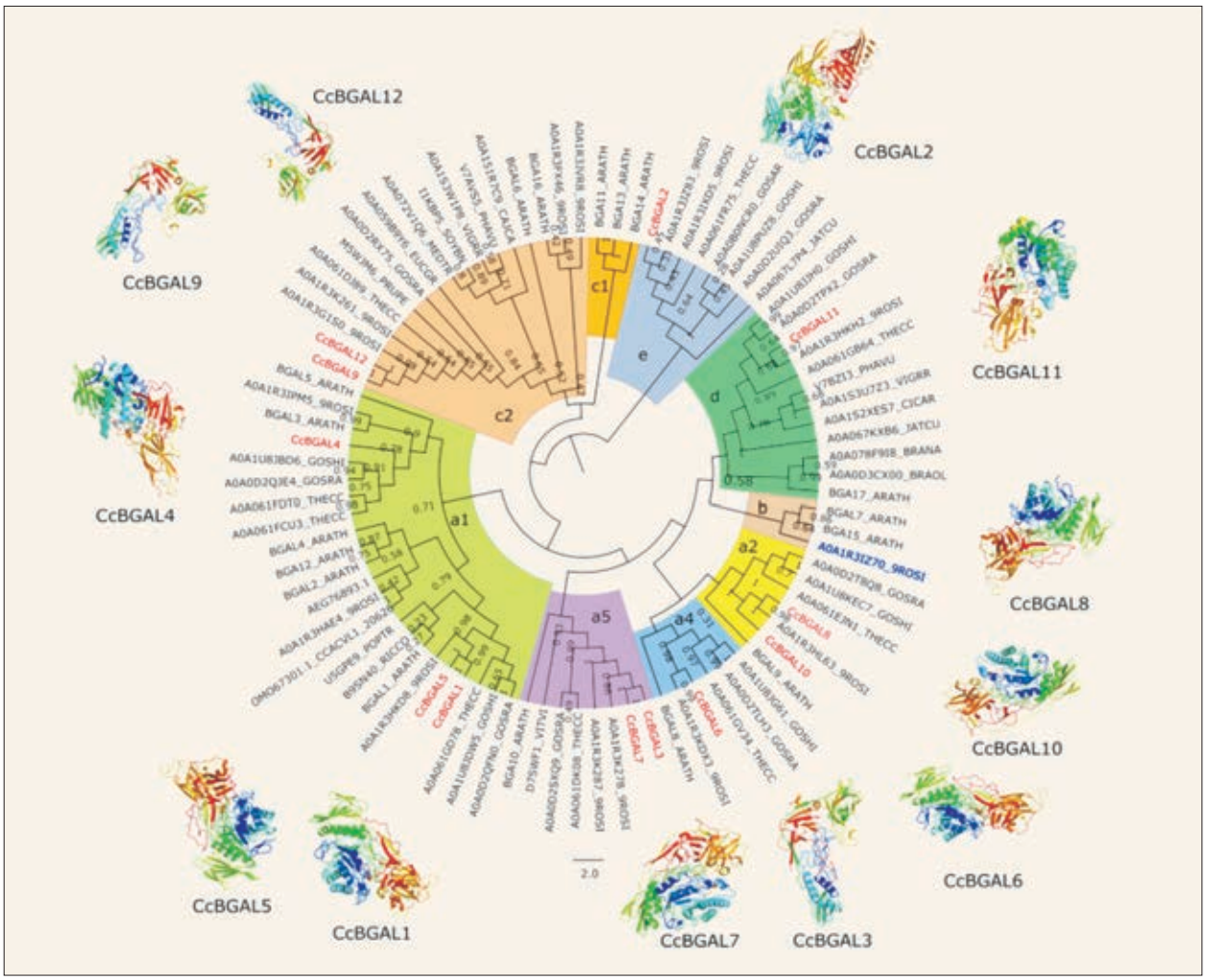


(A) Comparative annotation of Trinity assembled unigenes in four public databases; (B) Cross section of hypocotyl cells of the mutant (uneven cell wall structure leading to constricted cell shape) and the WT (even cell wall structure and round cell shape).

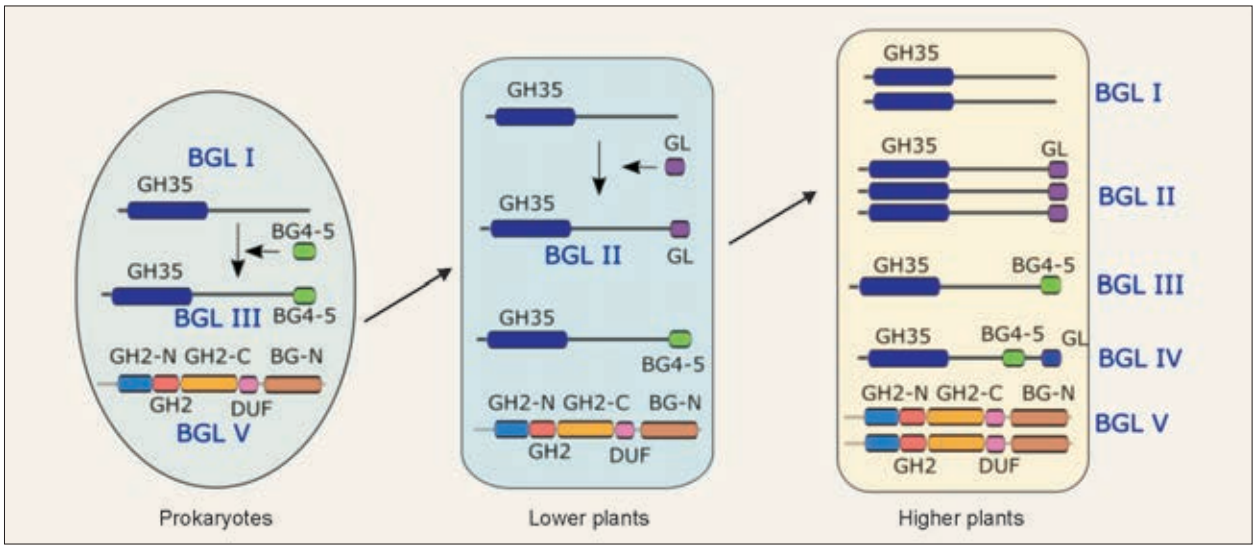
assemblies, CLC, Trinity and SOAPdenovo-Trans were used to assemble the clean reads of which the best results were obtained from the Trinity-assembled data. Finally, a total of 44,675 WT and 52,368 mutant unigenes were annotated using BLASTx. Further, more than 95% and 99% of the WT and mutant unigenes, respectively, were mapped to the draft genome of *C. capsularis*. The unigenes were further annotated using different databases, such as Non-redundant (Nr), Swiss Prot, COG and KEGG. The Nr-COG-annotated WT (19,149) and mutant (23,742) unigenes were classified into 25 different functional classes of orthologous group (COGs). Gene ontology (GO) mapping showed that unigenes had most of the matches from the UniProtKB database, falling in three main and 44 sub categories. KEGG mapping identified 1499 WT and 1691 mutant unigenes under carbohydrate metabolism pathway.

Beta-galactosidase enzyme in jute hypocotyl development: Genetic, biochemical and histological investigations identified beta-galactosidase (*BGAL*) as a candidate for influencing the unique undulated, slow growing hypocotyl-defect phenotype. A total of 12 beta-galactosidases from the WT (*CcBGAL*) and their corresponding homologs from the mutant (*CcmBGAL*) were identified mining the hypocotyl transcriptome databases through stringent homolog identification protocols based on protein sequence and structural similarity. The *CcBGALs* had high sequence similarity with *BGALs* of *Theobroma cacao*, *Gossypium raimondii* and *A. thaliana*. Differential gene expression study revealed that 10 out of the 12 *BGALs* were up-regulated in the mutant. *In-vivo* BGAL activity staining in hypocotyl also indicated higher BGAL activity in the mutant, particularly at the hypocotyl base. Enzyme assay also showed higher *in-vitro* enzymatic activity in the mutant. Genetic analysis of a F_2 population established high positive correlation between hypocotyl-defect phenotype and *in-vivo* enzyme activity and suggested the phenotype to be controlled by the action of two complementary genes. The information obtained from all these experiments suggested that BGAL plays a crucial role in degradation of cell wall components in the hypocotyl base to sustain the rapid growth of hypocotyl. Overexpression of BGALs in the mutant resulted in higher enzyme expression, triggering uncontrolled cell-wall degradation generating the hypocotyl-defect phenotype. The study provides the first evidence of role of BGAL in hypocotyl development in plant.

A novel bacterial beta-galactosidase in plant: The



A consensus cladogram (Neighbor-joining, 500 bootstraps) showing phylogenetic relationship of CcBGALs and their closest homologs from dicot plants. The predicted structures of the CcBGAL proteins are presented in the outside of the cladogram.



A domain centric evolutionary model for plant BGALs

hypocotyl transcriptome analyses also report, for the first time, presence of a bacterial beta-galactosidase in plant kingdom and confirm its expression in both the WT and the mutant. Domain analysis and phylogenetic relationship studies showed that this bacterial beta-galactosidase is ubiquitous in plant kingdom and was acquired in higher plants from bacteria through algae and lower plants, not by horizontal gene transfer. More interestingly, this gene was not transferred to the animal kingdom. It shares considerable sequence similarity with *E. coli* BGAL with five BGAL-specific conserved domains and conserved active sites. On the other hand, an animal-kingdom specific BGAL is also conserved in the plant kingdom and is expressed in jute. Based on the domain architecture of BGAL proteins, a domain-centric evolution of BGALs is established, which shows evolutionary pathway of five classes of beta galactosidases, some of which have originated through domain integration and gene duplication.

Seed production and seed technology research

Breeder seed production: During 2017–18, total breeder seed production in field crops was 1,16,999 q against the indent of 98,048.4 q. The major share in total breeder seed production belongs to cereal crops, i.e. 60,230.7 q against indent of 42,761.6 q. Under pulse crops a total of 26,011.1 q breeder seed was produced against the indent of 20,054.9 q. In oilseeds, total breeder seed production was 29,302.5 q against the indent of 34,003.2 q. Breeder seed produced in case of fiber crops was 162.7 q against the indent of 110.4 q and in forage crops 1,292.2 q was produced against the indent of 1,118.3 q.

Quality seed production: During the year 2017–18, total production of quality seed including all classes was 5,97,992 q against the target of 3,66,059 q. Production comprises 1,37,605 q of foundation seed, 3,14,216 q of certified seeds, 96,443 q of truthfully labelled seed and 49,728 q of planting material of field crops. In addition, 202 lakh planting material and 1.3 lakh tissue culture plantlets were also produced against the targets of 172 lakh and 1.1 lakh, respectively.

HORTICULTURE

Central sub-committee on crop standards, notification and release identified 86 varieties in horticultural crops. Sixty two in vegetable crops (tomato, brinjal, okra, cabbage, cauliflower, onion, french bean, Indian bean, radish, kale, chilli, winged bean, pointed gourd, bottlegourd, cucumber, chenopod, pumpkin, sponge gourd, garden pea, round melon etc.,), two in fruit crops (mango, papaya) and twenty two in spices and tubers (cadamom, potato, cassava, ginger, corinder etc.,)

Guava

Arka Poorna: The Arka Poorna guava variety has been identified for release. This variety is from the progeny selection of Purple Local × Allahabad Safeda cross. Plants are semi-vigorous in growth habit with prolific bearing and hence suitable for medium to high density planting. Fruits are round, medium to big in size (200–230 g) with smooth, and shiny pericarp. Pulp is firm, white with thick outer rind, good flavour, TSS (10–12°B), ascorbic acid (190–198 mg/100 g), medium soft seeds (10 to 12 kg/cm^2) and good keeping quality. It is a dual-purpose variety suitable for both table purpose and processing.

Banana

NRCB Selection 11 (Manoranjitham variant) performance in hills of Tamil Nadu: Manoranjitham (AAA) is a unique variety with an excellent aromatic and fragrant pulp from Kolli Hills of Tamil Nadu. A high-yielding somaclonal variant with 300% high yield over the parent. Comparative evaluation of ICAR-NRCB Selection 11 (Manoranjitham variant) in plains and hills indicated that the performance was better at higher elevations above 1,500 m above MSL. The

fruits were highly fragrant and they retained even after cold storage at 13°C for 30 days.

Coconut

High-yielding coconut selection of FMST, suitable for tender nut, copra and inflorescence sap production recommended for release for West Coast. In the coconut evaluation trial involving dwarfs and its hybrids, CGD × WCT exhibited root (wilt) disease tolerance and higher yield of 85 nuts/palm/year. Established coconut pollen cryo-preservation facility at CPCRI, RS, Kayamkulam with a capacity to store 6,000 pollen vials.

Tomato

A tomato hybrid Araka Abhed with multiple disease resistance to Tomato Leaf Curl Disease (*Ty2+Ty3*), Bacterial wilt, Early blight and Late blight (*Ph2 + Ph3*) was developed at IIHR. The plant is semi-determinate with dark green foliage and produce firm, oblate round and medium large fruits (90–100 g). This hybrid is bred for fresh market and suitable for summer, *kharif* and *rabi* cultivation and yields 70–75 tonnes/ha in 140–150 days.

Kashi Aman: The Kashi Aman tomato was notified by Central Sub Committee on Crop Standard Notification and Release of Varieties for Horticultural Crops for cultivation in Punjab, Uttar Pradesh, Bihar and Jharkhand. The average yield is up to 60 tonnes/ha. The attractive red coloured fruits weighing 80–110 g are round and very firm. The first picking can be started within 85 days after transplanting.

Kashi Amul : The Kashi Amul tomato was notified by Central Sub Committee on Crop Standard Notification and Release of Varieties for Horticultural Crops for cultivation in Karnataka, Tamil Nadu and Kerala. The average yield potential is 50–60 tonnes/ha. The attractive red round and firm fruits weigh 90–115 g. This variety carries Ty-3 gene and has shown high level of resistance ToLCV. The fruits mature in 85–90 days post transplanting.

Muskmelon

Muskmelon Arka Siri, a selection in F_{12} generation between open pollinated progeny of a commercial hybrid NS 910 and MHC 8, was developed at IIHR for high TSS (12–13%), good shelf-life (5–10 days under ambient conditions) and high fruit and pulp firmness. This selection is high yielding with 25 tonnes/ha and comes to maturity in 75–80 days. Fruits are elongated globe shape with appealing brownish yellow rind.

French bean

French bean Arka Sukumol is a pole bean type variety developed for rust resistance with high yields. With indeterminate growth habit, first harvest can be realized within 60 days and yields up to 24 tonnes/ha in 100 days. Pods are string less, oval, green and long (23 cm) with ten pod weight up to 87 g. Suitable for both *kharif* and *rabi*.

Capsicum

Capsicum Araka Athulya is a F_1 hybrid developed for powdery mildew tolerance with high yields. Plant is continuous in growth habit with dark green foliage, firm fruits, medium large size (100–120 g) and yields 45–50 tonnes/ha in 140–150 days. Suitable for fresh green market and can be grown in both *kharif* and *rabi*.

Velvet bean

Velvet bean Arka shubra is a high-yielding (4.5 to 5.5 tonnes/ha) variety developed for high L-dopa (5.43%) content. It is a long duration (180–190 days) variety with non-irritant trichomes and produces medium size seeds with white seed coat.

Palak

Thar Hariparna: Suitable for cultivation in arid region. The cropping season for harvesting is from: October to March and the leaf colour is light green to dark green. Average leaf yield 154 q/ha obtained from 7 to 9 pickings.

Sponge gourd

Thar Tapish: High temperature tolerance variety suitable for cultivation in arid region. The first harvest starts at 50 days after sowing. Average fruit wt. is 115 g and yield: 155 q/ha.

Ivy gourd

Thar Sundari: It is suitable for cultivation during spring-summer and rainy-winter season. The elongated-long shape, light green-green-dark green in colour with non-clear white strips and soft. Average Fruit yield: 1.5 kg/plant/season. Yield: 248–350 q/ha.

Potato

Kufri Ganga: It is main-season, table purpose, medium maturity, higher tuber yield, field resistance to late blight, good keeping/culinary quality and suitable for growing in north Indian plains. It produces attractive white-cream ovoid uniform tubers with shallow eyes and white-cream flesh.

Kufri Neelkanth: Kufri Neelkanth produces attractive purple, ovoid, uniform tubers with shallow eyes and yellow flesh. It possesses higher anti-oxidants as compared to other red-skin indigenous varieties. It is main season table potato variety having medium maturity with high tuber yield, field resistance to late blight, good keeping/culinary quality and suitable for growing in north-Indian plains.

Kufri Lima: It is early season variety for North-Indian plains. It produces attractive white-cream, ovoid, uniform tubers with shallow eyes and white-cream flesh. It possesses tolerance to hopper and mite burn, good keeping and culinary quality.

Cassava

Sree Reksha: Sree Reksha is a CMD resistant cassava variety has been approved for release by the Kerala State Seed Sub Committee for Varietal Release. It has a duration of 8–9 months and is completely resistant to cassava mosaic disease caused by the north Indian cassava mosaic virus and Sri Lankan cassava mosaic virus. It is also tolerant to post-harvest physiological deterioration. The average tuber yield was 40–50 tonnes/ha and potential yield is 125 tonnes/ha. It has medium starch (27–32%), low cyanogen (35.01 ppm) and low sugar (1.10%) contents. It is suitable for planting under rainfed and irrigated conditions especially in regions with high incidence of cassava mosaic disease.

Yam

Sree Nidhi (IC 625797): Sree Nidhi is a greater yam variety, which produces medium cylindrical tubers with pinkish cortex and white flesh colour, with no browning when cooked. It recorded an average yield of 35 tonnes/ha with optimum tuber size, good culinary quality, white flesh colour without any undesirable coloration, very little apical portion and less wastage. It was tolerant to anthracnose disease and has medium dry matter (32%), starch (23.2% FW) and crude protein (2.5% FW).

Sree Swetha: Sree Swetha is a high-yielding (34 tonnes/ha) bushy white yam variety with good culinary quality, which was released for cultivation in Kerala under non-trailing condition. It has medium dry matter (32.98%), starch (22% FW) and crude protein (3.8% FW).

Sree Haritha: It is a high-yielding (46 tonnes/ha) white yam variety with compact tuber shape which was released for cultivation in Kerala. It is a trailing type with medium dry matter (37.6%), starch (26% FW) and crude protein (3.22% FW).

Spices

NDH 8 (Narendra Saryu): This turmeric variety from Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, Uttar Pradesh with high curcumin content (5–6%), more number of primaries with yield advantage of 10% was recommended for release at national level.

Gujarat Coriander 3: The coriander variety from Centre for Research on Seed Spices (CRSS), (SDAU), Jagudan with high volatile oil (0.52%), high linalool (72.16%) and high-yield potential (16.94 q/ha) was recommended for release in Gujarat.

Ajmer Fenugreek 5: The fenugreek variety developed by ICAR-NRC on Seed Spices, Ajmer with high seed yield (17.21 q ha), high antioxidant content (66.428 mg/BHTE/ppm) and suitable for green leaf production under shade net condition in summer season was recommended for release at national level.

IISR Cassia (D1): A new selection of cassia with low coumarin content was developed for the first time in the country by Dr B S Konkan Krishi Vidhyapeeth, Dapoli in collaboration with ICAR-IISR, Kozhikode and TNAU, HRS, Pechiprai.

Ajmer Coriander 2: Developed by ICAR-NRC on Seed Spices, Ajmer for stem gall resistance, high linalool content (71.7%) and early maturing type was recommended for release at national level.

CL 34: The turmeric was developed by Tamil Nadu Agricultural University, Coimbatore with tolerance to leaf spot and leaf blotch and curcumin content of 3% was recommended for release in Tamil Nadu.

Onion

RGP 3 is an onion line suitable for *rabi* and its bulbs are a globe with medium red. It produced uniform bulbs and free from doubles and bolters. On the basis of two year data, this line produced 38.47 tonnes/ha marketable yield which is 24.70% higher than the best check Bhima Shakti (30.85 tonnes/ha). This line is early in maturity and harvested within 103 days after transplanting.

RGP 4 is an onion line suitable for *rabi* and its bulbs are a globe with dark red. It produced uniform bulbs and free from doubles and bolters. On the basis of two year data, this line produced 35.76 tonnes/ha marketable yield which is 15.92% higher than the best check Bhima Shakti (30.85 tonnes/ha). This line matures early and harvested within 105 days after transplanting.

DOGR 1605 is an onion line suitable for *rabi* and its bulbs are a globe with dark red. It produced uniform bulbs and free from doubles and bolters. On the basis of two year data, this line produced 41.85 tonnes/ha marketable yield which is 24.43% higher than the best check Bhima Shakti (33.63 tonnes/ha). This line is early in maturity and harvested within 113 days after transplanting.

DOGR 1606 is an onion line suitable for *rabi* and its bulbs are flat-globe with medium red. It produced uniform bulbs and free from doubles and bolters. On the basis of two year data, this line produced 40.46 tonnes/ha marketable yield which is 20.31% higher than the best check Bhima Shakti (33.63 tonnes/ha). This line is early in maturity and harvested within 107 days after transplanting.

DOGR Hy-6 *Rabi* 1 is an onion F hybrid suitable for *rabi* and its bulbs are flat-globe with medium red. It produced uniform bulbs and free from doubles and bolters. On the basis of two-year data, this hybrid produced 41.86 tonnes/ha marketable yield which is 17.87% higher than best check Bhima Kiran (35.52 tonnes/ha). The average bulb weight is 70 g with a thin neck. Its bulbs harvested in 108 days after transplant and good in storage.

Profiling of major nutraceuticals in mango: Pulp of thirty mango hybrids was analyzed for total antioxidants, total phenols, total flavonoids and total carotenoids. The total antioxidant content was 0.35–1.14 µmol Trolox/100 g, total phenols 23.05–92.08 mg gallic acid equivalent/100 g, total flavonoids 11–32 mg quercetin equivalent/100 g and total carotenoids

1.76–15.56 mg/100 g. The lowest carotenoids (1.78 mg/100 g) content was recorded in H-707 while hybrid H 4509 recorded highest carotenoids (15.56 mg/100 g) content indicating its potential as carotenoids rich hybrid.

ECS as a high throughput technique for mass multiplication of banana: ICAR-NRCB, Trichy has developed protocols for the development of ECS in banana cv. Grand Naine using immature male floral hands as explants. Grand Naine plants derived from ECS were evaluated in the farmers field at Theni along with shoot tip and sucker derived plants as control. The results revealed that the yield of ECS derived plantlets were on par with that of shoot tip derived plants but higher than the sucker derived plants in both main and ratoon crops. Therefore this could serve as a potential tool for mass propagation of bananas and plantains with minimal percentage of somaclonal variation. Further could be comfortably adopted by the tissue culture companies for the production of quality planting material in place of shoot tip culture.

Stress tolerant genes in tomato: Pyramiding of dreb2S (from sorghum) and pjvp1 (from *Prosopis* sp.) genes in tomato has been achieved and molecular analysis completed for abiotic stress tolerance.

SSR markers linked to powdery mildew resistance in bitter gourd: The SSR namely McSSR 57 clearly co-segregated with phenotypic data of powdery mildew resistance in F2 mapping population derived from highly susceptible (Arka Harita) × Highly resistance (IIHR 144-1). The SSR marker validated through bulk segregant analysis (BSA) and in 193 individual F_2 mapping population. McSSR 57 marker segregated in the ratio of 1:2:1. It also showed a recombinant frequency of 18.13% indicating that the marker is linked to the gene of interest.

Molecular marker analysis of genetic diversity in guggul: Genetic diversity *vis-à-vis* reproductive behaviour of guggul (*Commiphora wightii*) was conducted by including accessions of Gujarat and Rajasthan. Gujarat is the only place in India where sexual populations of the species are distributed. RAPD and ISSR markers were used since genome sequence information is lacking in the species. Twenty-four RAPD primers and 16 ISSR primers amplified a total of 185 and 128 reproducible DNA fragments, respectively with fragment sizes ranged from 200 to 3,000 bp. RAPD analysis showed higher polymorphism (80%) in comparison to ISSR (69%). Jaccard's coefficient of similarity showed that pair-wise genetic similarity coefficients ranged from 46 to 98.3% in RAPD analysis, whereas it ranged from 47.8 to 98.6% in ISSR analysis. The results showed that the trend of genetic variation was not strictly correlated to the geographical locations, but was related to the reproductive behaviour of the populations. The diversity was somewhat low in Rajasthan populations where only apomictic populations are distributed. Populations of maximum genetic diversity along with sexual forms were found distributed in Gujarat populations, especially in Kutchh, Dwarka, Jamnagar and Porbandar populations. Hence the study indicated these areas as the original areas of the species distribution from where it was spread to the other parts of Gujarat and Rajasthan.

Molecular characterization of orchid germplasm: Molecular characterization of a collection of *Coelogyne nitida* revealed that it natural hybrid between *Coelgyne nitida* and *Coelogyne corymbosa.* Both these species are co-flowering species and found in Darjeeling district of West Bengal.

Molecular characterization of another collection of *Coelogyne cristata* revealed that it is natural hybrid between *Coelgyne flaccida* and *Coelogyne cristata.* Both these species are sympatric and occur in Darjeeling district of West Bengal.

DNA isolated from 148 orchid species after identification, purified and stored in DNA Bank for future research work

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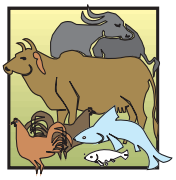


6. Livestock Improvement

Cattle

Holstein-Sahiwal crossbreds: The total population of Frieswal females at 25 Military Farms located in various agro-climatic regions of the country was 20,673 including 992 elite Frieswal cows during the reporting year. During the period, 235 Frieswal bulls were maintained at the bull rearing unit. The overall mean age at first calving was 967.24 days (31.82 months). The overall means of 300 days milk yield, total milk yield, peak yield (PY) and lactation length were 3,340.26, 3,358.86, 14.91 kg and 322.09 days, respectively. The least squares means of service period (SP), dry period (DP) and calving interval (CI) were 162.52, 116.98 and 433.05 days, respectively.

Improvement through selection in indigenous breeds: The programme covers Gir, Kankrej and Sahiwal breeds. Gir (24), Kankrej (26) and Sahiwal bulls (25) in three sets were inducted for progeny testing. The total number of inseminations carried out in Gir, Kankrej and Sahiwal units were 2,793, 2,417 and 1,174 with the conception percentages of 43.54, 46.21 and 44.80, respectively. Since the inception of the project, 5,112 Gir, 1,957 Kankrej and 1,326 Sahiwal daughters were born.

A flock of Kankrej cattle

Gir cattle

The average age at first calving in Gir, Kankrej and Sahiwal were 1,409.00, 1,195.21 and 1,114.32 days, respectively. The average first lactation 305-day or less milk yield, first lactation length and first peak yield were 2,344.5 kg, 410.9 days and 13.3 kg in Gir; 2,241.14 kg, 303.2 days and 10.6 kg in Kankrej; and 1,462.67, 9.74 and 268.97 days in Sahiwal, respectively. The first set of six Gir and eight Kankrej bulls were evaluated based on the first lactation 305 days milk yield of their daughters and the expected breeding values were estimated as 2,563.79 and 2,004.31 kg, respectively.

Field recording of performance data: The project envisages to progeny test Frieswal (HF × Sahiwal) bulls under field conditions at four different agro-climatic locations in India having a larger concentration of HF cross cows.

A total of 309, 292, 286 and 96 bulls have so far been introduced in GADVASU, Ludhiana; KVASU, Thrissur; BAIF, Uruli-Kanchan; and GBPUA&T, Pantnagar, respectively. During the year, a total of 3737, 5163, 4508 and 5651 AIs were carried out in GADVASU, Ludhiana; KVASU, Thrissur; BAIF, Uruli-Kanchan; and GBPUA&T, Pantnagar; with the conception percentages of 46.2, 46.0, 42.6 and 61.2, respectively. The number of daughters completed their first lactation in GADVASU, Ludhiana; KVASU, Thrissur; BAIF, Uruli-Kanchan; and GBPUA&T, Pantnagar, were 4,013, 1,807, 3,563 and 490, respectively. In all the four centres, the first lactation milk production showed an increasing trend over the years as 39.7, 51.2, 11.14 and 32.58% while the age at first calving has recorded per cent decrease of 12.23, 9.87, 2.3 and 5.5 in GADVASU, KVASU, BAIF and GBPUA&T, Pantnagar, respectively.

Buffalo

Network Project on Buffalo Improvement: Test mating from 16th set of 15 test bulls (5 from CIRB Hisar; 4 from NDRI Karnal; 3 from GADVASU Ludhiana; and 3 from LUVAS Hisar) was completed and; thereafter use of 16 test bulls (8 from CIRB Hisar, 4 from GADVASU Ludhiana, 2 from NDRI Karnal and 2 bulls from field) of 17th set was initiated, which will continue during the reported period through associated centres of Murrah breed under the project. The total herd strength including associated Murrah breed centres is 1,951, which includes 1,054 breedable females. The weighted average of 305 days or lesser lactation milk yield in the year was highest ever (2,487 kg) since inception of the project and showed an overall improvement of 52.38% since 1992–93 (2.01% per year). The weighted wet average was also highest (8.55

kg) since the inception registering an overall improvement of 61.62% (2.37%/year). Overall conception rate was 45.83%. Lifetime productivity traits, viz. herd life, productive life and lifetime milk yield, for buffaloes completed four or more lactations was 3,587 days, 2,263 days and 12,637 kg, respectively. Elite herds of Nili-Ravi, Jaffarabadi, Surti, Bhadawari and Pandharpuri breeds of buffaloes continued to be maintained in their respective breeding tracts. The Nili-Ravi and Bhadawari breed centers are functioning as conservation and improvement units; and Jaffarabadi, Pandharpuri and Surti breed centres are concentrating on field progeny testing along with maintaining the herds for young bull production.

Frozen semen doses (183,563) of Murrah bulls were produced, and 56,820 semen doses disseminated and 111,872 doses sold to farmers/NGOs/development agencies. For Nili-Ravi, Jaffarabadi, Bhadawari and Surti buffalo breeds, 85,533 semen doses were produced and 118,877 semen doses were sold/ supplied during the reported year.

Through three field centers of Murrah buffalo at CIRB Hisar, NDRI Karnal and GADVASU Ludhiana; about 13,195 artificial inseminations from 16th and 17th sets of breeding bulls were carried out at farmers' door in adopted villages under the program.

Sheep

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


Magra ram

In Magra unit, the average fibre diameter, medullation and staple length were 34.52 µ, 39.90% and 5.18 cm, respectively. Progeny born from distributed rams had higher body weight at birth (3.11 vs 2.82 kg), weaning (16.05 vs 14.71 kg), 6 months (22.50 vs 20.81 kg) and 12 month (29.78 vs 27.57 kg) than progeny born from farmer's ram.

In the Muzaffarnagri sheep average age at first service, age at first lambing, weight at first service and ewe's weight at lambing were 460 days, 612 days, 32.50 kg and 36.7 kg, respectively.

In Deccani sheep, average ewes' age at first service, age at first lambing, weight at first service and ewes' weight at first lambing were 476 days, 626 days 28.56 kg and 31.53 kg, respectively. Inter lambing period was 320 days.

In field unit Madras Red and Magra sheep available with sheep farmers were registered for performance recording and genetic improvement.

Mega Sheep Seed Project

The main objective of the project is the production and distribution of 70 genetically superior breeding rams of the assigned indigenous breed with coverage of 2,500 breedable ewes by each cooperating unit each year. The project has four cooperating units. The strength of the nucleus flock of different breeds covered under the project is given below:

Unit	Male	Female	Total	Breedable female
Mandya, KVAFSU, Bidar	64	415	479	325
Mecheri, TANUVAS, Chennai	139	452	591	331
Sonadi, RAJUVAS, Bikaner	102	315	417	269
Malpura, CSWRI, Avikanagar	211	544	755	396

During the year 346 rams were distributed/sold to cover 7,893 ewes for genetic improvement of sheep.

Performance of field sheep flocks

Breed	Average body weights (kg)				Annual lambing (%)
	Birth	3 month	6 month	12 month	
Madras Red	2.65	10.54	15.95	21.54	87.26
Magra	2.96	15.46	21.68	28.51	79.23

Goat

Genetic improvement by selective breeding: During the reporting period, least squares mean for weight at first conception, weight at first kidding and age at first kidding, first kidding interval and gestation period of Barbari, a dual purpose goat breed, were 18.6±4 kg, 22.0±6.7 kg, 511±12 days, 222±11 days and 146±0.43 days, respectively. The least squares means of body weight of kids at birth, 3, 6 and 9 months of ages for the kids born were 1.87±0.01,

Performance of farm sheep flocks

Breed	Average body weights (kg)				Annual GFY (kg)	Tupping (%)	Annual lambing (%)	Overall survivability (%)
	Birth	3 M	6 M	12 M				
Marwari	3.20	17.43	24.80	35.37	1.375	96.31	88.15	98.98
Muzaffarnagri	3.52	16.28	25.54	36.59	1.142	100.00	91.50	97.04
Deccani	3.20	13.67	23.40	28.23	0.951	95.83	90.28	92.36
Nellore	3.25	14.97	23.97	28.37	NA	95.91	85.94	92.23

Multiplier flock of Barbari breed goat

Five multiplier flocks in Bundelkhand, Uttrakhand and Rajasthan, provided breeding animals and technology support. They are playing great role in development of entrepreneurship and livelihood models, promoting scientific goat farming, innovative management and marketing with backward and forward linkages. The kidding rate at multiplier flocks varied from 1.5 to 1.8 and mortality rate from 2 to 8%. Adult goats sold @ ₹ 8,000 to 32,000/goat. Net profit/goat ranged from ₹ 4,700 to 9,000/year with average of ₹ 5,625. Multiplier flock owners are earning substantial amount (₹ 0.5 to 3 lakh/year) through sale of milk, marketing of farmer's goat, consultancy, health practices etc. Net saving of multiplier flocks ranged from ₹ 5 to 16 lakh/year.

8.47±0.08, 13.06±0.19 and 17.47±0.21 kg, respectively. Overall mean for 90 days milk yield, 140 days milk, total lactation yield and lactation length were 62.37±3.7, 80.6±1.6, 77.65±4.37 litres, and 134±5 days, respectively. The estimates of heritability (h^2) for body weight of kids at birth, 3, 6, 9, and 12 month of ages were 0.11±0.04, 0.23±0.07, 0.21±0.07, 0.27±0.08 and 0.17±0.07, respectively, indicating additive genetic variance for growth traits in this flock. There is a gradual reduction in age at first service and age at first kidding over the last few years. However, weight at first service and weight at first kidding showed increasing trend over the years indicating significant improvement in body weight at first mating and age at first kidding.

The Jamunapari goat is known for its milk production. The mean body weights at birth, 3, 6, 9 and 12 months of age were 2.93 kg, 8.72 kg, 14.68 kg, 19.24 kg and 24.27 kg, respectively. The highest value of ADG was 198 g/day during 6–9 months of age. Least square means of part lactation milk yield in 90 and 140 days were 74.04±1.84 and 105.02±2.84 liters, respectively. Reproductive performance of Jamunapari goats in terms of breeding efficiency and kidding were 91.95 and 136.45%, respectively.

Improving goat productivity in farmers' flock in different agroclimatic conditions

Andaman Goat Field Unit: The unit is operational in 3 clusters, viz. Port Blair, Baratang and Nimbudera. The overall least squares means of body weights (kg) at birth, 3, 6, 9 and 12 months of age are 1.43±0.01, 5.64±0.02, 9.68±0.04, 13.26±0.03 and 16.56±0.03, respectively. Least squares means of milk yield in 30, 60, 90 and 140 days were 432.4±10.96, 403.0±10.75, 358.7±11.74 and 319.±11.43 ml, respectively, during the reporting period. The kidding rate was 1.54. The mortality for the period reduced to 3.59 from 8.60%. The overall economic growth of the farmers is 52% after the intervention of the project.

Andaman Goat Field Unit, ICAR-CIARI, Port Blair, Andaman & Nicobar Islands

Assam Hill Goat Field Unit, Guwahati, Asom: The unit unit has 5 clusters, viz. Batabari, District Darrang; Tetelia Gandhinagar, District Kamrup (Metro); Nahira, District Kamrup (Rural); Tepesia, District Kamrup (Metro); and Digholbori. The rate of mortality was 7.50% during the reported period. The overall least squares means of body weights (kg) at birth, 3, 6, 9 and 12 months of age were 1.24±0.01, 5.29±0.02, 8.03±0.04, 10.73±0.06 and 13.94±0.09, respectively. The least square means of milk yield in 30, 60 and 90 days were 3.80±0.17, 6.63±0.40 and 11.45±0.97 liter respectively. The kidding rate was 1.58.

Assam Hill Goat Field Unit, AAU, Khanpara, Guwahati

Black Bengal Goat Field Unit, Kolkata, West Bengal: The unit is operational at 5 clusters, i.e. Ayeshpur and Ganguria (Nadia cluster); Jatirampur and Rangabelia (Sundarban cluster); Bamunia and Beliapukur (Murshidabad cluster); Lodhasuli (Jhargram cluster); and Purba Mallickpara (Dhupguri cluster). The average body weight at birth, 3, 6, 9 and 12 months were 1.32±0.01 kg, 5.43±0.04 kg, 7.74±0.04 kg, 10.85±0.05 kg and 13.49±0.06 kg, respectively, during the reporting year. The average milk yield of does was 3.40±0.04 kg, 6.76±0.06 kg, 9.06±0.08 kg and 10.14±0.10 kg in 15 days, 30 days, 45 days, and 60 days, respectively. The kidding rate (litter size) was 1.89. The income per doe is ₹ 3,274 which also increased from that of previous year (₹ 2,861).

Black Bengal Goat Field Unit, WBUV and FS, Kolkata, West Bengal

Changthangi Goat Field Unit, Kashmir, Leh-Ladakh, Jammu and Kashmir: The unit is operational at 3 clusters at Khanak, Samad and Karzok**.** The main objective was to improve pashmina fibre and meat production. The overall population growth for this year was 58.51% as compared to last year. The average body weight at birth, 3, 6, 9 and 12 months were 2.46±0.23 kg, 6.32±0.27 kg, 9.45±0.19 kg, 12.98±0.18 kg and 16.08±0.21 kg, respectively. The average pashmina production of all the three clusters for the year was recorded as 275±12.54 g.

Gaddi Goat Field Unit, Palampur, Himachal Pradesh: The unit has five clusters at Chamba, Kangra, Kullu, Bilaspur and Mandi. The least squares means for body weights at birth, 3, 6, 9 and 12 months of age were 3.12±0.07, 15.31±0.14, 19.67±0.15, 24.71±0.18 and 27.85±0.37 kg, respectively. All selected animals were provided health coverage under migratory field conditions, viz. vaccination against PPR (2,000 doses), de-worming against endoparasites after fecal sample analysis (1,655 animals), periodic health check-ups etc. The overall population growth was 105.28%. The overall mortality incidence was 6.78%. The kidding per cent of the flocks was 67.09.

Ganjam Goat Field Unit, Bhubaneswar, Odhisa: The unit is operational at 3 clusters, i.e. Chhatrapur, Rambha and Khallikote. The overall means of body weights were 2.51±0.02, 7.77±0.010, 9.95±0.11, 14.52±0.12 and 18.44±0.16 kg for weight at birth, 3, 6, 9 and 12 months of age, respectively. The kidding percentage was 85.7, and kid mortality 6.08%. The average milk yield at 30 days and 60 days was 8.03±0.22 and 15.54±0.41 kg, respectively.

Malabari Goat Field Unit, Thrissur, Kerala: The unit is operational at clusters located in Kannur, Kozhikode and Malappuram districts in northern Kerala. The mean body weight at birth, 3, 6, 9 and 12 months of age were 2.21±0.14, 8.53±0.32, 15.23±0.04, 21.43±0.42 and 22.24±0.32 kg, respectively. The mean average lactation yield was 75.50±6.80 litre with lactation length of 84.70±6.40 days. The mortality was 1.77% during the year. The kidding rate was 1.62.

Malabari Goat Field Unit, KV&ASU Mannuthy, Thrissur, Kerala

Marwari Goat Field Unit, Bikaner, Rajasthan: The unit is operational in five clusters, i.e. Deshnok, Daiya, Kalayansar, Raisar and Kan Singh Ki Sird villages. The overall body weights at different stages of growth were 2.66±0.01 kg at birth, 8.91±0.01 at 3 months, 13.91±0.02 kg at 6 months, 18.22±0.02 kg at 9 months, 24.14±0.033 at 12 months of age. The kidding percentage and kidding rate were 107.76% and 1.08, respectively. The overall mortality was 1.08%.

Osmanabadi Goat Field Unit, Phaltan, Maharashtra: The unit is operational in different clusters, i.e. Ahmednagar, Beed, Pune and Satara districts. This year the field unit adopted three new clusters—Patoda taluka in Beed district, Man taluka in Satara district and Baramati Taluka in Pune district. The least squares mean 90-day milk yield of Osmanabadi does was 110 kg with 1,398 records.

Sangamneri Goat Field Unit, Rahuri, Maharashtra: The unit is operational in Sangamner, Shrirampur, Rahuri, Belha and Sinner clusters. The overall least squares means of the body weight at birth, 3, 6, 9 and 12 months of age was 2.16±0.03, 9.57±0.12, 15.37±0.11, 19.25±0.13 and 23.31±0.18 kg, respectively. The kidding rate was 1.52.

Sirohi Goat Field Unit, Vallabhnagar, Rajasthan: The unit is operational in clusters at Devgarh, Karget, Bojunda Farm. The overall population growth was 73.91%. The least squares means for body weight at birth, 3, 6, 9 and 12 months of age was 2.44±0.03, 13.11±0.28, 17.53±0.36, 21.19±0.65 and 25.83±0.53 kg, respectively. The kidding rate (litter size) was 1.07. The overall mortality was 6.02% during the year.

Surti Goat Field Unit, Navsari, Gujarat: The unit is operational in the clusters at Bharuch, Karjan, Jambusar, Navsari, Bilimora and Vapi. The least square means for body weight at birth, 3, 6, 9 and 12 months of ages was 2.04±0.01, 8.35±0.06, 13.31±0.09, 18.69±0.09, 21.99±0.15 kg, respectively. The kidding rate (litter size) was 2.05 revealing higher prolificacy in Surti Goats.

Uttarakhand Local Goat Field Unit, Pantnagar, Uttrakhand: The unit is operational in clusters at Bara, Tilpuri, Bhimtal, Kunda and Majhera. The average body weights were 1.90±0.01, 9.76±0.07, 13.11±0.08, 16.70±0.11 and 20.06±0.14 kg at birth, 3, 6, 9 and 12 months of age, respectively. The kidding rate was recorded as 1.53 (153%).

Pig

Released three pig varieties: Location specific pig varieties, namely, TANUVAS KPM Gold, SVVUT-17 and Landlly, were released. These varieties are expected to benefit socio-economically weak communities including women folk and also address the issues of pig production system under changing climatic scenario by improved production and productivity.

TANUVAS KPM Gold


SVVUT 17


Landlly

Poultry

Improvement of germplasm: Two male lines, PD-1 (Vanaraja male line) and PD-6 (Gramapriya male line); two female lines, PD-2 (Vanaraja female line) and PD-3 (Brown egg layer line) are maintained for use in developing rural chicken varieties. In PD-1 line, the egg production up to 52 weeks of age improved by 7 eggs as compared to the last generation. In PD-6 (GML) line, the shank length increased significantly from 75 to 77 mm during this generation. In PD-2 line, the egg production up to 52 weeks of age was improved by 3 eggs and egg mass improved by 390 g during S-14 generation. In S-15 generation, body weight at 6 weeks of age was 662.4±0.02 g, while the shank length was 71.5±0.01 mm.

In PD-4 (improved Aseel) there was an improvement of 10.9 g in body weight and 0.01 mm in shank length at 8 weeks of age. In Aseel chicken (G-4), the egg production up to 72 weeks of age and egg weight were 58 eggs and 52.3 g, respectively. In Ghagus population (G-5), body weight and shank length of male birds at 40 weeks of age were 2.6 kg and 128.5 mm, respectively. Two-way cross chicks (PD-1 × PD-4) were evaluated at institute farm and in the field. The body weight was significantly higher in farm reared birds. Broodiness was observed in about 30% of birds that reduced egg production. The economic analysis of rearing these birds showed a net profit ₹ 610/pair of bird.

Three colour synthetic broiler lines (PB-1, a male line; PB-2, a female line and control) are being maintained and evaluated. In PB-1 (S-26) higher juvenile body weights were recorded in the S-27 generation as compared to previous generation. In PB-2 line (S-26) phenotypic and genetic response to selection for the 40 week part period egg production over the last 12 generations was 0.68 and 1.28 eggs/generation, respectively. In S-27 generation, the body weight, shank length and breast angle at 5 weeks were 758.8 g, 77.2 mm and 74.8°, respectively. The phenotypic and genetic response to selection for the 5 weeks body weight over the last 9 generations was 2.95 and 3.08 g/generation, respectively. The naked neck and dwarf gene lines were maintained as resource populations.

Six layer lines (IWH, IWI, IWK, IWD, IWF and control) were maintained and evaluated. The egg production up to 40 weeks of age in IWH, IWI, IWK and control increased by 9.78, 7.61, 7.72 and 9.63 eggs in the present generation during which egg weights at 40 weeks ranged from 48.36–52.15 g.

Parentage testing in equines

Parentage testing in horses has become a necessity for breeders to assure horse pedigree integrity. Microsatellite based genotyping for the confirmation of parentage of foal in cases when either of the parent is not known was adopted. Twenty-one microsatellite markers were grouped into five multiplex PCR reaction sets depending on the PCR conditions and size of PCR products. Samples (282) were genotyped with 5 multiplex PCR reactions covering total of 21 microsatellite markers. Mean number of alleles per locus was 33, mean proportion of loci typed 0.96, mean expected heterozygosity (marker for polymorphism) 0.8804, and mean polymorphic information content (PIC) 0.8678.

Under AICRP on Poultry Breeding, all the 12 centres are working on the development of location-specific chicken varieties; conservation, improvement, characterization and application of local native, elite layer and broiler germplasm; and development of package of practices for village poultry along with development of entrepreneurships in rural, tribal and backyard areas.

At KVASU, Mannuthy, egg production of native chicken germplasm (S-2) up to 40 weeks of age was 75.96 eggs with average egg weight of 42.5 g, which showed an increase of 3.88 eggs and 0.7 g in egg weight than in the previous generation. Hen housed egg production up to 40 weeks of age of layer strain (IWN) × Desi × Dalhem Red (NDR) cross was 80.87 eggs in farm and 49.73 eggs in field. The centre also evaluated IWN and IWP strains where hen housed egg production up to 40 weeks of age increased by 3.8 eggs in IWP (124.83) strain.

At KVAFSU, Bengaluru, body weight of native local chicks at 8 and 20 weeks of age was 477.8 and

Himsamridhi

Himsamridhi, a multi-colour dual purpose bird suitable for rural poultry production in hilly areas, was developed. The body weights of male and female birds at 20 weeks of age were 1.8 and 1.4 kg, respectively. The age at sexual maturity of these birds was 165 days. The annual egg production was 160 eggs and egg weight 56 g.

1110 g, respectively. The 8 week body weight of test cross (PB-1 × local native) was 886.9 g in males and 768.8 g in females. The body weight of PB-2 × native at 4 week of age was 612.0 g in farm and 359.1 g in field, while egg production up to 40 weeks was 77.2 eggs at farm condition. The average body weights at 6 and 7 weeks of age were 1,692 and 2,080 g in Raja-II (PB-1 × PB-2) at 47th RSPPT, Gurgaon, and the feed efficiency was 1.56 at 7 weeks.

At CARI Centre, the body weight of local native chicken germplasm at 4 and 6 weeks was 291 and 543.9 g, respectively. The phenotypic response of body weight in CSML and CSFL at 5 weeks of age was 16 and 15.9 g, respectively, while the genetic response was 14.3 and 14.2 g, respectively.

At OUAT, Bhubaneshwar, Hansli, a native chicken breed was registered at ICAR-NBAGR, Karnal. The body weight at 5 weeks in CSML × Hansli cross was 548.8 g. At ICAR Research Complex for NEH Region, Agartala Tripura, the body weight at 8 weeks of age was 316.4, 544.2, 1,044 and 550.1 g in Tripura Black, Dahlem Red, Coloured broiler dam line and Broiler line × Native (BN) cross, respectively. In Broiler line × Native × Dalhem Red (BND) cross, the 72 weeks egg production was 141 and 119 eggs under farm and field conditions, respectively. At BAU, Ranchi, the hen housed egg production up to 52 weeks was 52.89 eggs in native population (G-6). At AAU, Guwahati, the 5 weeks body weight, egg weight and egg production up to 52 weeks were 126.6 g, 39.3 g and 66.85 eggs, respectively. In Kamrupa variety, the hen housed egg production up to 52 weeks of age was 88.9 and 72.90 eggs at the farm and field conditions, respectively. At MPPCVVV, Jabalpur, the 6 weeks body weight was 397 and 827 g in Kadaknath and Jabalpur colour populations, respectively. On 40 weeks of age, the egg weight was 58.7 and 47.8 g in Jabalpur colour and Kadaknath, respectively. The Narmadanidhi variety of birds produced 168 eggs up to 72 weeks in the field condition.

At MPUAT, Udaipur Centre, the Mewari breed of chicken is maintained where 20 weeks and 40 weeks body weight and hen day egg production increased by 109 g and 196 g and 2.27 eggs, respectively. Body weight of Pratapdhan variety of chicken at 8 weeks of age has increased by 316 g.

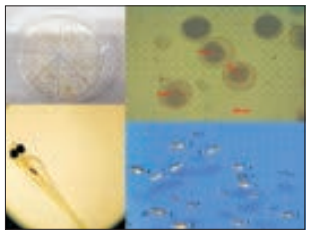
The Poultry Seed Project, has 12 centres located at West Bengal University of Animal and Fishery Sciences, Kolkata; Bihar Agricultural University, Patna; ICAR Research complex for NEH region, Nagaland Regional centre, Jharnapani; ICAR-National Organic Farming Research Institute, Gangtok; ICAR Research Complex for NEH Region, Manipur Regional Centre, Imphal; Tamil Nadu Veterinary and Animal Sciences University, Hosur; ICAR-Central Coastal Agricultural Research Institute, Panaji; ICAR-Central Island Agricultural Research Institute, Port Blair and Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar. The project was further strengthened with addition of 3 more centres, viz. PVNR Telangana Veterinary University, Warangal; Sri Venkateswara Veterinary University, Tirupati; and ICAR Research Complex for NEH Region, Umiam. Birds (631,543) of improved chicken varieties were distributed to the farmers during the year.

Fisheries

Captive breeding of Narayani barb: The indigenous ornamental fish Narayani barb, *Pethia narayani* was collected from river Sita, Shimoga, Karnataka. After four months of rearing fishes showed

Brood stock of Narayani barb

secondary sexual characters. Males were more colourful with white line on pelvic fin. Sexes were separated and further reared in separate tanks. Matured males and females (approximate 1.5 g) in 2:1 ratio were transferred to a breeding tank (200 liter glass aquaria fitted with hapa). After 36 hr eggs were obtained at the bottom of the tank. The brooders were removed and shifted back in brooder tank. Hatching of eggs occurred after 48 hr. The absolute fecundity was recorded in the range of 380–643.



Breeding stages of Narayani barb

Grow-out culture protocol of pengba: The pengba (*Osteobrama belangeri*) is a highly esteemed and endangered indigenous minor carp of Manipur. Although, the breeding and seed production technologies of the species have been developed earlier, the species has not yet spread in the culture system despite its potential, mainly due to non-availability of seed and lack of a standard grow-out protocol. Mass scale breeding and seed rearing protocol were standardized. Pengba showed compatibility with Indian major carps, catla and rohu in grow-out polyculture system. The growth performance of pengba was better when cultured with catla alone suggesting its better compatibility

Juvenile of *Osteobrama belangeri*

Haul of *Osteobrama belangeri*

Restoration of fish stock in river Ganga

Rivers of Indo-Gangetic Plains are native abode of the Indian major carps (catla, rohu, mrigal) and other carps. Hence, conservation of these fishes in this native range of population is an important national biodiversity goal. The ICAR-CIFRI and ICAR-NBFGR are undertaking large-scale stocking of carps in river Ganga to augment the natural population of these important carp species, which has declined due to various anthropogenic activities. Stocking in the protected areas gives fingerlings the opportunity to grow to adults and thereby support future generations of fish population. Fish seeds (6 lakh) were stocked in different stretches of river Ganga at various locations, viz. Rishikesh in Uttarakhand; Fatehpur Ghat, Allahabad; Dasawamedh Ghat, Varanasi, and Chapra Ghat, Bithoor (near Kanpur) in Uttar Pradesh, and Barrackpore, Balagarh and Nabadwip in West Bengal.

with catla compared to rohu. Grow-out culture of penba was also demonstrated in the farmers' fields.

Surrogate broodstock: Pluripotent stem cells transplantation, one of the promising assisted reproductive technologies for propagation of valuable genetic resources, can play a key role in conservation of endangered fish species. The spermatogonial cells from young goldfish (*Carrasius auratus*) were transplanted by non-surgical (through common urogenital papilla) method into the gonads of adult common carps (*Cyprinus carpio*). Inside the recipient gonads the transplanted gonial cells were able to migrate, colonize and undergo further differentiations to produce donor-derived gametes within 4–5 months. The presence of donor-derived gametes was confirmed by PCR in 90% of the recipients. These surrogate (common carp) parents were crossed through artificial fertilization and natural spawning to produce viable donor-derived (goldfish origin) progeny.

Shrimp farming in inland low saline waters: Farming of Pacific white shrimp (*Penaeus vannamei*), was demonstrated in inland low saline water at village Sangat Kalan, Bathinda, Punjab. The shrimp attained a marketable size of 20 g in three months and attained an average body weight of 26.3 g in four months. During the culture period, the survival rate was 79.18% and feed conversion ratio was 1.2. At the end of 120 days of culture, a production of 2.5 tonnes was obtained from each of the 4,000 m^2 ponds resulting in a productivity of 6.25 tonnes/ha. The harvested shrimp realised a farm gate price of ₹ 320/kg thus resulting in total revenue of ₹ 16 lakh against an operating cost of ₹ 12 lakh; generating a net profit of ₹ 4 lakh, i.e. 2 lakh/acre/crop.

Overview of steps involved in production of offspring from surrogate parents. (A–C) Donor-derived spermatozoa were harvested from the surrogate fathers and artificially fertilized with the eggs derived from pure goldfish mother to produce surrogate progeny. (D, E) The surrogate parents were coupled for natural spawning to generate the surrogate progeny. (F, G) The molecular confirmation of surrogate progeny was done by using markers developed from RAG2 gene. Scale bar indicates 2 cm (A–E).

Seabass farming in open brackishwater: Seabass (*Lates calcarifer*) rearing was taken up in the three tier model comprising nursery, pre-grow-out and grow-out cages in the backwaters at a coastal village Vennangupattu in district Kancheepuram, Tamil Nadu. Seabass fry (1 cm size), initially stocked in the nursery cages, were grown to fingerlings (7–8 cm size). These fingerlings were grown in pre-grow-out cages to juveniles (90–100 g). Later, juveniles were reared to a marketable size (900–1,250 g) in grow-out cages for six months. Final standing biomass of 12 kg/m^3 was obtained. Production of 460 kg was realized in one cycle with production cost of ₹ 190/kg, which was sold for ₹ 380/kg.

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7. Crop Management

PRODUCTION

Cereals

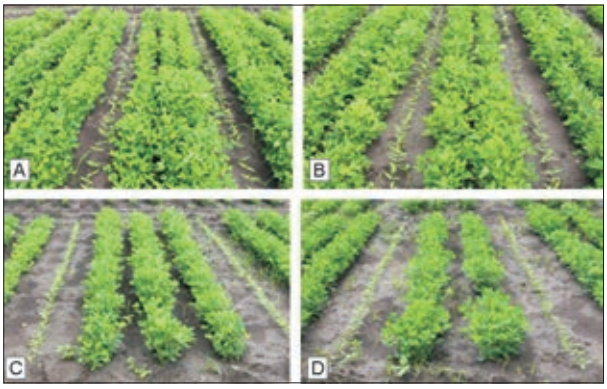
Urea coating with zinc and sulphur on seed yield: Field experiment was conducted at Regional Station, Karnal to study the effect of coated urea with zinc and sulphur as compared to prilled urea in basmati cultivars. Significant differences in the yield attributes, viz. number of panicles /plant, panicle length and 1,000 seed weight were recorded in basmati cultivars. Pusa Basmati 1 recorded significantly higher yield than PB 1121 and remained at par with PB 6. Number of panicles/m^2, panicle length were significantly higher in 100 kg N through prilled urea, 100 and 75 kg N through zinc coated urea and 75 kg N through prilled urea + 5 kg zinc compared to absolute control and zinc 5 kg/ha. Seed yield in zinc coated urea 75 kg N/ha (5.58 tonnes/ha) remained at par with 100 kg N through prilled urea (5.47 tonnes/ha) and 100 kg N zinc coated urea (5.64 tonnes/ha) and registered an increase of 20.5 and 10.4% increase over absolute control (4.63 tonnes/ha) and zinc 5 kg/ha (5.05 tonnes/ha) respectively.

Storability of cowpea seed under ambient conditions: Storability of cowpea seed using zeolite seed 'drying beads' was evaluated. Seeds were either dried in sun or with drying beads at 10 and 40% RH. The moisture content of the seed was reduced to < 6% on fresh weight basis using zeolite beads drying. The dried seeds were packed in moisture impervious packets and stored in ambient storage. Seed germination and viability was assessed at 4 months intervals till 3 years of ambient storage. Ultra-dried seed maintained germination well above Indian Minimum Seed Certification Standards after 36 months of storage. The germination in control was drastically reduced after 12 months of storage due to high infestation of bruchids.

Control of broadleaved weeds in wheat: This trial was conducted in all the five wheat growing zones to identify effective herbicides for control of broad leaved weeds in wheat. The trial was conducted at twenty one locations in various zones, i.e. four locations (Almora, Bajaura, Khudwani and Malan) in NHZ, eight locations (Bikaner, Durgapura, Gurdaspur, Hisar, Jammu, Karnal, Ludhiana and Pantnagar) in NWPZ, five locations (Coochbehar, Faizabad, Kalyani, Sabour and Varanasi) in NEPZ, three locations (Bilaspur, Indore and Udaipur) in CZ and one location (Dharwad) in PZ. In all the zones weed free treatment produced the highest grain yield which was closely followed by the treatment having combination of Halauxifenmethyl + florasulam + carfentrazone + surfactant. Among broad leaved herbicides, Halauxifen methyl + florasulam + carfentrazone + surfactant (10.21 + 20 g a.i. + 750 ml/ha) was found as the best treatment in controlling broad leaf weeds density and dry weight in all the zones.

Oilseeds

Precising plant stand and time of sowing: Groundnut pod and haulm yield was higher under 3:1 ratio while pigeon pea grain and stover yield and GPEY was higher under 2:1 ratio. Groundnut pod and haulm yield was higher when pigeon pea was relay sown 50 DAS while pigeon pea grain and stover yield and GPEY was higher when pigeon pea was relay sown at 30 DAS.



Pigeonpea relay sown 30 days after sowing of groundnut in 3:1 and 2:1 ratio in groundnut variety TG 37A (A, B) and GJG 22 (C,D)

Application of paclobutrazol: In Saurashtra region, due to cloudy weather during most of the rainy season, excessive vegetative growth takes place resulting in poor pod setting in groundnut. Hence, there is need to identify suitable growth hormones and standardize their doses and timing of application to prevent excessive vegetative growth and improve number of pods/plant to get higher yield of *kharif* groundnut. Application of paclobutrazol @100 ppm was found to reduce plant height at harvest significantly as compared to control. Application of paclobutrazol @100 ppm increased number of flowers and mature pods/plant and significantly increased pod yield as compared to control.


Groundnut crop sprayed with paclobutrazol @ 100 ppm (*left*) and control (*right*) at 45 days after sowing

Alleviation of drought stress and saving of irrigation water: Evaluation of five endophyte bacteria (*Bacillus firmus* J22, *Bacillus subtilis* REN51, *Pseudomonas pseudoalcaligenes* SEN29, *Acinetobacter junii* J20 and *Pseudoxanthomonas mexicana* R47) with five levels of irrigation water (one, two, three, four, and 10 flood irrigations at field capacity after emergence) with cultivar TG 37A revealed that application of endophytes and four irrigations can provide as much pod yield (average 1,873 kg/ha) as that obtained with 10 supplementary irrigations after emergence (1,766 kg/ha) in summer 2017. Inoculation of endophytes improved the pod and haulm yield of groundnut at all level of irrigations. Maximum benefit was received by *Acinetobacter junii* J20 and *Bacillus subtilis* REN51, followed by *Pseudomonas pseudoalcaligenes* SEN29 with application of four irrigations. However, during summer, 2018, maximum benefit was accrued with application of *Bacillus firmus* J22 followed by *Pseudomonas pseudoalcaligenes* SEN29 with four supplementary irrigations. Thus, it would be feasible to reduce quantity (at least 30–50%) and frequency of irrigations (3–4) substantially for raising summer groundnut with endophytes and there is possibility of horizontal spread in areas with the application of endophytes with the available quantity of irrigation water.

Alleviation of salinity stress

On-farm trials conducted at Bhuj, Gujarat, with an endophytic bacterium *Bacillus firmus* J22 not only alleviated salinity stress in groundnut but also improved yield. In 30 such field demonstrations within different villages of Bhuj with cultivar GG 2 during *kharif* 2017 and with initial soil salinity of 4.5 to 6.2 EC, seed treatment with *Bacillus firmus* J22 resulted in 17.9% average increase in pod yield over the control. The haulm yield increased by 5.65% due to seed treatment. An average increase in net returns due to seed treatment was 24.1% over the control. Thus, endophytic bacteria would be useful in alleviating salinity stress and preventing yield losses in groundnut.

Liquid formulation of bio-fertilizer with high shelf-life: Liquid formulations of DAPG-producing *Pseudomonas putida* DAPG 4 and *Pseudomonas putida* FP86, which have been recommended for enhancing growth, yield and nutrient uptake in groundnut, besides development of suppressive soils for management of stem and collar rot diseases of groundnut, were developed in different combinations for enhancing shelf-life of bacterial culture at room temperature. While formulation 8 maintained the population of the bacterial culture at 6.15×10^{10} cfu/m1 after 270 days of inoculation at room temperature, the same formulation also helped *Pseudomonas putida* FP86 to maintain a population of 3.85×10^{10} cfu/m1 after 210 days of inoculation at room temperature.

High zinc- and iron-containing groundnut cultivars: One hundred ninety groundnut cultivars were screened to identify high zinc and iron contents in their seeds. Out of these, 13 groundnut cultivars, viz. GG 7, GG 20, Tirupati 1, Tirupati 3, Tirupati 4, CO 2, GG 13, ICGS 76, CSMG 884, TAG 24, DH 8, KRG 1 and Gangapuri were found to have high seed zinc content, while 10 groundnut cultivars MH 4, Somnath, ICGV 86031, ICGV 86325, Tirupati 3, GG 2, M 145, M 13, DSG 1 and TAG 24 were found to have high iron content in their seeds and hence these genotypes can be used for growing at farmers' fields to reduce the widespread problem of zinc and iron deficiency.

Soil P-fractions in different soil textures: *In-vitro* lab studies were conducted to check out the differences in soil-P fractions of black calcareous *vertisols* of Junagadh and sandy soils of Bikaner. Olsen P was found to be high in sandy soils (20.2 kg/ha) than in *vertisols* (15.26 kg/ha). Total P was found to be more in *vertisols* (420 ppm) followed by sandy soils (285 ppm). The order of P-fixation in *vertisols* is Ca-P>Fe-P>Al-P>Saloid-P and in sandy soils it is Ca-P > Fe-P >Saloid-P >Al-P. Labile-P was more abundant in sandy soils compared to black soils. In black soils P-fixation (%) ranged from 82.5% to 96.3%, while in sandy soils the range is 71% to 92%. Al-P and Fe-P was markedly higher in *vertisols* at 45°C than at 15°C. Similar trend was observed in sandy soils, but with lower values than black soils.

Maintaining higher microbial biomass carbon: Among cropping sequences soybean–chickpea maintained significantly higher microbial biomass carbon (257.26 mg C/kg + soil) and AMF biomass in terms of PLFA (2.08 nanomoles/g + soil) and NLFA (33.617 nanomoles/g soil) over soybean–wheat and soybean–mustard.

Rust resistant soybean varieties: Estimated economic benefits from adoption of rust resistant soybean varieties in rust prone districts of Karnataka and Maharashtra using economic surplus model. Total benefits from the adoption of rust resistant soybean varieties have been estimated at ₹ 99.3 crore at a discount rate of 8% or ₹ 1,159/ha/annum at 2012–2014 average prices.

Pulses

Microbial consortia for alleviating moisture stress in chickpea: Three microbial consortia developed by ICAR-IIPR, Kanpur (UP) for alleviating moisture stress in chickpea were evaluated at six locations namely Ludhiana (Punjab), Hisar (Haryana), Kalaburagi (Karnataka), Kanpur (Uttar Pradesh), Sehore (Madhya Pradesh) and Durgapura (Rajasthan). They gave 14.1 to 17.4% more mean grain yield than the control across the locations. Pooled mean of different locations indicated highest grain yield with Consortia II, being 17.7% higher than the control, 8% over *Mesorhizobium* CH 1233 and 32.9% over *Mesorhizobium* CR 13 (IIPR). In general, consortia II was found better than two others at all locations, except at Durgapura where consortia I was observed better than it.

Enhancement of seed yield and quality

- In vegetable pea, seed priming with commercial formulation of sodium molybdate @ 0.5 g/litre + seed coating with *T. harzianum* @ 15 g/kg seed prior to sowing enhances the plant stand and health that leads to increase in number of pods/plant, seed weight, seed germination and seed vigour, resulting in higher yield.
- In dhaincha, sunhemp and pillipesara, foliage application of DAP (20 g/1 water) incorporated with micronutrient mixture containing zinc as zinc sulphate (5 g/litre water) + boron as boric acid (3 g/litre water) at flowering stage and removal of terminal bud (pinching or nipping) enhances the number of pods/plant, root nodules and seed quality characters resulting in higher yield. Nipping should be done on daincha at 60 DAS, Pillipesara at 30 DAS. In sunhemp, the main stem when attains a height of 90 cm, nipping shall be done to break apical dominance and more branching.

Crop health management through seed treatment: In safflower, seeds hydroprimed for 12 h and treated with *Trichoderma harzianum* + *Pesudomonas fluorescens* (10 g/kg) at the rate of 5 g each reduces the incidence of *Fusarium carthami* in field and increases seed germination, seedling vigour index and field emergence. Groundnut pod (<10% MC) treatment with emamectin benzoate (5 SG) @ 2 ppm (40 mg diluted in 15 ml water/kg of pod) or spinosad (45 SC) @ 2 ppm (4.4 mg diluted in 15 ml water/kg of pod) can provide effective management of groundnut pod-borer during storage up to 6–9 months under ambient condition without affecting seed quality.

Commercial crops

Balanced fertilization for maximizing sugarcane productivity: Sugarcane is a principal commercial crop of subtropical India that covered about 55% area and contributed 45% of the total cane production in India. The average sugarcane productivity and sugar recovery in subtropical India is low than tropical conditions. Apart from climate, irrigation and weed management, the imbalanced fertilization is one of the major factors responsible for low cane productivity in subtropical conditions.

Imbalanced fertilization not only affects the cane yield but also juice and soil quality adversely. Restless use of imbalanced fertilization in already low SOC, available N and P causes more adverse effect on cane productivity and soil quality. To overcome this, the targeted yield equations for plant cane (FN=5.78T–1.47 × SN–0.55 ON-FYM (tonnes/ha), FP_2O_5=0.97T–1.86 × SP–0.08 OP-FYM (tonnes/ha) and FK_2O = 2.13 T–0.54 × SK–0.19 OK-FYM (tonnes/ha) and ratoon crop (FN=5.87T–1.63 × SN–0.56 ON–FRM (tonnes/ha), FP=1.68T– 4.47 × SP–0.41OP-FYM (tonnes/ha) and FK=3.07T–1.08 × SK–0.29 OK-FYM (tonnes/ha) were developed for alluvial soil to achieving 100 and 120 tonnes/ha target cane and root yield by applying balanced fertilization based on initial soil test value and targeted yield equations. The targeted plant cane yield of 100 tonnes/ha and 120 tonnes/ha were achieved with a variation of –1.5 (98.47 tonnes/ha) and –13.1% (104.31 tonnes/ha) without FYM and +5.9 (105.9 tonnes/ha) and –9.25% (108.9 tonnes/ha) with FYM, whereas targeted ratoon yield of 100 and 120 tonnes/ha were achieved with + 4.09% (104.9 tonnes/ha) and –7.42% (111.1 tonnes/ha) without FYM and + 10.1% (110.1 tonnes/ha) and + 4.42% (114.7 tonnes/ha) yield deviations with FYM, respectively.

Evaluation of balanced fertilization based on soil test and targeted yield of plant and ratoon crop

Post-harvest management

***Leuconostoc lactis* responsible for post-harvest sucrose losses in sugarcane:** Cut to crush sucrose loss due to delayed crushing of cane is one of the major reasons for leading to low sugar recovery. Inversion of sucrose caused by entry of bacteria from cut/damaged regions reduces sucrose content during delayed crushing.

Utilizing various juice samples, species-specific molecular marker developed based on conserved region of 16S rRNA gene yielded a 742 bp PCR fragment. Along with this, biochemical indicators confirmed *L. lactis* is responsible for inversion of sucrose in sugarcane. DNA sequencing of the selected isolates revealed high homology among their 16S rRNA nucleotide sequences. In addition, sequence analysis by the BLAST tool indicated a very high level of sequence homology.

Soil and water productivity in tobacco: Flue cured Virginia tobacco is grown in an area of 21,000 ha under irrigated conditions in northern light soil area (NLS) of Andhra Pradesh. Soil fertility evaluation of NLS was done during 2017–18 and thematic maps of different soil fertility parameters were developed. Identified varied soil fertility areas/zones (major and micronutrients) in FCV tobacco growing areas of NLS. The available phosphorus content in 88% of area is high and the highest index value (2.95) observed in Gopalapuram auction platform area. Zinc availability is low in most of the NLS region (very low 22% and low 51% samples) followed by available copper (very low to low 25%). Zn deficiency in FCV tobacco growing soils is attributed to high level accumulation of soil phosphorus.

Assessment of carbon and moisture fluxes over jute based agro-ecosystem: The memorandum of understanding (MOU) has been signed between ICAR-CRIJAF, Barrackpore and ISRO-NRSC, Hyderabad for a collaborative project on "Quantitative assessment

of carbon and moisture fluxes over jute based agro-ecosystem: Integrating ground observations, satellite data and modeling" for the 3 years duration (2017–20) under the National Carbon Project of ISRO Geosphere Biosphere Programme. Under this project, the latest world class technology of Eddy Covariance System has been installed at research farm of ICAR-CRIJAF, Barrackpore to measure real time net ecosystem CO_2 exchange, ecosystem respiration, and energy balance components at different growth stages of jute, rice and wheat crops in hot and humid climatic condition. These real time data are to be used for the estimation of gross primary productivity of jute–rice–wheat ecosystem and the up-scaling of the carbon and energy fluxes will be carried out at regional level using remotely sensed proxies.

Eddy Covariance System at ICAR-CRIJAF, Barrackpore

HORTICULTURE

Potato cultivation under zero-budget farming: Productivity of Kufri Mohan (41.7 tonnes/ha) and Kufri Surya (41.7 tonnes/ha) was very good, whereas Kufri

Potato crop under zero budget farming at Gurukul, Kurukshetra

Gaurav (25.5 tonnes/ha), Kufri Pukhraj (27.8 tonnes/ha) and Kufri Bahar (25 tonnes/ha) recorded moderate productivity under zero budget package of practices.

Seed potato production: A total of 2,861 tonnes of nucleus and breeder seed was produced and supplied to the various government and private agencies for further multiplication and distribution to growers.

Aeroponics-based seed potato production

Flood resilient brinjal: An inter-specific grafting on resilient brinjal rootstocks was identified as an alternate strategy to combat the deleterious effects of flooding in tomato. Brinjal variety Arka Neelkant was identified as the best flood resilient and compatible rootstock for tomato and yields up to 70%.

CROP PROTECTION

Locally adapted host differentials for Indian pathotypes of wheat leaf rust: To overcome the maintenance problem of winter genotypes of leaf rust differential sets A and B work was initiated to develop near-isogonics o*r* lines in the background of a locally adapted variety NP 4. NILs carrying leaf rust genes *Lr13, Lr18, Lr19* and *Lr26* were developed by backcrossing NP 4 line with Thatcher lines carrying these genes. A total of six backcrosses were done in succession followed by selection and testing which was completed in 2015–16. The lines, viz. HI KK 10 (NP 4+*Lr13*) (IC 0624491, INGR 17034), HI KK 11 (NP 4+*Lr18*) (IC 0624492, INGR 17035), HI KK 12 (NP 4+*Lr19*) (IC 0624493, INGR 17036) and HI KK 13 (NP 4+*Lr26*) (IC 0624494, INGR 17037) carrying these leaf rust resistance genes were registered with ICAR-NBPGR, New Delhi.

Managing bruchid infested seed of lentil: Lentil seed, cultivar L 4076, grown at ICAR-IARI, Regional Station, Karnal during *rabi* 2013–14 and stored under ambient storage conditions up to *rabi* 2016–17 having 9.76% bruchid infestation was taken for the study. The seed was passed through air machines (air blowers) which reduced the bruchid infestation to 6.59% only by eliminating only the completely hollow seeds but were unable to eliminate the infested seeds with dead insects inside them. This material did not meet the IMSC standard of 1% insect damage in legumes and 98% physical purity. Therefore, the infested seed lot was reprocessed on specific gravity separator (SGS). A total of 12 treatment combinations, comprising three deck slopes (S1: 2.50, S2: 2.00, S3: 1.50), two feedings (F1: 8 kg, F2: 11 kg/min) and two air volumes from

Patent IN290170 : VL White grub beetle trap

The uniqueness of the trap is the space between the light source and the hitting fins and the gap between the funnel stem and the collection pot. It allows the beneficial insects being weak fliers and attracted towards light to pass on and not getting hit and trapped. The trap is found to capture 68% of scarab beetles, 32% others (mostly of Isoptera and Lepidoptera) and <0.8% of beneficial insects. A trap normally capture around 10,200 beetles per season (June–October) in the first year of installation at a site and around 5,000 beetles in the second year at the same place which reduce to 800 in the fifth to sixth year.

four air blowers (A1: 50, 50, 50, 50%; A2: 50, 100, 50, 100%) blowing through the porous deck of SGS, were studied. Minimum infestation in the final product (0.73%), which is below the IMSC standards, maximum healthy seed recovery (9.32 kg/min) with 93.9% recovery efficiency was obtained by treatment S3F2A2. Of the three slopes studied, 1.5 slope of the deck gave minimum bruchid infestation in final output (0.98%), maximum final output of healthy seed per min (7.53 kg) and maximum recovery efficiency of 87.17%. With increase in slope of the deck, infestation in the final output increased but final output per minute and recovery efficiency decreased. On the other hand, increased feeding and air volume to specific gravity separator led to significant increase in final output of healthy seed per minute and recovery efficiency. Thus, mechanical processing reduced bruchid infested lentil seed by more than 90%, and improved seed quality, i.e. physical purity by 5.53% and seed germination by 10.3%.

Nano emulsions of neem and citronella oils: Nano emulsions of crude neem oil and citronella oils with surfactants were developed and characterized by dynamic light scattering (DLS) and transmission electron microscope (TEM). TEM study showed the spherical shape of neem and citronella oil nano emulsions. The average size of droplets of neem nano emulsion (NNE) with different percentage of citronella oil ranged from 11.23±3.86 nm to 17.80±4.52 nm while that of citronella nano emulsion (CNE) with different percentage of neem oil ranged from 8.12±2.80 nm to 12.04±3.74 nm. It was found that increase in surfactant ratio to neem oil or citronella oil decreases the size of droplets in nano emulsions.

Molecularly imprinted polymers for determination of chlorpyriphos: Selective magnetic molecularly imprinted polymers (MMIPs) were synthesized using acrylic acid as monomer and ethylene glycol dimethacrylate as a cross linker by precipitation polymerization. Polymers are highly selective in extracting chlorpyrifos (94.14±1.5%) in the presence of structurally similar compounds. The polymers can be successfully reused thrice without any loss in selectivity. The prepared polymers can be applied for the extraction of chlorpyrifos from fortified honey and eggplant samples.

Synthesis of curcumin conjugated zinc oxide nanoparticles for atrazine: Curcumin conjugated zinc oxide nanoparticles were synthesized to develop nano-probes for the detection of pesticides. Curcumin was incorporated in ZnO [Zn(cur)O] through a wet chemistry method. The materials were characterized by spectroscopic and other techniques. Nanoparticles were effective in detecting atrazine up to 0.1 ppm concentration and showed linearity up to 10 ppm concentration. The nanoparticles can be used as nano-probe for atrazine detection.

Estimation of dithiocarbamate pesticide: A simple and sensitive high performance liquid chromatographic method was developed for quantification of yellow complex obtained from dithiocarbamate fungicides (Mancozeb, Zineb and Propineb) in different formulations as well as food commodities. Limit of detection and limit of quantification methods were 0.01 and 0.05 mg/kg, respectively. Method is useful for quantification of different dithiocarbamate formulations, viz. Mancozeb 63 WP, Zineb 75 WP and Propineb 70 WP, and active ingredients in formulation were in the range of 57–75.14% (RSD 14.18), 68.8–73.07% (RSD 2.98) and 69.07–78.98% (RSD 7.07), respectively.

Quantification of 101 pesticides: A method for simultaneous identification and quantification of 101 pesticides using LC-MS/MS was developed for assessment of pesticide residues in fruits and vegetables. The various validation parameters, viz. linearity, specificity, sensitivity and uncertainty measurement were determined. Seven-point linear calibration curves for each pesticide were obtained in a range of 0.01–2 µg/g with correlation coefficient (r) of ≥0.98. The method LOD and LOQ for all the pesticides were achieved in the range of 0.01–0.05 µg g and 0.03–0.15 µg/g, respectively.

Biomixtures for removal and degradation of azoxystrobin and imidacloprid: Four biomixtures comprising soil, rice straw (RS)/corn cob (CC) and compost (C)/peat (P) (1:2:2) were evaluated for adsorption of azoxystrobin and imidacloprid and were named as: RS+C, RS+P, CC+P and CC+C). Biomixtures varied in their capacity to adsorb imidacloprid and percent imidacloprid adsorption in biomixtures RS+C, RS+P, CC+P and CC+C varied from 94.4–97%, 66.2–85.4%, 66.2–85% and 40.6–55.2%, respectively. The respective values for azoxystrobin adsorption were 86.6–93.1, 91.3–95.4, 85.7–92.4 and 90.2–91.2%.

First report of tomato leaf curl New Delhi virus in association with tomato leaf curl New Delhi alpha satellite and tobacco leaf curl Patna beta satellite causing mosaic disease on sponge gourd

Total DNA molecules extracted from symptomatic samples of mosaic disease infected sponge gourd samples collected during field survey were subjected to rolling circle amplification (RCA). They were tested positive for the presence of begomovirus, using universal primer pair reported earlier through PCR analysis. RCA product of representative samples subjected to restriction analysis yielded ~2.7 kb presumed bands of virus was cloned, sequenced and analyzed. Analysis of sequenced RCA product revealed the presence of bipartite begomovirus Tomato leaf curl New Delhi virus (ToLCNDV) constituting two distinct DNA A molecule having 88.9% identity among themselves and one DNA B molecule sharing identity of 96% with earlier reported isolate of ToLCNDV from India. Amplification of alpha and beta satellites with universal primers revealed the association of tomato leaf curl New Delhi alpha satellite (ToLCNDA) and tobacco leaf curl Patna beta satellite (TbLCPB). This is the first report of association of ToLCNDV in association with ToLCVA and ToLCPB causing mosaic disease on sponge gourd in India.

Adsorption isotherm optimization results suggested that the Freundlich adsorption isotherm was best suited to explain the adsorption. This study suggested that compost and rice straw based biomixture can be utilized for decontamination of imidacloprid and azoxystrobin.

Bioactivity of chitinolytic *Bacillus* against *Plutella xylostella*: Mortality/growth reduction based-bioassay study with a collection of chitinolytic *Bacillus* against *P. xylostella* led to identification of eight bioactive isolates. Further bio-efficacy testing of these identified isolates against *H. armigera* revealed a significant growth reduction when evaluated at three different concentrations although no mortality was recorded. Among the eight isolates studied, only three isolates (UKCH27, UKCH29 and UKCH77) showed a sizeable reduction in weight of larvae even at the lowest concentration (10^2 cfu/ml) tested. However, the effect was not much dependent on dosage although a nominal variation was observed. Three of these isolates were selected to test their synergistic potential with *Cry* toxins of *B. thuringiensis* strain HD-1. Initial bio-efficacy of HD1 Cry toxins against *H. armigera* and *P. brassicae* revealed LC_{30} of 0.15 and 0.6 µg/ml, respectively. These LC_{30} values were tested in combination with the selected isolates at two different concentrations. The results showed an increase in the mortality of both the test insects. Especially, *P. xylostella* was found to be highly susceptible to the mixtures of chitinolytic bacteria and Cry toxins with 100% mortality even at the lowest concentration combinations. *Helicoverpa armigera* was also found to be highly susceptible to the mixture as indicated by elevated mortality range of 85 to 97%.

Efficacy of Cry toxins against neonates of pink bollworm: Five day old larvae of seven population of pink bollworm collected from Adilabad, Warangal, Guntur, Kurnool, Parbhani, Anand and Delhi (Lab) were screened by subjected to the one ppm concentrations of toxins, viz. Cry1Ac, Cry2Ab, BGII (MRC 7031) seed powder under controlled condition of 27±1°C and 65±70% RH. Results showed that Guntur and Kurnool populations were least susceptible to BGII (Cry1Abc+Cry2Ab) and rest of the population attained >60% mortality. Adilabad population attained only 40% mortality to Cry2Ab toxins, whereas other populations attained ≥50% mortality. Anand population was found most susceptible to both BGII and Cry1Ac with highest mortality of 83.3% and Guntur population was most tolerant of the tested populations with 26.67% and 30% mortality with BGII and Cry1Ac respectively.

Resistance to *Chilo partellus* in maize: A set of selected maize genotypes were characterized for changes in certain nutritional and anti-nutritional biochemical compounds, and activity of various enzymes in response to damage by *Chilo partellus*. The contents of chlorophyll-a, chlorophyll-b and total chlorophyll were significantly higher, while total protein, total starch and total sugars lower in healthy as compared to *C. partellus* damaged seedlings. Amount of anti-nutritional biochemical compounds such as PAL, total carotenoids and total phenols was significantly higher in *C. partellus* damaged as compared to healthy maize seedlings. The activity of enzymes, viz. ascorbic oxidase, catalase, total anti-oxidant, and FRAP was significantly lower, while that of ascorbic peroxidase higher in *C. partellus* damaged as compared to healthy maize seedlings.

Simultaneous detection of capsicum chlorosis virus, groundnut bud necrosis orthotospovirus and watermelon bud necrosis orthotospovirus: A multiplex RT-PCR protocol for simultaneous detection of groundnut bud necrosis orthotospovirus (GBNV), watermelon bud necrosis orthotospovirus (WBNV) and capsicum chlorosis virus (CaCV, unclassified) was optimized. For optimization, we designed and used three forward primers specific to CaCV, GBNV and WBNV (CaF', GbF' and WbF') and a single degenerate reverse primer (CaGbWb-R') common to all. The optimized protocol resulted in specific and simultaneous amplification of targeted N-gene segments of CaCV (~189 bp), GBNV (~271 bp), and WBNV (~554 bp). The optimized protocol will have its wider applications in specific, simultaneous, cost-effective and non-laborious detection of these viruses in plants and their thrips vectors, and subsequently in virus characterization, epidemiology, quarantine, virus resistance breeding, etc.

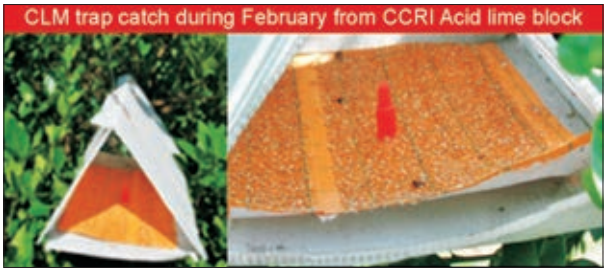
HORTICULTURE

Mango hopper: Field efficacy of newer insecticides was tested against mango hopper at panicle development stages under field conditions. The significant difference was observed among the treatments with respect to the reduction in the hopper population at three days and seven days after the spray. Among all the treatments Imidacloprid 17.6SL, Fipronil 5 SC and neem oil has reduced the hopper population up to 89.4, 78.21 and 86.2% respectively. Spraying of these insecticides at the panicle emergence stage of the crop will help in effective management of the hopper population.

Insecticides against mango thrips: Field efficacy of newer insecticides was tested against mango thrips under field conditions. The significant difference was observed among the treatments with respect to the reduction in the thrips population at three, seven and and 14 days after the spray. Among all the treatments neem oil was found superior followed by Fipronil 5 SC and Thiomethoxam 25WG. Spraying of neem oil, Fipronil and Thiomethoxam reduced the thrips incidence up to 90.0, 82.2 and 72.9%, respectively. Minimum fruit damage (%) by the thrips was found in neem spray.

Pheromone traps for citrus leaf miner: Under a collaborative research programme with Indian Institute of Chemical Technology, Hyderabad, efficacy of indigenously synthesized sex pheromone against citrus leaf miner, *Phyllocnistis citrella* for the management of citrus groves under central Indian conditions was conducted at ICAR-CCRI, Nagpur. Field experiments

at ICAR-CCRI nursery (@ 1, 2 and 3 traps/30,000 seedlings) and in young orchards of Acid lime and Nagpur mandarin (@ 2, 3 and 4 traps/0.3 ha) showed that pheromone dose @ 15 mg/30,000 seedlings in nursery and 20 mg lure per 0.3 ha in pre-bearing acid lime/Nagpur mandarin orchards had maximum significant trap catch and could be used for monitoring of citrus leaf miner and further for reducing infestation levels if installed coinciding with peak flushing seasons. An integrated module consisting of delta traps with graded yellow sticky cards loaded with 15 mg lure per 30,000 seedlings in nursery and 20 mg lure/0.3 ha for open field + foliar application of thiamethoxam @ 0.008% at 10 days interval followed by acephate @ 0.008% and fenvalerate @ 0.02% at 10 days interval reduced the infestation levels up to 68%. This pheromone lure can be used for the purpose of monitoring of incidence levels of citrus leaf miner during flush emergence and its timely installation in the field/nursery helps to check the pest population under economic threshold levels.



Modified integrated disease management schedule: The modified integrated disease management (IDM) schedule (using bioformulation, SAR agents and need based pesticides without bactericides) in pomegranate was tested in second year. The schedule gave 100% blight free yield of 11.45 kg/plant (8.47 tonnes/ha). The incidence of fungal spots/rots was below 2%.

Organic fungicide (Fungidote) for shot hole disease: Fungidote a mixture of several plant extracts was evaluated against shot hole disease of apricot fruits (CITH-AP-1) @ 3 ml/litre of water, twice at 30 days interval during the year 2018 at organic block of ICAR-CITH, Srinagar. The first spray was done at fruit let stage and second spray was done after 30 days of first spray. The results confirmed that the severity of disease both on fruits as well as leaves was very less on fungidote treated plants as compared to control plants where only water was sprayed.

Treated with fungidote | Control (treated with water)

Integrated disease management

Arecanut: Prophylactic spraying of 1% Bordeaux mixture or 0.5% Mandipropamid 23.3% SC was effective in management of fruit rot of arecanut.

Placing of perforated sachets containing 3 g of Chlorothalinil 75 WP in the inner most leaf axil was effective for the management of bud rot in coconut.

Pests and nematodes in coconut: Conservatory bio-suppression of rugose spiralling whitefly and bio-scavenging of sooty mould by spraying of water or neem oil 0.5% and without any insecticide, parasitoids (*Encarsia guadeloupae*) and scavenger beetle, *Leiochrinus nilgirianus.*

A crop habitat diversification with spectrum of intercrops in coconut garden (Kalpasankara) in root (wilt) disease affected zone induced volatile admixture and stimulo-deterrance which reduced incidences of rhinoceros beetle and rugose spiralling whitefly and increased nut yield to 161 nuts/palm/year.

Bio-suppression of arecanut white grub with aqua formulation of entomopathogenic nematodes (EPN), *S. carpocapsae* @ 1.5 billion IJs/ha with imidacloprid 0.0045% and neem cake 2 kg/palm recorded 91.8% reduction in root grub (*Leucopholis* spp.) population with significant increase in yield (62%).

In the investigations on semio-chemicals for management of tea mosquito bug (TMB), the delta sticky traps having horizontal stick liner were utilized for the field observations on TMB pheromone studies. It was found that the virgin TMB females aged between 4 and 5 days after emergence elicited maximum response when they were used as live bait in delta sticky traps. The whole body extract (WBE) could also elicit response indicating stability of pheromone volatiles.

Management of diamond-back moth: A neem seed powder pellet formulation with higher efficacy and

Light trap based integrated management of tomato moth, under polyhouse conditions

An IPM module was standardised specially for the management of *Tuta absoluta* under polyhouse conditions. Tomato moth is an invasive pest, reported from India in 2014 and presently spread to majority of the tomato growing states and regions of the country. It causes extensive damage (even up to 100%) to the tomato crop, particularly under polyhouse conditions. The IPM module includes use of incandescent yellow bulb 60 W @ one bulb/150 m^2, pheromone traps/300 m^2, need based spray of spinosad 45 SC @ 0.25 ml/litre or flubendiamide 480 SC @ 0.20 ml/litre in rotation at 2–3 weeks interval. Coinciding with the peak emergence of *Tuta* adults, deltamethrin 2.5 EC @ 1 ml/litre has to be sprayed. In green houses, the incidence of fruit damage by *T. absoluta* was reduced to 5–6% against 35–56% in control, when IPM practised. Light trap based IPM can be an effective and eco-friendly approach for the management of *T. absoluta* under greenhouse conditions.

First report on *cucumber mosaic virus* infecting antamul vine in India

Antamul vine (*Tylophora indica*) (Family: *Asclepidaceae*) is an important medicinal perennial climbing herb and consisting of more than 60 species. It is distributed throughout the world in tropical and subtropical regions. In India, normally found in northern and north eastern regions. Recently, the cucumovirus like symptoms of yellow chlorotic rings or irregular yellow spot and in severe condition necrotic rings were observed on the leaves of infected vines. The symptoms persisted throughout the year and observed consecutively during 2016 and 2017, in the herbal garden of ICAR-Directorate of Medicinal and Aromatic Plants Research, Anand, Gujarat. *Cucumber mosaic virus* is under genus *Cucumovirus* of the family *Bromoviridae,* reported to infect about 1,287 plant species. The association of virus with the disease was, as the spherical virus particles ranging from 28 to 32 nm size had been observed under the electron microscopy in the processed symptomatic leaf samples. Further, it was confirmed by using a set of novel degenerate primers (RM07F/CMVATYCAYGGHGGTT-ATGAYATGGG and RM07R/CMVCRAYRATYTTAT-ASGTCATRAT) in RT-PCR to amplify ~410 bp of the RNA1 genomic region. The sequencing results confirm the association of cucumber mosaic virus with yellow ring spot disease of antamul.

long shelf-life was developed at ICAR-IIHR, for management of diamond-back moth and aphid management in cabbage. The cumulative mean diamond-back moth count was 0.60 in the treated plot compared to 5.3 in the untreated control, whereas the aphid count per plant was 0.12 against 4.48 in control.

Diagnostics of begomovirus: Among 34 samples of tomato from Mirzapur and Varanasi districts, 25 samples showing leaf curl showed positive test for begomovirus. Among the 25 samples, 12 samples were found infected with tomato leaf curl New Delhi virus (ToLCNDV), 3 samples with tomato leaf curl Karnataka virus (ToLCKV) and 1 sample with tomato leaf curl Palampur virus (ToLCPalV) and none of the samples were infected with tomato leaf curl Bangalore virus (ToLCBV). Interestingly, mix of more than one begomoviruses combinations such as ToLCNDV + ToLCGV, ToLCNDV + ToLCKV, ToLCNDV + ToLCGV + ToLCKV and ToLCNDV + ToLCPalV + ToLCKV were also observed. Around 20 of 34 samples were associated with β-satellite and 27 of 34 samples associated with α-satellite. Among them, 17 of 34 samples were associated with both β-satellite and α-satellites.

Diagnosis of fungal pathogens infecting tuber crops: Loop mediated isothermal amplification (LAMP) was employed for rapid and effective detection of fungal pathogen. Three types of LAMP primers, viz. F3c, F2c and F1c regions at the 3' side and the B1, B2 and B3 regions at the 5' side were designed using *P. colocasiae* (Accession KY432681), *C. gloeosporioides* (Accession KJ632430) and *Sclerotium rolfsii* (Accession. KC894861) based on the six distinct regions of the ITS target gene. Using LAMP technique, DNA of *P. colocasiae* and *C. gloeosporioides* was amplified under isothermal conditions of 63°C for one hour in PCR which could detect the pathogen by visual evaluation of the reaction mixture. Visual detection of amplification product was done in-tube by adding different nucleic acid dyes like ethidium bromide, calcein and HNB in LAMP reaction mixture. The products of LAMP reaction could also be detected by electrophoresis on 2% agarose gels which showed ladder-like patterns. Given its specificity, sensitivity, easy handling and cost-efficiency, the LAMP assay is recommended to be suitable diagnostic kit for fungal pathogens infecting tuber crops relative to the conventional PCR technique.

Managing bacterial wilt in ginger: An integrated strategy for managing bacterial wilt of ginger under organic/inorganic system of cultivation was developed and successfully demonstrated in farmers' plots. It involves solarizing soil for 30–40 days prior to ginger sowing and soil amendment with calcium chloride 3% or *Bacillus licheniformis* (GAP 107) at the time of planting and at 30, 45, 60 and 90 days intervals.

Pest and disease management in fenugreek: Significant reduction (<50%) in powdery mildew and leaf blight diseases of fenugreek was observed in the spray schedule [copper oxychloride (0.2%) followed by propiconazole (0.05%)/ difenoconazole (0.05%)/ chlorothalonil (0.2%) and hexaconazole (0.1%) at 15 days interval].

Promising accession for pest and disease resistance with higher yield in isabgol: Isabgol (*Plantago ovata*) is one of the most important medicinal crop for both health as well as commercial point of views. The crop is highly sensitive to rainfall during the flowering time and prone to the pest and diseases particularly aphids, downy mildew and wild disease. In this connection we have identified an accession (RPPO 19) showing tolerance to the aphid (*Aphis gossypii*) infestation and moderately resistance to the both downy mildew (*Peronospora plantaginis*) as well as wilt (*Fusarium* spp.) diseases.

Field screening of onion germplasm against *Stemphylium* blight disease: Total 52 lines of onion germplasm maintained at ICAR-CITH, Srinagar, were screened under field conditions against *Stemphylium* blight disease. Among 52 lines, on the basis of disease reaction (1–5 disease scale), all the lines were classified into 4 groups. Two lines with disease score 1 were categorized as resistant, 10 lines with a disease score 3 were classified as moderately resistant, 14 lines with a disease score 4 were classified as moderately susceptible, 26 lines with disease score 5 were categorized as susceptible.

Mushroom flies: Placement of UV fly catcher (365 nm) at 5' height during night proved highly effective for trapping and controlling killing of mushroom flies.

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8. Livestock Management

Nutrition

Biogeography of gut microbes in ruminants: Cattle, buffalo, sheep and goat metagenomes were profiled based on 16s rRNA amplicon sequencing, and metagenome diversity among these species was compared. The metagenomes of the cattle and buffalo were closer than the sheep and goat in terms of microbial diversity. Buffalo had less metanogens and fibre degrading bacteria as compared to cattle.

Web based sheep database management system: To record the data on production, reproduction, growth and related activities in each of the project related to sheep breeding at any platform (NWPSI, MSSP, CSWRI and agency), the web based portal (www.sheepdbms.org.in) was developed. This portal is user friendly and any investigator who works with sheep breeding can become a user. The platform is helpful to upload the data related to production, reproduction and other related formats. The data are centrally stored at CSWRI for further analysis.

Alternative feed resource: A modified hydroponic way to produce mold-free sprouts on local crop residue bedding was developed. Quality maize grains (QMG) were soaked in water for 24 hr and tightly packed in a wet cloth thereafter for 36 hr in a dark place to ensure rapid germination. Germinated grains were placed in 4% vinegar solution for 30 min to prevent the mold growth. Later, the grains were transferred on to half inch thick paddy straw beds and placed in plastic trays with fine holes at the bottom and on sides. The trays were housed in a shelf made with locally available low cost materials. Approximately 8 litre water was required to obtain 3.95 kg of wet sprouts (QMG) from 1 kg of QMG. The cost of production was approximately ₹ 4/kg of wet sprouts of maize.

Germinating maize grains on straw bed (A). Maize sprouts ready for feeding (B).

Cattle

Silkworm pupae meal: Feeding value of byproducts of silkworm pupae was evaluated in crossbred cattle. Supplementation of different inclusion levels of defatted silkworm pupae meal (DSWP) by replacing soybean meal (SBM) in the concentrate mixture of finger millet straw (FMS) based diets revealed no significant difference in pH, NH_3-N, TVFA, PF, MBB, ME, IVDMD and IVOMD among the treatments. The study indicated that DSWP can be incorporated in the ration of cattle up to 30% by replacing SBM without compromising the rumen fermentation and nutrient utilization.

Effect of stimulants: Supplementation of tree leaves rich in essential oils (EOs), affect the rumen microbial ecosystem by selective inhibition of specific group of microbes depending on the dose and constituents of essential oils as well as diet of animals. The results indicated that the level of essential oils-rich-feed additives did not affect the nutrients intake and their utilization. However, the methane concentration in exhaled air decreased after three months of feeding of the feed additives rich in essential oils.

Buffaloes

Hyper-ammonia producing bacteria and their inhibition: Investigations were carried out to determine predominant hyperammonia producing bacteria (HAB), isolate and characterize HAB, and screen and select suitable additive for inhibition of HAB in rumen of buffaloes. Study indicated that at phylum level Proteobacteria (61.1 to 68.2%) was the most predominant HAB followed by unclassified bacteria (24–29%). At genus level, among sequences with valid genus name *Acidaminococcus* was the most predominant. Other genera detected includes *Candidatus, Carsonella*, *Allisonella*, *Oscillobacter, Bacteroides, Proteus, Fusobacterium, Pyramidobacter, Paraeggerthella, Denitrobacterium, Succinoclasticum* and *Acidaminococcus*. Twenty isolates of HAB were isolated from rumen of buffaloes and they had very high rate of ammonia production (up to 200 times higher than that reported earlier) and had low16S rRNA gene similarity to cultured bacteria indicating that many more culturable HABs exist than that is known so far. *In-vitro* studies with rumen fluid of buffalo indicated that most of the plant based additives tested (origanum oil, clove oil, lemon grass oil, eugenol, saponins, reetha extracts, bargad leaf extracts, etc.) tend to affect feed digestibility significantly at dose level required for meaningful reduction in ammonia production. However, a combination of additives reduced ammonia production significantly without affecting feed digestibility. Feeding the additive blend to adult fistulated buffaloes reduced ammonia level 55% in rumen fluid, which was much higher than that observed (17%) in *in-vitro* studies. Further, there was no reduction in VFA production or total bacterial population or important fibrolytic enzymes. Feeding of the additive blend to growing buffaloes resulted in 14% increase in average daily gain in BW with a trend in improvement of feed and

protein utilization efficiency with no change in feed digestibility or blood biochemical parameters suggesting that these additives can be safely used for improving performance of buffaloes.

Pigs

Locally available feed resources: The locally available and most commonly utilized feed resources by the farmers, were identified and their nutritional profiles characterized. The most commonly used local feed resources are rice polish, wheat bran, dry fishes, fresh squash, tree leaves etc. for feeding of pigs.

Camel

Calcium nanoparticles as oral calcium supplement: Caclium carbonate as a nanoparticle mineral supplement was evaluated in growing camel calves as compared to traditional calcium carbonate salt. The calves supplemented with calcium carbonate nanoparticles showed good growth rate with disappearance of signs of deprived appetite or pica.

Higher plane of nutrition: In order to hasten puberty the effect of higher plane of nutrition was studied in female camel calves fed in two groups of camels–one fed on sole feed of crop residue of *guar phalgati* (GPH) fodder and the other on crop residue groundnut fodder (GNF), *ad lib.* along with 1.5 kg concentrate (GNF+C). Both groups of animals had higher body weight (> 380 kg) and the ovarian follicles were seen in all the animals. The ovarian function seems to be related with the body weights of she camels and all the camels were efficient in utilizing sole fodder also to achieve proper weights required for sexual functionality. Similar uniform feeding and management conditions were followed in general herd resulting in successful pregnancy in 13 heifers at an early age. The milk production of she camels bred at lower age of puberty and calved at an early age of 3 years was compared to females calved at 4 years of age and it was found comparable in Jaisalmeri breed of camels but was slightly lower in Kachchhi camels. Advantage of the early age at puberty and higher life time production is possible. Use of the male camel calves at early age of 4.5 years also reared for breeding did not have any adverse effect on the calving performance of females it served and resulted in a birth weight of 38.2 kg for calves born to these females. In an effort to reduce calving interval by early post partum breeding, 9 she camels out of 12 were bred during postpartum period from 56 to 116 days of calving and based on calving of 4 animals, the inter-calving period was found to be an average of 443 days indicating that successful breeding can happen even after 2 months post calving.

Ensiling in polythene bags to combat winter feed scarcity

At high altitude areas, where yaks are reared by the pastoral nomads for their livelihood and nutritional support, the scarcity of fodder during winters is one of the major problems affecting animal health and production. Yaks lose around 25% of their live body weight owing to non-availability of fodder during winter. To mitigate the winter feed crisis and supplement green fodder in the form of silage to yaks in winters, *Salix* silage was prepared in polythene bags (500 kg capacity) at an altitude of 2,800 m above msl. Green leaves along with tender twigs of a fast growing *Salix* tree were lopped and conserved through ensiling in polythene bags. The quality and acceptability of the *Salix* silage by the growing yaks was comparable to the maize silage. Therefore, *Salix* silage making in polythene bags is an alternative way of conservation of green fodder to address the winter feed scarcity. This method is also superior over the traditional silo method owing to ease of carry and flexibility in making small batches of silage as per the availability of green fodder.

Mithun

Feeding management of dams: Feeding management of dam showed a significantly higher average daily gain (ADG) of the calves (500.7±98.90 g/days) when both the dams and calves are kept under confinement than the calves (209.3±19.51 g/days and 304.7±51.78 g/days) when either dams are let loose or both the dams and calves are let loose.

Poultry

Broilers: In the process of clean poultry meat production, the study on efficacy of synbiotic (Mannan oligosaccharides-MOS at 0.2% and *Lactobacillus acidophilus* at 10^6 cfu/g of feed) in low-energy low-protein diet of broiler chickens (0–6 wk of age) revealed that synbiotic was beneficial for significant improvement in performance, immuno-competence, structural and microbial gut health, physio-biochemical characteristics of fresh and stored meat, and reducing entero-pathogen counts in fresh as well as stored meat.

Dietary inclusion of betaine @ 0.25 g/kg and 0.5 g/kg was beneficial for improving growth performance, ameliorating heat stress and economic broiler production during hot dry and hot-humid conditions, respectively. Feed cost of broiler meat production was reduced by 3.3–6.7% use of additives (synbiotics and betaine) during hot-dry and hot-humid conditions.

Inclusion of 80 ppm of zinc was optimum during summer, and nano zinc (NZ either commercial or green) proved to be better source than inorganic or organic sources of zinc for improved performance and immunity of broiler chickens during summer. Considering production ease, health hazards if any, and cost of production, the green nano zinc is recommended.

Supplementation of choline chloride alone could not spare the requirement of methionine in broiler diet, but improved the growth, immune response and carcass traits of broiler chicks at 120% choline chloride level when diet contains 100% methionine.

Layers: Inclusion of *Kappaphycus alvarezii* and red sea weed based formulations (AF-KWP) at 1.50% level in layer diet lowered age at sexual maturity and improved significantly the production performance,

immune response and egg quality traits.

Nutritional manipulations for optimising performance in chicken: The egg production, egg mass and feed efficiency in layers were significantly improved by enhancing dietary ME from 2,400 to 2,500 kcal/kg diet and by supplementing low energy diet with microbial enzymes during summer. Increased concentrations (0.65 to 0.8%) of digestible lysine improved performance of layers fed *guar* meal based diet (10 %). In Vanaraja chicks, inclusion of 20% alternate feed ingredients like distillers dried grains with solubles (DDGS), rape seed meal or cotton seed meal significantly depressed performance and immune response, and increased stress responses. Feed efficiency, immune response and activity of anti-oxidant response were improved in Vanaraja chicks fed OxyCure, a supplement (blend of antistress agents). The rice DDGS could be used up to 10% in Vanaraja chicks diet with beneficial effects at lower level (5%). The nutritional status of backyard chickens of the country as studied in Tripura, Himachal Pradesh, Rajasthan and Telangana, indicated deficiency of energy, protein and calcium in the diet being consumed by the birds. In a field study in Telangana, supplementing 15 g of feed/bird improved growth rate in Vanaraja chicks. Zinc sulphate was found suitable for producing organic Zn using yeast. Further, strain (*S. cerevisiae* strain 050) and inorganic Zn concentration in media (200 ppm zinc sulphate) were optimized for the purpose. Organic Se improved body weight in Vanaraja chicks at 0.2 ppm level. Feeding nutrient specific maize cultivars (QPM and QPM + Provit A) resulted in better body weight gain and improved feed efficiency in Vanaraja chicks, besides improving carcass quality. Select plant bioactive compounds were evaluated, out of which some could inhibit *Escherichia coli* at as low dose as 2µl/30 ml medium with ability to spare *Lactobacillus*.

Physiology

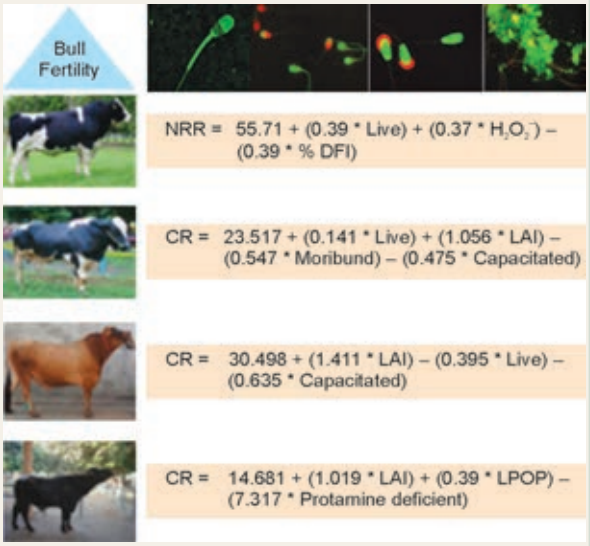
Cattle

Semen collection and freezing: Frozen semen doses of Gir (41,020), Kankrej (15,329) and Sahiwal (8,944) bulls were produced at respective germplasm units. Frozen semen doses (67,243) of Frieswal bulls were distributed to Military Farms and Field Progeny Testing Project (36,400). The doses available from Gir, Kankrej and Sahiwal bulls at the end of the reporting period were 85,598, 15,1593 and 83,761, respectively. About 20 lakh frozen semen doses of Frieswal bulls are available with the institute (ICAR-CIRC) for utilization in field/farm animals.

MicroRNA-related variants associated with corpus luteum tropism: Data obtained from deep sequencing of corpus luteum tissue from different physiological stages w.r.t. corpus luteum tropism was used for the identification of the miRNA-related variants (SSRs and SNPs) using *Bos taurus* as reference genome. Five annotated and 176 annotated miRNA were deduced by BLAST2GO for detection of variants (SSRs and SNPs) while comparing with *Bos taurus* genome. In addition, 4 SSRs and 9 SNPs were deduced in the miRNA sequences on the key genes confirming their role in governing the corpus luteum tropism in buffaloes during estrous cycle and pregnancy through angiogenesis, cellular transformation, immuno-regulatory functions.

Fertility prediction models in cattle and buffalo bulls

Cryopreserved semen doses from HF crossbred, Jersey crossbred and Murrah buffalo bulls with known field fertility were utilized for development of fertility prediction model. Functional attributes of spermatozoa were assessed for each bull and related with the fertility. For each breed, the sperm parameters accounting to high variability were identified. Based on these results, the most suitable combination of tests for fertility prediction was identified and fertility prediction model developed for the three breeds studied. The model showed high accuracy for identification of high and low fertility bulls. These findings would help in selecting superior quality semen for use in artificial insemination thus facilitating high conception rates at field level.



Development of sperm function based fertility prediction models in cattle and buffalo bulls

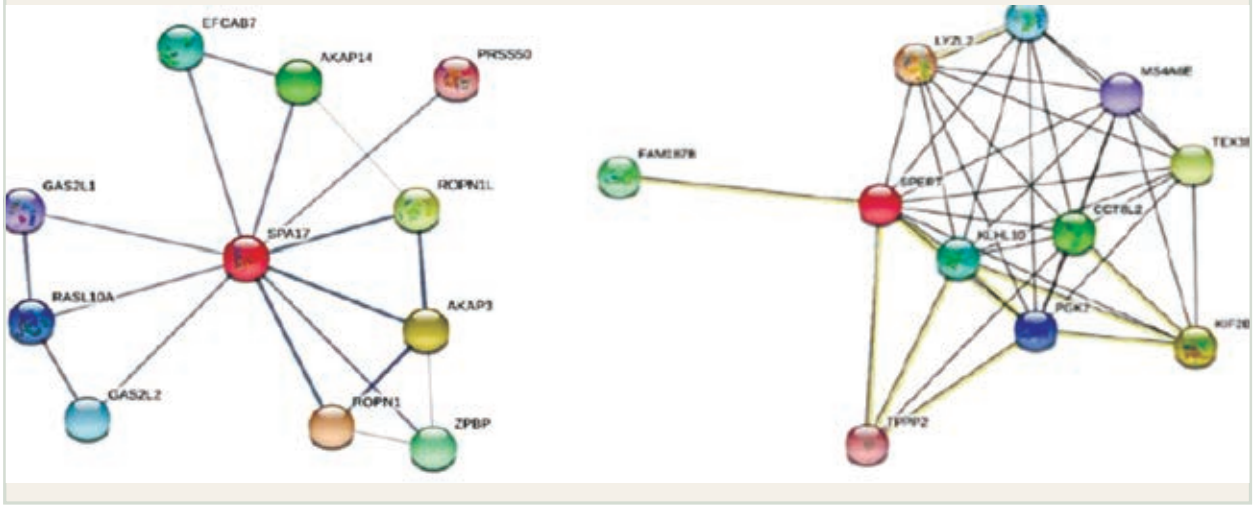
Buffalo

Semen extender: Efforts were made to develop a novel semen extender for improved post-thaw motility of cryo-preserved buffalo semen. The study established that Agent-A and genistein have the potential to reduce cryopreservation-associated loss of post-thaw viability and motility and can minimize other oxidative biomolecular changes in buffalo semen/sperm.

Estrus specific candidate proteins in saliva: Saliva samples collected from Murrah buffaloes at different stages of estrous cycle, were subjected to global proteome analysis. A total of 275, 371, 304 and 565 proteins were identified with ≥2 peptides during proestrus, estrus, metestrus and diestrus stages of estrous cycle. Among the identified proteins 31, 62, 32 and

Early fertility markers in pigs

Increasing number of idiopathic infertility and inability to explain differential fertility of boars with similar motility and morphological parameters points to the inadequacy of conventional methods for more precise assessment of fertility. The spermatozoa transcriptome of boars differing in fertility was examined and compared with the fertility status of boars used in the AI programme. Based on the transcriptome, 30 genes were selected representing roles in the spermatogenesis, spermatozoa, fertilisation and zygote development. Expression profiles of these 15 genes in the spermatozoa of 18 boars were compared with known fertility status to validate the transcriptome study. The pathways of important differentially expressed genes were analyzed.



104 proteins were specific to proestrus, estrus, metestrus and diestrus. Among the identified proteins 74 were common to all the stages. Gene ontology revealed that majority of the proteins were involved in catalytic activity (44.1%), binding activity (39.8%) and rest of the proteins were involved in structural molecule activity (7.5%), transporter activity (5.4%) and receptor activity (3.2%). Identified estrus specific proteins were involved in several pathways which are important for events associated with estrus. Few salivary proteins, identified as estrus-specific, are important for estrus physiology. Further analysis revealed 583 differentially expressed proteins (DEPs), out of which 28 proteins identified with at least two peptides were up-regulated and 32 proteins identified with at least two peptides were down-regulated at estrus stage as compared to other stages of estrous cycle. Out of up-regulated proteins, Vomeronasal type-1 receptor, Nucleobindin-1, Mucin-19, Cadherin-19, Thioredoxin, Tudor domain-containing protein 6 and protocadherin gamma-C3 proteins were found highly abundant at estrus.

Simplification of nuclear transfer technique: Semen contains sufficient number of epithelial cells and these cells can be used to produce cloned copies of a particular breeding bull. To achieve this, the efficient somatic cell isolation protocol is required to culture cells from ejaculated semen *in-vitro*. Epithelial cells were isolated from the semen of two buffalo breeding bulls. Undiluted semen samples were stored in a 4°C refrigerator for different time periods. The cell attachment rates were 100 % and 66 % for the samples which were stored for 24 hr and 72 hr, respectively; whereas, 66% for one bull and 33% for other bull for 144 hr storage. Established cells were of an epithelial origin type. Cloned blastocyst production rates of semen-derived cells were comparable with that of skin-derived cells. This study indicated that epithelial cells can be cultured from stored semen and they can also be used as donors to produce cloned embryos of breeding bulls.

DOKA-a sign of impending oestrus: A peculiar phenomenon 'DOKA' (temporary engorgement of teats) shown by lactating buffaloes prior to commencement of estrus was studied in Murrah buffaloes. Doka is an important sign used by farmers for prediction of estrus in buffaloes. The study examined physical and morphological changes before, after and during Doka. Doka is widely expressed in lactating buffaloes (~ 66% animals) during mid-lactation for approximately four days prior to onset of estrus. The present study concluded that animals expressing Doka are cyclic and have normal ultrsonographic and hormonal (progesterone and estrogen) levels except PGFM, which showed high concentration during this phenomenon expressed over about 4 days.

Goat

Cryopreservation of semen and artificial insemination: Semen diluter with the composition of tris -egg yolk- fructose diluent, having 7.5% (v/v) egg yolk and glycerol 5.4% (v/v) was standardized. Frozen semen doses (4,124) of Jamunapari, Barbari and Jakhrana goats were cryopreserved. The overall post-thaw motility irrespective of breed was 50.55%. Overall, a success rate of 35.32% was achieved on the basis of actual kidding rate irrespective of goat breeds under semi-intensive management system. The pregnancy was confirmed at or after 28 days post mating using trans rectal ultrasonography in inseminated does.

Advancing puberty: Pre-pubertal supplementation of organic Cu and Zn advanced the puberty by 28–35 days in indigenous bucks and the quantitative and qualitative characteristics of semen improved at fresh, pre-freeze and post thaw stages improved the antioxidant defense mechanism and resulted in significantly higher expression of selected genes in sperm cells and blood samples of the treated bucks. Further, organic Cu supplementation was better than the Zn and/or combination of Zn and Cu.

Gold nano particles

Attempts on conjugation of the gold nanoparticles (AuNPs) prepared in colloidal form by reduction of gold salt through a nucleation process were made with the anti-progesterone antibodies. The gold nanoparticles prepared were also characterized by dynamic light scattering measurements. These measurements showed that the prepared gold nanoparticles are suitable for conjugation experiments. Attempts were also made for *in silico* analysis for interaction between peptide identified from M × 2 protein and the gold nanoparticle surface. Gold nanoparticles were successfully conjugated with the BSA as a representative protein. The *in-vitro* stability of the prepared conjugate was assessed in different concentrations of sodium chloride and other solutions mimicking biological conditions.

Mithun

Estrous synchronization and timed AI: Using Co-synch protocol, 40 animals were synchronized and among them, 82.50% animals exhibited the estrus signs. On artificial insemination of these estrous animals, pregnancy was confirmed in 24 (72.72%) animals. During the reporting period 17 calves were born.

Effect of melatonin on reproductive efficiency: Exogenous administration of melatonin (@18 mg/kg b.wt.) in mithun bulls exhibited a significant protective effect on sperm parameters both in fresh as well as cryopreserved semen. Addition of melatonin (@ 3 mM) in semen diluents also showed a beneficial effect on sperm functional parameters irrespective of the season.

Fetal lubricator for dystocia cases: Device for proper lubrication of fetus during handling of dystocia, was developed. It prevents wastage of lubricating material thereby making it economical for use. Reduces handling time and obviates the need for repeated insertion of hands, hence reduces stress to the dam.

Poultry

Semen cryopreservation: Chicken semen cryopreservation using dimethylacetamide (DMA) in French straws was standardized. Supplementing vitamin E analogue (0.2 mM) during cryopreservation of semen along with N-methylacetamide (12%) improved fertility. Other supplements like BHT, L-glycine and L-carnitine, however, showed no such beneficial effect.

Livestock protection

Disease informatics: Livestock Diseases Forewarning-Mobile Application 'LDF-Mobile App' (Version English) was developed for extending the reach of the National Animal Disease Referral Experts System (NADRES) predicting forewarning report of 13 economically important livestock diseases in the country to various stakeholders including the field veterinarians**.** LDF-Mobile App also provides details of the clinical samples to be collected in case of outbreaks of the listed diseases for laboratory confirmation.

A quantitative stochastic risk assessment model for porcine reproductive and respiratory syndrome virus (PRRSV) was developed to estimate the seasonal probabilities of PRRSV release into rest of India from north eastern region through local transportation. Analysis of haemorrhagic septicaemia (HS) outbreak data revealed that most of the HS outbreaks were occurring during August followed by June. Anthrax outbreaks were significant in September and minimum in May in Odisha and Tamil Nadu. The risk maps for haemonchosis up to Taluk level in Rajasthan state were developed.

Disease screening: Screening of Frieswal bulls for infectious bovine rhinotracheitis (IBR) and brucellosis revealed seropositivity in bulls for IBR. All bulls were negative for brucellosis. Frozen semen samples (399) from IBR seropositive bulls were tested for IBR virus and all were found negative.

Veterinary type culture collection-rumen microbes: Two new anaerobic bacteria, *Clostridium*

Cloned Assamese buffalo calf born in the field

A male cloned calf named as Sach-Gaurav of Assamese buffalo was born through a normal delivery at Sirsa (Haryana). The birth weight of the cloned calf was 54.2 kg. The genotype of the calf was confirmed by microsatellite analysis (parentage verification) and chromosome analysis. This achievement has multiple uniqueness and several firsts:

- World's first cloned buffalo born in the field; 100 km away from the cloning laboratory
- Small tissue of Assamese buffalo was airlifted from College of Veterinary Science, AAU, Khanapara, Guwhati, which is 2,000 km away from our cloning laboratory, to establish the cultures of donor cells
- India's first cloned Assamese buffalo calf
- Cloned embryos were transported for approximately 2 hr before being transferred into the recipient mothers
- Ovaries of Murrah buffaloes were used as a source of recipient oocytes, it proves that one breed of buffalo eggs can reprogram donor cells of other breeds of buffalo; also, Murrah buffalo served as a surrogate mother to support pregnancies of cloned embryos of Assamese buffalo
- Singlet method of embryo reconstruction, in which only one recipient oocyte cytoplasm (current method) was used instead of two cytoplasm (standard buffalo cloning method used in India), it is a step towards simplification of buffalo cloning technique

acetobutylicum NRCC 1 and *Clostridium butyricum* NRCC 2 from camel rumen fluid were isolated characterized and submitted to VTCC-RM repository.

Epidemiology

Serum samples (4,223) from cattle, buffalo, sheep, goat and pig were screened for anti-*Brucella* antibodies from Asom, Tripura, Nagaland, Manipur, Uttar Pradesh, Jammu and Kashmir, and Goa, which revealed an overall 3.12% seropositivity.

The multilocus sequence typing (MLST) analysis of 117 *Brucella* isolates revealed ST1 as the predominant sequence type (ST), among the *B. abortus*, whereas ST8 and ST14 as predominant sequence types among *B. melitensis* and *B. suis* circulating in India**.** Methicillin-resistant *S. aureus* (MRSA) isolates collected from cattle samples from Bengaluru, were subjected to *spa* typing, which showed t17242 as the most predominent type. Virulence typing of 43 drug resistant *E. coli* isolates from Tripura, revealed that 16% of the isolates were harbouring Shiga toxin (stx2) gene, 12% traT gene and 21% cnf1 gene.

Post vaccination serum samples (2,773) from cattle and buffalo belonging to different states of India were screened by fluorescent polarization assay (FPA), which revealed highest vaccination coverage in Himachal Pradesh. Samples (92) from animals and environment (16) from Odisha, were screened for the presence of *B. anthracis,* and 11 samples were found positive.

For surveillance of *Leptospira* serogroup specific antibodies in livestock and human, serum samples (1,678) from Karnataka, Maharashtra, Andhra Pradesh and Kerala were tested by microscopic agglutination test (MAT). Out of 1,295 animal and 383 human serum samples,753 animal and 147 human samples showed positive reactivity for *Leptospira* serogroup specific antibodies. Screening of bovine serum samples (1,276) from 13 states of India for the presence of antibodies against IBR revealed 27.03% seroprevalence.

Clinical samples (56) received from Mizoram, Asom and Sikkim were screened for TTV (porcine torqueteno virus) infection by PCR, 9 samples were found positive from Sikkim, and 2 each from Asom and Mizoram.

Screening of goat serum samples (5,598) collected from 12 states and sheep serum samples (1,277) from 8 states for bluetongue, revealed that among sheep, the highest sero-prevalence was in Odisha and among goats, highest seroprevalence was in Madhya Pradesh. During sero-surveillance, 47.58% sero-conversion for bluetongue was found in sheep and goats. Sero-conversion was more in adult goats (above 6 months of age) in comparison to the younger animals. BTV serotypes and BTV-1 was the most predominant (63.88%) followed by BTV-10 (41.66%), BTV-23 (30.55%), BTV-9 and 16 (22.22%) and BTV-2 (13.88%) by serum neutralization test. Clinical specimens from flocks of sheep from Karnataka; blood samples suspected for BT from Tamil Nadu; isolates from Karnataka and Tamil Nadu were studied. Screening of the isolates indicated circulation of at least five serotypes (1, 2, 3, 16 and 24)**.**

Portable semen thawing kit

A device for thawing of frozen semen straws was developed with the following features:

- Digital temperature control for frozen semen straw thawing at 37°C for 30 sec
- Cut-off at 37.5°C, restart at 36°C
- Digital timer with beep after 30 sec
- Indicator for cell charging
- Water holder (50 ml, 14 cm height) for straw thawing
- Water holder with scale resistance properties
- Rechargeable (DC power output) coupled with solar charging
- Cell power to last for 15–20 cycles for 2–3 days
- Light weight, durable and affordable
- Provision for keeping accessories like scissor, tong and tissue paper
- Marking platform with divisions for frozen semen straw identification

Out of 90 samples from sheep and goat pox outbreaks, 72 samples were found positive for the virus and six isolates were recovered in cell culture. The capripox virus was further confirmed in the clinical samples and cell culture by P32 gene-based PCR and sequencing. PCR amplification for ORF 74 (IMV envelope protein), ORF117 (fusion protein, virus assembly) and ORF122 (EEV glycoprotein) was standardized.

Field survey results revealed 87% overall sero-prevalence of PPR in sheep and goats, which on Chi-square analysis, revealed the significant difference in sero-positivity across age groups and sex. Assessment of PPR post vaccination sero-conversion in small ruminants after annual mass vaccination campaign (MVC) implementation indicated a protective level of 55% in small ruminant population.

The estimation of sero-prevalence of Surra in north eastern region of India showed the highest sero-prevalence in Mizoram (92.45%) followed by Sikkim (70.16%), Asom (61%) and Tripura (52.55%). Screening of human serum samples (Maharashtra, 1,991; Karnataka, 10) for toxoplasmosis showed positive reaction for IgG *Toxoplasma gondii* antibodies in 18.18%.

Drug resistance and pathogenicity of *Trypanosoma evansi*: The blood samples from camels from different parts of Rajasthan, were examined for possible presence of drug resistance strain of *T. evansi* in field. Samples found positive for *Trypanosoma* infection revealed a specific amplicon size of 540 bp. One transporter gene TeAT1(~1453 bp) was identified from all the stocks of *T. evansi* thus studied. The comparison of these with the laboratory-made-resistant strain of *T. evansi* revealed the existence of quinapyramine resistance. Out of 21 positive field samples 5 samples were resistant (23.8%) to quinapyramine salts indicating appearance of resistance in *T. evansi* organisms.

Respiratory diseases of camels: Clinico-pathological and diagnostic studies on respiratory

diseases of camels revealed four cases of tuberculosis and one case of interstitial pneumonia in adult camels. Isolation revealed *Staphylococci* spp. infection.

Udder health and milk quality: Evaluation of udder health of lactating camels revealed that all four quarters were healthy (68%), while 12 animals (24%) had one quarter positive for sub clinical mastitis (SCM) and only four animals (8%) had either two or three SCM quarters positive. Number of colony forming units (viable bacteria)/ ml in normal camel milk was 10 times lesser than cattle. Field mastitis diagnostic tests were demonstrated to tribal farmers in TSP areas for timely mastitis diagnosis of their lactating camels. This will help in reducing economic losses due to mastitis, and help increasing their income.

Diagnostics

- Five monoclonal antibodies (mAb) against smooth lipopolysaccaharide (LPS) antigen of *Brucella abortus* S99 were produced and characterized.
- The duration of indirect ELISA protocol for surveillance of brucellosis was reduced to 3 hr instead of 5 hr duration and was evaluated to suit the hand-held ELISA reader with ready to use reagents.
- Recombinant BP-26 antigen based indirect-ELISA for sero-diagnosis of brucellosis was developed; its performance was better than the available kit.
- The gene coding sequences of the OMP of pathogenic *Leptospira* namely OMP37L, LSA 27, Loa 22, LigB, were cloned, expressed in prokaryotic system and purified. Reactivity of purified recombinant expressed OMP protein was assessed.
- Recombinant antigen based latex agglutination test (LAT) was developed for the sero-diagnosis of bovine leptospirosis.
- Fusion protein involving two non-structural proteins was produced through recombinant DNA technology and used in the ELISA being developed for sero-surveillance of bluetongue.
- Modified double disk approximation assay for detection of *ESBL* production was able to detect all the 25 ESBL producers.
- Listeriosis- A latex agglutination test (LAT) and indirect ELISA employing synthetic peptides of LLO were developed for serodiagnosis of listeriosis in caprine and bovine species.
- Further, an LAT using polyclonal IgY antibodies against recombinant LLO and synthetic peptides of LLO were also developed for direct detection of *L. monocytogenes* in foods and clinical samples after enrichment in broth.
- Japanese encephalitis- An indirect IgM ELISA was developed to know the active infection of Japanese encephalitis virus in pigs.
- For sero diagnosis of JE virus in equines, an indirect IgG ELISA having diagnostic sensitivity of 79.66% as compared to a commercial ELISA kit (12.65%) and HI test (15.85%), was also standardized.

Screening for genetic diseases

Tetra primer-amplification refractory mutation system based polymerase chain reaction (T-ARMS–PCR) was used for genotyping of rs445709131-SNP responsible for the bovine leukocyte adhesion deficiency (BLAD) in cattle. The procedure was modified with the use of thermostable strand displacement polymerase (SD polymerase) instead of commonly used Taq DNA polymerase. The amplification efficiency, reaction sensitivity, specificity, and need of PCR enhancer in reactions containing SD polymerase and Taq polymerase were improved as all amplicons were generated by 25 cycles. Further, modified assay amplified all amplicons at a wider range of annealing temperature (50° to 60°C), without the addition of dimethyl sulphoxide. The replacement of Taq polymerase with SD polymerase found beneficial in the T-ARMS assay for development of user-friendly faster assay, which is lesser affected by the reaction and cyclic conditions.

- Closed tube LAMP assay for simple visual detection of capri pox viruses in sheep and goats: The developed closed-tube LAMP assay could be a field applicable diagnostic tool in clinical surveillance of CaPV during control and eradication phases of capri pox infection in sheep and goats.
- Diagnostic assay for enterotoxaemia: Indirect ELISA was developed for detection of protective antibody titer against enterotoxaemia post-vaccination using two different antigen candidates, viz. partially purified epsilon toxin from culture supernatant and peptide antigen 'SFANTNTNTNSK'. Purified toxin based iELISA (PT-iELISA) has the sensitivity to detect anti-epsilon antibodies as low as 1:500 from known source and the peptide based iELISA (P-iELISA) could detect anti-epsilon antibodies up to 1:100. This makes the PT-iELISA more sensitive and the Pi-ELISA as more specific to minimum cross-reactivity.This would improve the way the vaccination is scheduled to offer better protection against ET.

Inflammatory gut diseases: Surface layer protein/ total surface proteins were extracted from six strains of probiotic *Lactobacilli* namely *L. plantarum* LpA1, Lp91, Lp9, LpA5, *L. fermentum* Lf1, LfS4 along with two reference strains of probiotic lactobacilli, viz. *L. acidophilus* NCFM and *L. rhamnosus* GG. A prominent band of 45 kDa size in *L. acidophilus* NCFM representing S layer protein was observed. Since, similar type of band was not observed in any of the test strains of *L. plantarum* and *L. fermentum* strains, the bands of surface proteins near 45 to 50 kDa were excised from SDS-PAGE and subjected for MS/MS spectrum. No protein was identified as s-layer protein with very high score and did not match with respective s-layer proteins in the public protein database (NCBI/Uniprot), suggesting that given lactobacilli do not possess s-layer proteins on their surfaces as many *Lactobacillus*

strains were documented as non surface layer producers. The bands with apparent molecular mass of 45–50 kDa from *L. planatrum* and *L. fermentum* strains were identified with molecular weight of 43.447 kDa.

Equine

Sero-surveillance of equine infectious diseases: The sero-prevalence for various diseases were–60.78% for piroplasmosis, 15.56% for EHV1, 6.98% for trypanosomosis, 2.35% for JE and 0.62% for EI. None of the equines was found positive for EIA, brucellosis and *Salmonella* Abortus-equi.

Surveillance for influenza A, Japanese encephalitis and trypanosomosis in north-eastern region was undertaken as there is continuous threat of emergence of trans-boundary infectious diseases from neighbouring countries. During this year, a highly sensitive indirect ELISA for Japanese encephalitis and whole cell lysate antigen of *Trypanosoma evansi* were supplied to AAU, Guwahati, for developing diagnostic competence in this region. Out of 50 cattle and 49 pigs tested for *T. evansi* antibodies, 2 cattle and 3 pigs were found positive. Out of 98 pig serum samples tested for JEV antibodies, 15 (15.3%) were found positive. None of ducks (23), yaks (30) and bovines (22) tested positive for JEV antibodies. Out of 69 pigs' nasal swabs tested for influenza A viruses, 13 samples were detected positive. District-wise JEV sero-prevalence in pigs in Asom was done during the year. On screening 304 pigs, maximum seroprevalence was reported from Kamrup followed by Jorhat district of Asom.

Equine infectious disease outbreaks: In view of the emergence of glanders in the country, 33,249 equines were tested for glanders, and 407 equines were found positive for glanders (253 from Uttar Pradesh, 51 from Delhi, 23 from Rajasthan, 18 from Maharashtra, 16 from Uttarakhand, 12 from Gujarat, 11 from Jammu and Kashmir, 8 from Haryana, 14 from Madhya Pradesh and one from Himachal Pradesh). In addition, 70 human serum samples from in-contact equine handlers tested negative for glanders.

Two (0.07%) of 2,618 equines were positive for equine influenza H3N8 antibodies and 34 (89.47%) of 38 equines were sero-positive for equine piroplasmosis. None of the 383 serum samples tested positive for EIA. For African horse sickness (AHS), 127 random samples from 5 states were found negative.

Outbreak of equine herpes virus 1: Identification of latently infected horses might help in EHV1 control programs as these animals are responsible for maintenance of virus in the equine population. Aborted mares (24) were tested after 6 months for the presence of viruses in their nasal and vaginal swabs. These animals were negative for virus shedding; however, latent infection could be confirmed by demonstration of expression of LAT in cDNA isolated from PBMCs.

Recombinant EHV1: EHV1 vaccines currently in use in India induce short-lived humoral and cellular immunity. Therefore, development of live attenuated vaccine is priority to boost immune response. The bacterial artificial chromosome (BAC) cloning and mutagenesis approach is being used to develop an effectively attenuated EHV1 virus. A recombinant EHV1 was developed using bacterial artificial chromosome mediated mutagenesis to develop it as potent modified live vaccine candidate.

Reverse genetics-based EIV: The inactivated recombinant equine influenza virus vaccine having a backbone of H1N1 and H3N8 from 2008 to 2009 equine outbreak in India, adjuvanted with Montanide + CpG, provided enhanced protection in mice.

Diagnosis of glanders: World Organization for Animal Health (OIE), Paris, France, sponsored a project for validation of assays as alternate to routinely used complement fixation test diagnostics. ICAR-NRCE participated in this project as collaborating partner for validation of indirect ELISAs for glanders diagnosis.

The overall activity of the project was coordinated by OIE-Reference Laboratory on Glanders, Germany. The glanders true positive and true negative serum samples collected from glanders endemic and glanders free countries were sent to the laboratory. Using these 254 positive and 3,000 negative samples serum samples, all the assays were evaluated. Recombinant Hcp1-ELISA developed at NRCE showed 95.28% sensitivity and 99.57% specificity.

Detection of subclinical mastitis

For detection of subclinical mastitis, conditions for support based strip test were optimized. Six different supports (I, II, III, IV, V and VI) and two substrates (I and II) were evaluated for their suitability for development of the test. The supports were functionalized by loading different substrates and further dried. Milk samples were screened for mastitis status by somatic cell count, pH and California mastitis test. Functionalized strips were dispensed in vials, impregnated with milk samples and incubated to observe colour development. Selection of substrate and support was based on minimum time required for color development. Among the studied substrates and supports, substrate-I and support III were selected as they showed better activity in terms of colour development in minimum time. The optimized substrate levels and volume demonstrated differentiable colour development in minimum time for marker enzyme. The developed test will be helpful in detection of subclinical mastitis in dairy animals under field conditions in minimum time.

Mithun

Medicinal plant extract against leech: In order to find out efficacy against leech infestation, different herbal crude aqueous extract like tulsi (*Ocimum sanctum*), garlic (*Allium sativum*), cucumber juice (*Cucumis sativus*), ginger (*Zingiber officinale*), neem (*Azadirachta indica*), and bahak tita (*Phlogacanthus thyrisformis*) were attempted with different concentrations. Out of these, tulsi, garlic showed *in vitro*-efficacy against land leech.

Pig

Rapid detection of porcine parvovirus: A LAMP (loop mediated isothermal amplification) assay was developed for detection of porcine parvovirus (PPV) from pigs, which is rapid, cost effective and can even be used in field level.

Serodiagnosis of porcine reproductive and respiratory syndrome: The NIHSAD-PRRS antibody ELISA is a qualitative, recombinant antigen based indirect ELISA for detection of antibodies against PRRS virus in porcine serum samples. The test had a sensitivity of 97.5% and specificity 93.5%. Analytical sensitivity of the assay was 1:4800. The earliest detection in serum of experimentally infected pigs was on 6-day post infection. No cross reactivity was observed with CSFV, PRCV, TGEV, PEDV, PRV antibodies. The reproducibility and repeatability coefficients of the assay were 0.9 and 0.85, respectively.

IVRI-M bluetongue indirect ELISA kit: Bluetongue is an economically important arthropod-borne OIE notifiable viral disease of domestic and wild ruminants specially small ruminants. The indirect enzyme linked immunosorbent assay (I-ELISA) detects bluetongue virus antibodies in ruminant serum. The assay has high sensitivity (96.4%) and specificity (96.8%) and results are available within 3–4 hr. The stability of the reagents was estimated to be more than one year.

Poultry

- The ALV (avian leukosis virus) incidence in breeding flocks was 2.4%.
- The immune response to virosome vaccine prepared from mesogenic Newcastle disease virus induced antibody titres equivalent to currently used lentogenic live vaccine.
- The pathogenicity of IBV–DPR isolate was characterized where a heterologous strain was detected having poor cross neutralization with wild type strains.
- *E. coli* and *Salmonella* isolates were characterized based on morphology and biochemical parameters.

H5N1 avian influenza viruses: Complete genome sequence of seven H5N1 highly pathogenic avian influenza viruses isolated from chickens, ducks, turkey and crows in different epicenters in Gujarat and Odisha and the Union Territory of Daman and Diu, was determined. Phylogenetic analysis of the hemagglutinin (HA) gene revealed that the isolates formed two distinct groups within clade 2.3.2.1a of H5N1 virus. One of the groups comprised five isolates from all the three States and Union Territory clustered together and is closely related (98.3% homology) to a crow virus (A/crow/India/01CA02/2014) of 2014 indicating epidemiological link between the outbreaks. In the second group, the viruses isolated from two outbreaks in Odisha (December 2016 and February 2017) are closely related (99.9% homology), and shared ancestry with a duck virus from Bangladesh (A/duck/Bangladesh/28250/2016) indicating link between the outbreaks. These findings indicated cross-border movement of the H5N1 virus in South Asia.

IVRI-M antigen capture ELISA kit

An improved sandwich ELISA and a more sensitive homologus capture antibody was developed for *peste-des-petitis-ruminants* (PPR). The test is very sensitive (95.31%) and specific (96.81%) and results are available within 4–5 hr. The kit can test 100 samples in duplicate and its reagents are stable for more than one year. It is ready for commercialization.

Indirect ELISA kit for avian influenza: The indirect ELISA kit was validated as per the OIE Manual for Antibody Detection Assays. The kit showed high diagnostic performance (diagnostic specificity: 99%; diagnostic sensitivity: 99.1%), and exhibited high accuracy. The inter-laboratory validation of the kit was carried out successfully in National Institute of Virology Pune; ICAR-IVRI Izatnagar; and ICAR-NRCE, Hisar. The ELISA kit was tested and demonstrated at Regional Disease Diagnostic Labs (RDDL) of the country.

Foot and mouth disease (FMD)

During the reporting year, 149 incidences of FMD were recorded and investigated in the country. Almost 60% of the incidences were in the southern region of the country and 92% of these incidences were in

Emergency preparedness against emerging equine viral diseases

The country is to be equipped to test many exotic equine viral diseases of zoonotic importance. The preparedness assumes significance as many of the carriers of such diseases do not exhibit symptoms. Diagnostic facilities are also required for testing the horses and suspected carriers of these diseases crossing international borders. Initially to develop diagnostic facilities for equine viral diseases like vesicular stomatitis (VS) and venezuelan equine encephalitis (VEE), the recombinant proteins having immunogenic potential were cloned, expressed and purified. The expressed proteins were used as antigen to develop immunoassays for emergency preparedness. The multiepitope protein of about 15 KDa was expressed in *E. coli* and immunoassay was standardized for vesicular stomatitis antibody detection. Nucleic acid based diagnostic PCR assays were also standardized with the potential to detect VSV (NJ) and VSV (Ind) viruses and multiple serotypes of VEEV affecting equines using synthetic gene technology. In addition, serum samples from diverse geographical locations having humid weather were screened for Rift Valley fever by ELISA and found negative for antibodies.

Karnataka. Most of the incidences were sporadic in nature involving only a few animals with very mild clinical lesions. During the period, Andhra Pradesh, Telangana, Maharashtra, Punjab, Madhya Pradesh and Arunachal Pradesh and two UTs (Pudduchery and Andaman and Nicobar Islands) had no incidence of FMD. The serotype O continued to be the most predominant one and was responsible for 98% of the incidences recorded during the reporting period. The serotype Asia1 was recorded in Rajasthan and Kerala only.

During the year, 50 serotype FMDV field isolates of serotype O were characterized antigenically using bovine vaccinate serum (BVS) against in-use vaccine strain INDR2/1975. The vaccine strain demonstrated optimal antigenic coverage with 88% of the isolates showing antigenic match. Phylogenetic analysis of serotype O virus revealed extended and exclusive dominance of lineage Ind2001 strains. The lineage Ind2001 has been dominating the scenario since 2008 with emergence of sub-lineage Ind2001d in 2008 and sub-lineage Ind2001e in 2017. Serotype O virus isolates (121) were added to the repository. At present the National FMD virus Repository holds 2,188 isolates (O–1,482, A–325, C–15 and Asia 1–366).

Under FMDCP seromonitoring, 159,790 serum samples from Punjab, Telangana, Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu, Kerala, Gujarat, Uttarakhand, Chhattisgarh, Rajasthan, Goa and Puducherry were received and tested to assess the effectiveness of vaccination. Till today, 1,002,437 serum samples, collected under FMDCP, have been tested (>30 lakh tests) for post-vaccination protective antibody response in cattle and buffalo. Under National FMD serosurveillance, 42,010 bovine serum samples collected at random from various parts of the country were tested for assessing the prevalence of NSP-antibody (NSP-Ab) positive animals, which is an indicator of FMD virus exposure regardless of vaccination status and virus circulation. The test revealed overall seropositivity in ~21.2% samples/animals, which is comparatively lesser than the previous year's average. Gradual clearance of virus has resulted in gradual decrease in DIVA-positivity in the country and concurrent reduction in incidences of FMD.

Potential vaccine candidate: FMD virus serotype O vaccine strain with enhanced thermostability was constructed using reverse genetic approach to open the way for thermostable FMD vaccine. Thermostable mutant of serotype O FMD virus IND R2/1975 was produced and characterised and satisfied all the parameters. The vaccine-worth attributes and animal (cattle) efficacy study was carried out.

The thermostable mutant FMD virus remained genetically and antigenically stable. Thermal inactivation kinetics revealed comparatively better thermostability of thermostable FMDV type O candidate than its parent virus.

A short-term immunity study was conducted in cattle aged 1–2 years, to assess the efficacy of the thermostable vaccine. Antibody titre in serum samples was comparable in both thermostable and parent type O vaccinated animals. Upon challenge with parent O virus, 5/6 animals were protected in thermostable vaccine group as against 6/6 in parent O vaccine group.

BVDV vaccine candidate strains: Based on the earlier antigenic and phylogenetic data, three isolates of BVDV-1 (Ind S-1449, Ind S-10241 and Yak-06), one isolate each of BVDV-2 (Ind 141353) and BVDV-3 (BHA5309) were selected for further characterization. Purity of each isolate was tested, and probes and all were species-specific without any cross contamination. Similarly, the purity of isolates was tested by antigenic characterization using type specific MAbs. The selected isolates were tested for bacteria, fungi and mycoplasma

Management of compound fractures of long bones

Compound fractures are difficult to manage due to open wound contamination and infection at the fracture site. For the management of compound fractures novel external fixation techniques were developed. In animals weighing less than 150 kg, epoxy fixators and animals weighing more than 150 kg bilateral linear and circular fixators made from mild steel and aluminum were developed. One adult buffalo weighing about 350 kg with midshaft oblique open fracture of left tibia and a cow weighing 400 kg with the compound fracture of right radius ulna were treated using four-ring circular fixators fabricated. The animals were not putting weight on the affected limb before application of fixator; however, with due course of time and proper postoperative management they started bearing weight on the fractured limb after about 1 week. The fixators were well maintained and tolerated by all the animals. The fractures healed completely by 90–120 days postoperatively.

FMDV serotype Asia 1 Marker virus candidate and companion diagnostic

Epitope-deleted negative marker vaccine strategy seems to have an advantage over the conventional vaccines in identifying the infected animals with accuracy. NSP 3AB contains an abundance of immunodominant B-cell epitopes of diagnostic importance. An infectious cDNA clone of FMDV serotype Asia 1 strain was used to engineer an array of deletion mutations in the established antigenic domain of 3AB. The maximum length of deletion tolerated by the virus was found to be restricted to amino acid residues 87–144 in the C-terminal half of 3A protein along with deletion of the first two copies of 3B peptide. The 3AB-truncated marker virus demonstrated infectivity titres comparable to that of the parental virus in BHK-21 and LFBK-$\alpha_V\beta_6$ cell monolayer culture. The protein fragment corresponding to the viable deletion in the 3AB region was expressed to standardize a companion assay for the negative marker virus which showed reasonably high diagnostic sensitivity (96.9%) and specificity (100% for naive and 97.1% for uninfected vaccinated samples). The marker virus and its companion ELISA designed in this study provide a basis to devise a marker vaccine strategy for FMD control when the country reaches stage 4 of FMD PCP.

and other adventitious bovine viruses such as BHV-1, BTV, BPV, BRSV and bovine adeno viruses and found to be free from all extraneous agents.

Exotic and emerging diseases

Avian influenza: Out of 20,428 morbid/swab/fecal samples tested, 10 samples tested positive for H5 notifiable avian influenza from Karnataka (01-H5N8), Odisha (06-H5N1), and Uttar Pradesh (03-H5N1).

H9N2 (6 from Gujarat, 3 from Karnataka, 7 from Madhya Pradesh, 3 from Odisha and 1 from Punjab) viruses were isolated. All the random (1,125) and emergency (81) serum samples received were negative for AIV antibodies.

Three H9N2 viruses were isolated from the cloacal swabs from Odisha. Out of 380 POSP serum samples received, 30 samples (27 from Kerala and 3 from Odisha) were positive for H5 virus antibodies; and 9 samples from Karnataka were positive for H9 virus antibodies. 76 out of 7,360 random serum samples, from chicken were positive for antibodies to avian influenza virus subtype H9.

Malignant catarrhal fever: Screening of sheep tissue, pet food, ruminant's whole blood samples (81) received/collected from different AQCS, Veterinary Colleges and Research Institute, Thirunelveli for MCF, revealed that 6 blood samples were positive while all others were negative.

Enzootic bovine leukosis: Blood samples (168) and serum samples (174) collected from organized farms of 5 districts of Gujarat, one organized farm at Namakkal, Tamil Nadu and from Veterinary College Farm, Udgir, Maharashtra, were screened for BLV and four cattle blood and three sera from Banaskantha district were found positive while rest of the samples were negative.

Swine influenza: Pig nasal swabs, tissue and serum samples (221) were screened for SIV. Five serum samples from Madhya Pradesh were positive for H1N1 antibodies while rest of the samples were negative.

Porcine reproductive and respiratory syndrome: Pork, semen, tissue and serum samples (578) were screened for PRRS. Serum samples (52) from Mizoram were found positive for PRRSV antibodies, while all other samples were negative.

Crimean Congo haemorrhagic fever: Tick pools samples (25) were tested and found negative.

Chemotherapeutic efficacy of novel drugs: Three drugs, viz. chlorpromazine (CPZ), indatraline and SC-1, exhibited significant growth inhibition efficacy against *T. evansi.* The *in-vitro* cytotoxicity assays revealed that the drugs were not toxic even up to 5–20 × of effective drug concentration, indicating wide margin of safety. To develop herbal therapeutics against *Theileria equi,* methanolic bark extracts of plants were tested against *T. equi* in MASP culture system. Ethyl acetate elutant fraction of methanolic extract from the bark significantly inhibited *in-vitro* growth of *T. equi.*

SERCA regulates paramyxovirus replication: In an attempt to find target for development of novel antiviral therapeutics, sarco/endoplasmic reticulum calcium-ATPase (SERCA) was evaluated. SERCA, a membrane bound cytosolic enzyme regulates the uptake of calcium into the sarco/endoplasmic reticulum from the cytosol. The study revealed that SERCA can also regulate *peste-des-petits ruminants* virus (PPRV) and Newcastle disease virus (NDV) replication.

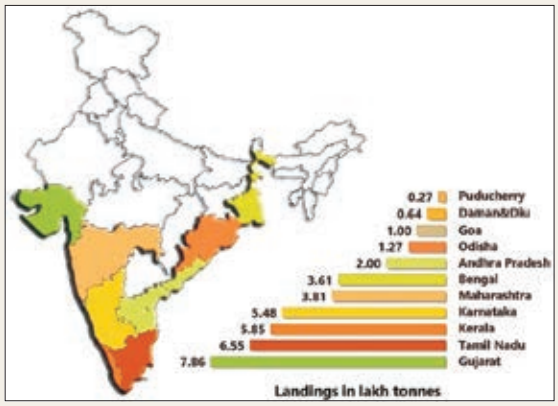
Isolation of mastitis causing bacteria: Mastitis is economically devastating and the most important disease of dairy animals. Various bacteria identified in mastitis included *Staphylococcus aureus* ssp. *aureus, Staphylococcus haemolyticus*, *S. agnetis, S. sciuri, S. xylosus, S. chromogene, S. epidermidis, E. coli, Streptococcus dysgalactiae* and *Klebsiella pneumoniae.* Fourteen bacteriophages were isolated from these animal farms and biological activity of the phages indicated that the phage cocktails were active against majority of mastitic pathogens and phage-BPA116 alone was active against various species of Staphylococci.

Fisheries

Cage culture in inland open water bodies: In Chhattisgarh, Jharkhand, Odisha, Maharashtra, Manipur and Asom, the socio-economic impact of cage culture technologies on the livelihood and employment generation of beneficiaries, was assessed. The interim estimate showed that around 14,018 cages were installed allover India in different reservoirs with higher contribution around 43% from the eastern states of Odisha and Jharkhand. Western region (Gujarat, Maharashtra and Goa) contributed around 33% of the cages. State Fisheries Department, Fishers Cooperatives and Private Entrepreneurs were the major agencies involved in cage culture. Fish yield in cages varied

Marine fish production

The marine fish landings from the coast of the main land of India in 2017 was estimated as 3.83 million tonnes showing an increase by about 5.6% compared to the landings in 2016. As in the last four years maximum landings took place along the Gujarat coast, which is 20.5% of the total landings in India. Tamil Nadu, Kerala and Karnataka are the other top three states with respective contributions of 17.1, 15.3 and 14.3%. The union territories of Puducherry and Daman and Diu, respectively, had 40 and 45% reduction from the landings in 2016.



from 2 metric tonnes in Odisha to 4 metric tonnes in Chhattisgarh. The technology yielded positive net returns across the states. The net return per cage (6 × 4 × 4 m) per year for Pangasius was estimated at 42,054 metric tonnes, which is around 16% of the current reservoir production. All the cages in the country generated 7.46 lakh man-days of labour per year.

Detection of EHP in shrimp: Hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP) is an emerging microsporidian parasitic disease in shrimp. It is often associated with severe growth retardation and/or white feces syndrome resulting in considerable economic loss to shrimp aquaculture. A new semi-nested PCR for diagnosis of EHP in shrimp was developed. This protocol was sensitive and specific to detect EHP in different species of shrimps, artemia, polychaetes, bivalves and environmental samples, such as, faeces, soil, water etc., from shrimp ponds.

Development of inactivated vaccine against nervous necrosis virus (NNV): Viral encephalopathy and retinopathy (VER), also called as viral nervous necrosis (VNN) is an acute viral infection of brackishwater and freshwater fishes. It affects 120 fish species and causes up to 100% mortality in Asian seabass fry. The virus is transmitted vertically through infected broodstock, eggs, and ovarian fluid. One of the best possible control measures against VNN is by vaccination of the broodstock, fry and fingerlings. Oral and immersion vaccine was produced. The vaccinated group produced 60% relative percent survival (RPS) suggesting the possibility of developing an effective vaccine against NNV.

Tilapia lake virus detection kit

One-step PCR based Tilapia Lake Virus detection kit was developed for the fast and sensitive diagnosis of Tilapia Lake Virus in the Tilapia fish population.

Dual combination vaccine against *Flavobacterium columnare* and *Edwardsiella tarda*: A dual combination vaccine for protection of rohu against the bacterial pathogens, *Flavobacterium columnare* and *Edwardsiella tarda* was developed. *F. columnare* vaccine showed 47% relative percentage of survival (RPS) on immersion treatment and 65% RPS on pre-vaccination salt treatment for 30 sec. *E. tarda* vaccine showed 51% RPS on immersion treatment and 71.6% RPS on pre-vaccination salt shock for 30 sec against challenge. The dual combination vaccine showed 85% protection. ❑

9. Mechanization and Energy Management

FARM-MECHANIZATION

High clearance multipurpose vehicle: A self-propelled hydraulically actuated specialty carrier for horticultural crops like chilli, pigeon pea, sugarcane, maize, okra, cotton etc. of height up to 2 m was

High clearance multipurpose vehicle

developed to carry out different operations like spraying, weeding, harvesting etc. Novelty of this machine over the existing system is that, ground clearance and track width can be adjusted according to crop geometry. Track width can be adjusted from 2 m to 2.6 m, whereas ground clearance can be adjusted from 1.5 m to 2 m. The maximum road speed of the vehicle is 20 km/h but it can easily be operated at 1.5 km/h in the field for spraying and weeding operations. The field capacity for the spraying operation is 1.4–1.5 ha/h and cost of operation for spraying is ₹ 400/ha.

Variable width raised bed former: Raised bed prevents soil compaction, provide good drainage and aeration, and also serve as a barrier to pests such as slugs and snails. A tractor operated variable width raised bed former for vertisol was developed. Overall dimensions of variable raised bed former are 1,000 × 2,000 × 1,000 mm and it weighs 3,000 N. Its field capacity is 0.64 ha/hr and field efficiency 95%, at a forward speed of 4.5 km/hr with maximum horizontal draft of 4,000 N and vertical force of 1,000 N.

Three-row automatic vegetable transplanter for potted seedlings: The automatic vegetable transplanter was especially developed for tomato and chilli seedlings, grown in cylindrical paper pots of volume 90 cc and pot diameter of 54 mm. The labour requirement and fuel consumption of an equipment are 18 man-h/ha and 3.5 liter/ha respectively. The average field capacity of the transplanter is 0.11 ha/h, and field efficiency 56%, at the forward speed of 1.2 km/h, whereas transplanting efficiency is 92% and overall efficiency 85%. The operational cost of the transplanter is ₹ 6,492/ha. It saves 72% labour and 86% time as compared to manual transplanting.

Tractor operated automatic vegetable transplanter for plug type seedlings

Automatic vegetable transplanter: The tractor drawn 3-row plug type automatic vegetable transplanter consists of split cell type metering device suitable up to 2 km/h forward speed for transplanting plug seedlings. It gives field capacity and field efficiency of 0.23 ha/h and 63.13% respectively. The planting rate of the developed vegetable transplanter is 56 seedlings/min/row. It transplants 7.93 to 8.50% seedlings in tilted orientation and covers about 83.79 to 84.13% plants with soil. It saves 97% labour and 98% of operational time compared to manual transplanting method.

Ginger planter: The field performance parameters of the ginger planter were determined at the various forward speeds (1 to 4 km/h). The average miss index, multiple index and field capacity increased with the speed, whereas the quality of feed index decreased as the forward speed increased. The average miss, multiple and QF index were 0.9 and 0.26, and 0.65 respectively. The average spacing of the planting was 22.5 cm and the field capacity about 0.25 ha/h at the forward speed of 2 km/h. The suitable size of rhizomes for sowing was about 2.5 to 5 cm at mean depth of 8 cm; and the seed rate of the planter was 1,200 kg/ha. The field efficiency of the planter was 70%.

Real time uniform spraying system for field crops: The newly developed real time uniform spraying system was developed that maintaines uniform spray volume throughout the field irrespective of speed of operation. The effective field capacity of the machine is 0.7 ha/h at 3 km/h. It consists of hall effect sensor IC, magnetic ball, micro-controller, servo motor, flow rate controller, HTP pump, tank, hoses, boom, nozzle, etc. The input signals are sent to the micro-controller for flow control, the output singles from the micro-controller to the servo motor and servo motor controls the flow rate according to the forward speed of the tractor.

Real time uniform spraying system for field crops

High ground clearance platform for small tractor: The government is promoting mini tractors to decrease initial investment on farm power sources in drylands but availability of matching implements is a problem for small tractors. To address these problems, a high ground clearance (165 cm) and track width (90 cm) platform for mini tractors was developed. In castor and pigeon pea interculture weeding efficiency varied from 77 to 80% for castor and 79 to 84% for pigeon pea. The weeding efficiency for pigeon pea decreased with increase in crop canopy. The machine help timely completion of field operations and drudgery reduction.

High ground clearance platform for small tractor

Variable width raised bed planter : Raised bed helps to conserve soil moisture and improve water usage efficiency. A variable width raised bed planter was developed to suit the crop geometry of pigeon pea, cotton, sorghum etc. The machine is designed in such a way that in wider row spaced crops, the tractor wheels follow the furrow so that the weeding and other operations can be done easily without disturbing the bed configuration.

Tractor operated variable width raised bed planter

Multi-crop planter for sowing on beds: In traditional practice of sowing on beds, first ridges are formed with the help of bund maker and then seeds/ seedlings are planted manually, which is time consuming and not economical for the farmers. The plant-to-plant spacing is also not maintained in traditional method resulting into lower yield of crops. A tractor operated multi-crop planter was developed for sowing on beds. The planter was evaluated for sowing of pea, coriander, mustard, gram, and carrot seeds in field. The seed rate and average width of sowing can be varied for all the five crops. The field capacity of planter varied from 0.29 to 0.31 ha/h. The field efficiency of planter is 78.62% in pea, 79.17% coriander, 80.80% mustard, 81.57% gram, and 81.11% in carrot.

Potato cum sugarcane bud planter: The manual practice of planting sugarcane and potato is time consuming and arduous operation, and in mechanized states, farmers used two types of planters for planting these crops. Therefore, a potato-cum-sugarcane bud planter was developed for planting of both sugarcane bud and potato. The cost-effective and time saving equipment suiting to soil and variety prevailing in the region was developed to increase use of equipment for planting two major crops. The developed potato-cum-sugarcane bud planter showed net saving of ₹ 5,141/ha for potato and ₹ 6,433/ha sugarcane planting. The labour requirement with the developed planter was 3 man–h/ha. The break-even point was 180 h. The payback period and benefit cost ratio of the planter was one year and 2.06 respectively.

Potato-cum-sugarcane bud planter

Planter-cum-herbicide applicator for direct sowing of paddy: The independent methods of sowing and herbicide applications in paddy crop in Andhra Pradesh consume time and labour delaying operations during peak period. The commercial 9 rows planter with vertical rotor type metering mechanism was selected for development of planter-cum-herbicide applicator suitable for direct sowing of paddy. The machine was evaluated at farmer's field in clay loam and black cotton soils for direct sowing of paddy. It plants and applies herbicide in a single pass. The effective field capacity of planter and field efficiency was 0.4 ha/h and 90% for both the soils at 15–20% (db) moisture content. The fuel consumption of 34 kW tractor was 3 litres/hr. The cost of operation of planter-cum-herbicide applicator was ₹ 1,200/ha.

Sorghum and pearl millet ear-head separator: To overcome the problem in separation of ear-heads, a low cost, light weight, easy to operate ear-head separation device was developed. It is suitable for separation of ear-heads of sorghum and pearl millet crops of height ranging from 1,450 to 2,100 mm. The output capacity of the machine is 0.8 tonne/h. The equipment resulted in 42–45% saving in total labour requirement for harvest and threshing the crops. Ear-

head cutting efficiency was 95%. There was net saving of ₹ 1,518/ha for sorghum ear-head separation and ₹ 1,773/ha for pearl millet.

Self-propelled ridge plastering machine: Improved plastering equipment was developed for plastering ridges to reduce human drudgery. The trials of machine were conducted at forward speed of 0.4 km/h at soil moisture content of 31% (w.b). The width and height of the bund were 241 and 174 mm respectively. The fuel consumption was 0.98 litre/h.

Self propelled ridge plastering machine

Torque measurement sensor for 2-WD tractor: A transducer was developed to measure axle torque of 2 WD tractor. It is based on the concept of development of extension shaft on which the strain gauges are mounted to measure the strain during twisting. The developed device was mounted on the test tractor with the tillage implements and tested in the field. The drive torque of the tractor increased with the increase of draught force. It was able to measure the real time torque of an implement with a variation of + 5 to 8% on both the wheels.

Remote controlled power tiller: A remote controlled power tiller turning mechanism was developed by actuating the steering clutch. A 12 volt DC motor with integrated gear box arrangement having 300 RPM and 30 kg-cm torque is fitted at the end of the hand grip with fabricated holder. The motors are placed in such a way that they do not hamper the manual operation of the machine. The primary trials of the developed remote controlled turning mechanism were conducted in the dry land with and without the engagement of rotavator. The minimum turning radius of power tiller with and without rotavator on dry land was 1.12 m and 0.68 m respectively, which was approximately 31–33% higher than the existing method.

Remote controlled power tiller

Bullock-drawn multipurpose tool carrier: A multipurpose tool carrier which facilitates the integration of improved implements to the animal based farming with added advantage of providing comfort to the animal and the operator was adopted. It has the provision of attachment of an inclined plate planter, sprayer and three tyne ferti-hoe. The average draught it required for operating is 620 N. Its field capacity with seed covering device and three tyne hoe having two furrow opener is 0.19 and 0.30 ha/h respectively. The average discharge from each nozzle is in the range of 195.9 and 197.6 ml/min. The uniformity coefficient of the sprayer was observed 74% with weeding efficiency of 84% in soybean.

Power-operated red-gram protray seeder

There is low productivity and high labour requirement for pigeon pea cultivation in traditional method in Tamil Nadu which covers 72,389 ha area. The transplanting of pigeon pea seedlings is preferred to reduce water requirement and period of growth for red-gram crop. In general, 74,100 seedlings are required for transplanting in 1 ha. A red-gram portray seeder was developed that can be flexibly configured to suit different tray sizes and cell layout. This arrangement of protray seeder makes it suitable for bold seeded crops as well as small seeded crops. The seed pickup unit is designed as a modular that can be changed to suit different seeds. The entire unit is automated. The speed of the conveyer can be changed to obtain different speed of sowing to suit different seeds and cell geometry. The equipment can sow 200 trays/h and the cost of sowing the protray is ₹ 0.5/tray. The machine can sow protrays required for transplanting 1 ha of red gram in one day. This developed technique for nursery raising operations of red gram reduces human drudgery and cost of nursery raising due to mechanized operation for preparation of nursery medium, filling in protrays and sowing the seeds in the protray.

Animal-drawn mulch laying machine: The design of existing mulch laying machine was refined to make it animal drawn. Two mould boards are provided adjacent to the wheels for covering the mulch sheet end with soil. Circular clamps are provided for adjusting hitch angle, working width and depth of operation. The speed of operation is 2.5 km/h with the working width of 60 cm and the draught requirement is 280 N.

Pneumatic wheeled bullock cart: To overcome the shortcoming of the traditional carts and to reduce the drudgery of animal during transportation by cart, a pneumatic wheeled bullock cart was developed for rural areas of the Chhattisgarh. The bullock cart performed significant change in draught, speed and wheel slippage with different payloads. The average draught and average power requirement increased with simultaneously increasing the payloads.

Bullock-drawn fertilizer applicator-cum-ridger: A bullock-drawn fertilizer applicator-cum-ridger was developed for applying fertilizer and ridging simultaneously in line sown maize crop under dry land condition. Its field capacity is 0.05 ha/h with field efficiency of 67.94% at average depth of operation of 12 cm. The technology can provide 15–20% less operating cost as compared with traditional practices. The cost of the technology is ₹ 2,800.

Air-brake system for agricultural tractor-trailer: The air pressure brake system has certain distinct advantages, especially over a hydraulic-pressure brake system in agricultural tractor-trailers used to carry heavy loads (20–40 tonnes). The supply of air is

unlimited, so the brake system can never run out of its operating fluid, as hydraulic brakes can. Minor leaks do not result in brake failures. So these brakes are better in efficiency and safety. A tractor-trailer air pressure brake system was developed. The average stopping distance after application of sudden brake is 1.0–3.5 m in the range of engine speed of 1,000–2,800 rpm in second high and fourth high gear.

Motorized protray, poly-bag and pot-filling machine: Vegetable seedlings raising, an important but time consuming and laborious activities, involves cleaning, mixing and filling of media. A motorized growing media siever, mixer and protray/bag filling machine. It consists of growing media elevator, growing media siever-cum-protray filler and growing media mixer-cum-bag filler. All the components are fitted on a 4-wheeled trolley frame for transportation. The capacity of the machine is around 1.5–2 tonnes/h of growing media. Almost 60% of man power can be saved per day compared to manual method. The cost of the machine is ₹ 5 lakh.

Motorized protray, poly bag and pot filling machine for horticultural nursery

Manually-operated gladiolus planter: The gladiolus, one of the most important floriculture crop, is sown in 16,600 ha and requires 130 man-h/ha of labour for planting in traditional method. For timely planting of gladiolus corm, a cost-effective light weight, manually-operated gladiolus planter was developed. The planter was evaluated at three forward speeds of 1, 1.25 and 1.5 km/h. The highest percentage of single, multiple and miss was 73.36, 19.74 and 6.90% respectively, at forward speed of 1 km/h. The per cent seed in upright, inclined and downward positions ranges 37–38%, 53–59% and 3.33–10.06% respectively. It saved 44.5% labour requirement and 39.5% in cost of operation compared to traditional manual planting method.

Development of deep-furrow sugarcane cutter planter: Prototype of tractor-operated PTO driven sugarcane planter was developed with modified furrow opener was designed and developed at ICAR-Indian Institute of Sugarcane Research, Lucknow. Modified furrower opens deep furrow (20–25 cm) and maintains loose soil bed (2.5–4 cm) at the bottom of the furrow. It performs all the unit operations involved in sugarcane planting namely deep furrow opening, seed-sett cutting, placement of seed-setts in furrows, application of fertilizer and insecticide in furrows, soil covering over planted seed-setts and pressing of soil covers, simultaneously in a single pass of the equipment. It saves operational cost of sugarcane planting by 50% and labour by 40 man-days (more than 90%)/ha. Multiplication field trials of the planter were conducted at farmers field at Muzaffarnagar (western Uttar Pradesh), Balia, Shravasti, Baharaich (eastern Uttar Pradesh), Lucknow, Hardoi (central Uttar Pradesh), East Champaran and Muzaffarpur (Bihar). Prototype of the planter (wide spaced especially designed and developed for tropical region) was supplied to TNAU Coimbatore, and prototype feasibility trials (PFT) were conducted. Planter was commercialized and Memorandum of Agreement (MoA) was signed with agricultural machinery manufacturers.

Solar energy for FCV tobacco curing: A polycarbonate chamber 645 cft on roof-top of tobacco curing barn was designed and developed to make use of solar energy through greenhouse effect to reduce the wood consumption for curing FCV tobacco. Due to polycarbonate roof chamber, the temperatures in the top layers of the barn were high. Fuel wood to an extent of 22–24.9% can be saved with polycarbonate roof barn when compared to traditional barn.

Briquette-making machine: Agribiomass briquette making facility was established at ICAR-CTRI, Rajahmundry to prepare various agribiomass briquettes. Agribiomass briquettes along with polycarbonate roof chamber was evaluated for curing FCV tobacco. Consumption of agribiomass briquettes (chickpea/pigeon pea husk and saw dust) + maize rinds with polycarbonate roof chamber was 4 kg/kg cured leaf against 5.66 kg wood in traditional barn. Polycarbonate roof chamber over the existing barn along with agribiomass briquettes can have the potential to replace the total wood requirement for curing.

Pedal-operated chaff cutter suitable for hilly areas: Keeping in view the acute shortage of quality green fodder during winter months, wastage of fodder and straw resulting from direct feeding and cost of electrically operated cutter, a pedal-operated chaff cutter suitable for hills has been developed. In this machine, it is easy to feed the straw/fodder in the hopper by the same person who is running the machine while in

Tea plucking aid to reduce finger injury

A tea plucking is synonymous with harvesting in other crop. The tender apical portions of shoots consisting of 2–3 leaves and the terminal buds are nipped off in plucking. The tea worker work in an awkward posture for the whole day during peak season which is twice in a year. The tea leaf plucking operation creates muscle pain in hand, arm and finger injury of tea leaf plucker. The plucking is done with the help of forefinger and thumb. A finger mounted plucking aid was developed, which helps in cutting the leaf instead of tearing with naked finger. A thin metal circular guard with sharp cutting mechanism was provided in the forefinger and a metal circular guard is provided for safety of the thumb. The plucking of tea leaves by the developed finger mounted plucker, decreased plucking rate as compared to the traditional method of plucking but reduced finger injuries. The average heart rate for the male during rest and work was found 89 and 101 bpm, and for the female it was 95 and 103 bpm respectively.

conventional chaff cutter two persons are required. The output capacity of the machine is about 170 kg/h for green fodder and 29.4 kg/h for dry fodder. The machine has 39.2% higher RPM than conventional manual hand operated chaff cutter with 18.1% higher output capacity. However, in pedal-operated chaff cutter the heart rate was slightly higher (9.1%) than conventional manual hand operated, which was mainly since, the test subjects were not habitual cycle riders.

Urea ammonium nitrate (UAN) applicator: The UAN applicator was designed to place the fertilizer 2.5 cm beside the seed at a depth of 5 and 10 cm. The study on response of wheat crop to UAN indicated comparative advantage in terms of yield, nitrogen-use efficiency and fertilizer saving to the tune of 30 kg N/ha compared to prilled urea.

An 8-row tractor-drawn planter was designed and developed to plant wheat seeds in the hills for system of wheat intensification. The row to row distance was adjustable from 20 cm to 25 cm. It opens the furrow, places the seed at 5 cm depth maintains seed to seed distance of 20 cm and firmly covers the seed. The tractor-drawn SWI planter was evaluated in the field at two forward speeds (1.5 and 2 km/h). The wheat seeds used for sowing were dry and soaked. Draught requirement was 320 kgf.

Equipment for small farm mechanization: A three wheel-riding type small farm equipment was developed along with different accessories to perform multiple agricultural operations. The integral power equipment performs operations like ploughing, roto-tilling, sowing, weeding and irrigation with a single power source. MoU with industrial partner, i.e. M/S SAS Motors was signed for commercialization of technology.

Variable width raised bed planter-cum-herbicide applicator for resource conservation: A variable width raised bed planter-cum-herbicide applicator has been developed for resource conservation and tested on rainfed crops at Byrapur village of Wanaparthi district in Telangana. The implement can be used to make the raised beds around 5 cm above the ground level. The width of the bed can be varied from 80 to 120 cm as per the tractor track. Ridgers make the furrows with 35–40 cm top width. The depth of the furrow can be varied from 15 to 20 cm as per the need of the farm.

During the *kharif* 2017, newly developed variable width raised bed planter-cum-herbicide applicator was tested and 60 other farmers field. Results showed that there is an increase in moisture content by 20% over the conventional method in the soil after 5 days of rainfall and there is a consistency in bed shape and size when compared to conventional bed makers and further there is an increase in yields from 15 to 35% in castor and pigeonpea crops when compared to the conventional flat-bed sowing with planter. Due to more *in-situ* rain water conservation, the crops could withstand initial draught of 10 days more than the flat-bed sowing. Farmers have option to use the herbicide applicator for chemical weed control. The unit can be mounted on 45-hp tractor for comfortable operation in all types of soils. Weeding can be done with a specially designed tractor-drawn harrow. Reshaping of beds can be done for removing the weeds in the furrows as well as increasing the water conservation volume of the furrows.

Solar-powered bird scarer

Birds are serious threat to standing crops. It was reported that 20–22% of maize, sorghum and pearl millet (bajra) get damaged due to birds. The extent of damage varies as per location if the field is isolated the damages are much higher. A gadget to scare away the birds was developed. The solar powered bird scarer comprised a solar panel (20 Wp), battery (12 V, 7 Ah), motor (5 W), a steel pan, and a watch movement unit and two speakers. The unit produces both mechanical and musical sounds for 20 sec at an interval of 3 min to restrict birds' entry in the crop field. Noise produced by the unit is 98.5 and 109 dB by mechanical and musical means, respectively at source. However, the noise produced at a distance of 100 m distance was observed as 45 and 58 dB respectively, for mechanical and musical means. The device was tested in maize crop for 45 days and no damage was observed on account of birds. Cost of the unit is approximately ₹ 2,600 and it can save 480 man-hours per crop season.

Solar powered bird scarer

Horticulture

Arka power operated onion detopper: An onion detopper with detopping efficiency of 98% that saves 22% cost when compared to manual method, was developed at IIHR. The detopping unit is a set of rollers comprising one plain metal roller and the other one is a helical roller. Five such sets are mounted on a main frame and each set is counter rotating. The detopped onion bulbs roll on the rollers and conveyed to the collection chute. Its capacity is 300 kg/h against manual method of 80 kg/h/person.

Animal power

Animal-drawn bio-fertilizer applicator-cum-maize planter: A bio-fertilizer applicator-cum-maize planter for sowing of maize crop in hilly terrain for organic farming, was developed. The average field capacity of the machine is 0.08 ha/h at an operating speed of 2.35 km/h. Average draught of the machine is 185 N at a seed sowing depth of 45 mm. It placed fertilizer at 50 mm depth and 30 mm horizontal distance from

the seed. The technology can provide 18–20% less operating cost as compared with traditional practices. The cost of the technology is ₹ 1,500.

Pineapple-harvesting machine: The machine works on the principle of cutting action of the blades at the stalk of standing pineapple. The conventional method of harvesting is time consuming, laborious and causes backache as harvesters have to stoop while harvesting. This machine reduces drudgery and fatigue of the operator as harvesters will not suffer from sharp pricks of the pines or back pain. The field capacity (Number of pineapple fruit harvested) is about 250–280 fruits/hr as compared to 150/ hr in conventional method (suitable in hilly terrains/terrace land).

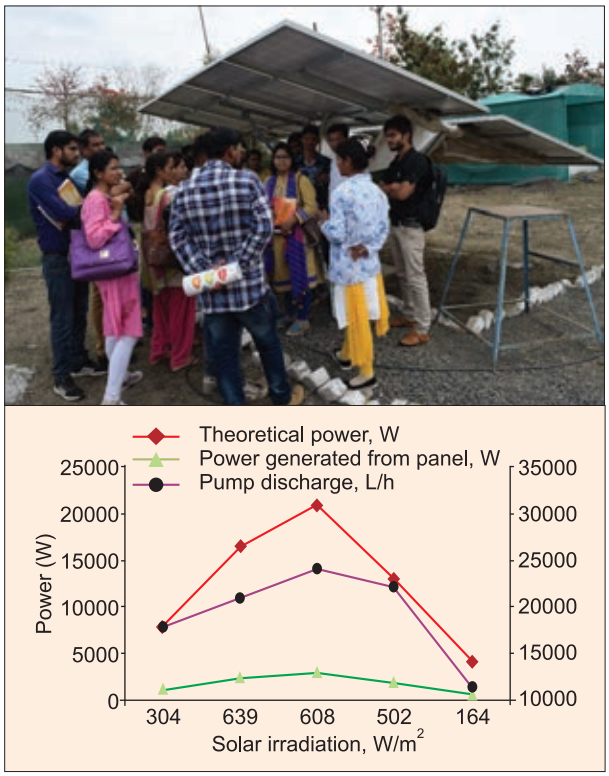
Pineapple harvesting machine

Brush cutter with fruit holding attachment for pineapple harvesting: Traditionally, pineapple is harvested manually using a special knife. Some leaves of pineapple plant are pruned prior to detach the fruit from the plant as a pre-harvest operation. To overcome such problems, improved unit for harvest of pineapple was developed. The speed of blade and fuel consumption of unit were 6,500 rpm and 1.1 litres/h, respectively. The average time for harvesting 10 fruits is 4 min. Maximum diameter of fruit which can be harvested is 140 mm. It helped in reducing human drudgery and required less time for harvesting new variety of pineapple.

Brush cutter with fruit holding attachment for pineapple harvesting

Energy Management

Solar-powered micro-irrigation systems for field crops: The pumping system was used with micro-irrigation systems for irrigating rice crop sown in nearly one acre area. Different micro irrigation systems such as drip, portable sprinkler and perforated pipe irrigation, conventional irrigation, used in the study, were operated



Power generated from SPV panel and discharge of pump

with solar powered pump set. All the four irrigation systems were operated at a time using solar pump. The discharge rate of pump was 11,400 to 24,120 litres/h at a dynamic head of 2.5 m corresponding to solar insolation range of 164 to 808 W/m^2 during time period from 8 AM to 4 PM. The peak power generation from the panel during this period was as 3.0 kW. The ambient temperature was in the range of 30°–31°C. The excess solar power generated can be used for other purposes. The estimated excess power availability/season/ha in drip, sprinkler, rain hose and flood irrigation systems ranged between 235–1,160 kWh, 246–1,213 kWh, 246–1,213 kWh and 220–1,084 kWh respectively.

Agri-voltaic system for simultaneous crop production and electricity generation: To meet the future requirement of energy and food, an agri-voltaic system has been designed and developed in which electricity generation, crop production and rain-water

Continuous bio-char production system

A continuous bio-char production unit was developed. The reactor's production capacity was 20 kg/h which produces char with retention time of 4 min at 450°C temperature. The carbonization efficiency of developed system was about 30%. Calorific value of 5,936 kcal/kg was estimated in the laboratory from the produced bio-char which was 58.3% higher than the calorific value of the initial mass fed in the reactor. The bio-char produced from agro residues can be used as soil amendment. Further, it can be pelletized to meet the energy required for both domestic and industrial applications. The application of biochar as soil amendment reduces the chemical fertilizer demands.

harvesting can be done on a single land unit. Such system of 105 kW capacities was established at ICAR-Central Arid Zone Research Institute, Jodhpur. The electricity generated from the system is supplied to local grid through net metering system. About 400 units of electricity (kWh) can be produced per day from the established 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. During *kharif* 2017, mungbean (*Vigna radiata*), mothbean (*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 has also been designed and developed in the agri-voltaic system. The system of 105 kW capacity installed in 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 is used to clean the dust deposited on the top surface of PV module as well as to irrigate the crops in the system. Annual income from the developed agri-voltaic system has been estimated to be around ₹ 7.5–8.0 lakh/year.

Micro-planning and management of a rural energy system: Micro-planning and management of rural energy system is a village level assessment of energy footprints in available energy flow pathways to find and suggest the need of energy intervention. Saving in the energy consumption is the main aim of energy planning and management at micro level. Assessment of energy scenario of rural eco-system of village Ganiyari revealed that the total energy consumption was 4 TJ/annum, covering all four sectors, namely, crop production, livestock raising, domestic sector and post-harvest. The maximum energy consumption was in the domestic sector during cooking which consumes highest energy in the village. Fuel (53%) and dung cake (18%) are the highest energy sources in the village. Planning for energy management was done and finalized to partially replace the existing cooking fuels (fuel wood and dung cake) by alternate crop residues based binder-less briquetted fuel. The briquettes are well accepted by rural families for domestic cooking. Renewable energy supplementation using briquettes was estimated to be 60±20 MJ/day/family. The replacement of 50–80% of the fuel-wood consumption for cooking by rural families saved 20–25% energy.

Bio-oil production: The continuous pyrolyzer was developed for production of bio-oil from crop residues. The developed system facilitates continuous production of bio-oil with higher bio-oil yield recovery of 8% as compared to lab scale batch type reactor. The developed system is suitable for production of bio-oil from woody mass (saw dust), agro residues (rice husk, groundnut shells and cotton stalk etc.), pellets and wood chips. Efficient utilization of agro-residues generated on field otherwise squandered for unprofitable tasks. Also the farmers will earn an extra income from selling crop residues.

Semi-continuous bio-methanation reactor: Bio-methanation reactor with horizontal stirring arrangement was developed to produce biogas from paddy residues. The unit comprised a digester; inlet and outlet for substrates; filtration and recirculation of digested slurry water; biogas outlet, water level indication, gas-storage unit. The stirring setup is operated by using 1-hp electric motor controller using a variable frequency drive. The total volume of the reactor is 0.5 m^3 and suitable for digestion of 10–15 kg of ground biomass having particle size of 0.2 to 2 mm. The reactor is insulated to maintain the inside temperature. Provision for adding hot water from solar water heater is provided in the reactor. Temperature sensor and controller are fitted in the reactor to monitor the reactor temperature. The reactor resulted cumulative biogas production of 266 litre/kg of paddy straw. Methane content in the gas was measured as 55% and carbon dioxide 40%. The stirring was found very effective in enhancing the biogas production up to 5–10%. Crop residues can be utilized to produce biogas as well as compost. The residue burning can be avoided with reduced air pollution. ❑

Portable paddy-straw briquetting machine

Managing paddy straw is a great challenge. Many farmers burn the straw in field which results into loss of soil nutrients and environmental pollution. One of the envisaged solutions could be using the straw as fuel. The developed portable briquetting machine for paddy straw has capacity of 50–60 kg/h. Briquettes from paddy straw were prepared using this machine and the performance was satisfactory. Mixture of paddy straw and soybean stalk are taken in a ratio of 70:30 and cow dung @ 20% w/w was added to the mixture as binder. The moisture content of feedstock is maintained at the range of 50–60% by adding water. The density of produced briquettes was obtained at the range of 520–550 kg/m^3 having excellent resistance to shattering and durable as well. Calorific value of paddy straw briquettes is 3,600 kcal/kg. The cost of operation was ₹ 4.81/kg. The briquettes produced can fetch a price of ₹ 6/kg. The machine can be used at farm site and utilization of briquettes as domestic fuel can reduce dependency on conventional fuel.

10. Post-harvest Management and Value-addition

An essential component of the agriculture in achieving food security for all is preserving, processing and value adding the raw produce in the postharvest chain. Value-addition and preservation in postharvest chain would help making available healthier and nutritious food choices for the consumers throughout the year; reducing postharvest losses, and creating employment opportunities.

Processing equipment

Sugarcane-rind removing equipment for juice making: Rind peeling enhances quality and hygiene of sugarcane juice as it enables the removal of dirt and other unwanted particles as well as microbial load from the stalk in juice. Traditional manual method of using knife is time consuming, unsafe and unhygienic. The sugarcane rind remover consists of four metallic brushes attached to the rotating shaft. When the sugarcane is inserted between the four metallic brushes, skin of the sugarcane is removed due to the rotation of the brushes. The feeding arrangement is made of two nylon rollers rotating at about 270 rpm, which

Sugarcane rind removing equipment for juice making

enables retention of the canes to be peeled for sufficient time in the peeling zone. The equipment is mounted on wheels enabling easy transportation from one place to another. The overall size of the equipment is 1,350 × 900 × 1,500 mm. Capacity of the power operated sugarcane-rind removing equipment is 240 canes/h and 175–200 kg/h. The potential stakeholders are suagrcane juice vendors and suagrcane juice bottling plants.

Manually-operated palmyra-endosperm remover: The developed equipment is user friendly to operate for extracting palmyra endosperm in a hygienic way. The manually-operated palmyra-endosperm remover consists of the main frame, cutting assembly, tray holder with tray for endosperm collection and fruit waste dropping chute. The overall dimension of the equipment is 900 × 450 × 1,600 mm, and weighs 22 kg. The capacity of the equipment is 50 fruits/h. The extraction efficiency is 100%.

Bay-leaves (Tejpatta) grinder: An animal drawn rotary mode gear operated grinder for bay leaves was developed. It consists of cyclone separator, frame, cutting blade and rotary gear power system. Efficiency of the animal-drawn hammer mill ranges from 35.78 to 57.71%, average particle size varies from 0.143 to 0.227 mm, minimum value of flow-ability varies from 7.56 to 8.27 sec. By decreasing the particle size the flow-ability of powder decreases. The hygroscopic value of the bay leaf powder ranged from 3.65 to 4.79%. The value of lightness increases with increase in temperature during animal drawn grinding. The quality of the product is better than that of traditional method and has higher value as compared to traditional method.

Ragi thresher-cum-pearler: A ragi thresher-cum-pearler to be operated by a bullock-operated system was developed for simultaneous threshing and pearling of harvested matured and dried ragi ear heads. This equipment consists of a hopper, threshing cylinder, a pair of oscillating screens and one aspirator. The cost of operation is ₹ 200/q by the developed machine as compared to ₹ 500/q in manual method resulting in financial benefit of ₹ 300/q to the farmers, time saving and reduced drudgery in threshing operation. The cost of the technology is ₹ 35,000.

Turmeric polisher for dust reduction: The conventional method to polish turmeric is a machine of rotary type, made up of octagonal shaped drum covered with expanded wire mesh. Polishing is affected by rubbing and abrasive actions of turmeric rhizomes one over the other and over the metal surface. The removed skin pieces are thrown out through the perforations in the drum and produce a dusty atmosphere in the polisher operating area, leading to the respiratory problem for the operator and hazard to the environment. The new turmeric polisher is provided with a special cover possessing the characters of 100% waterproof, highly durable, very tough to tear, repairable by heat sealing, stays light in rains, easy to handle, fungus and termite resistant and UV stabilized. The

Turmeric polisher for dust reduction

capacity of the polisher is 600 kg/batch. The dust was observed only at the rhizome discharge end and majority of the dust particles were collected at the bottom portion of the cover. A small fraction (0.6%) of very small size dust below 100 µm was found floating. The improved dust proof polisher could trap 99.4% of the emerging dust from the polishing action.

Composite peeler-cum-juice extractor: A semi-automatic peeler was developed for peeling of kinnow and sweet orange fruits to facilitate easy juice extraction. The major components of the machine includes, gear assembly two fruit holders, revolving shaft, clearance of the tool for peeling and knife. This peeler was operated using a motor (0.5 HP, 1440 rpm) with the gear assembly, rotation of the fruit while peeling was adjusted to about 200–220 rpm for attaining maximum peeling efficiency. The fruit has to be placed manually between the fruit holders. A conical shaped support (Φ 34 mm) was fitted for smooth functioning of peeling blade (Φ 36 mm). The peeling machine is combined with the juice extractor to make it as a composite unit utilized for peeling as well as juice extraction. A conical hopper with flattened base was fitted to facilitate the extraction of juice from peeled fruits. The hopper of juicer was modified by fitting a sigmoidal blade to eliminate the use of plunger for fruit pressing to automate the juice extraction. Some portion of the fruit which does not come in contact with peeling blade can be easily removed using cutting knives assembly. Fruit with variation in size can be placed easily with a provision of handle and simultaneously the knives assembly is also adjusted with fruit size. The whole machine is placed within a frame. Kinnow and sweet lime fruits were peeled using the developed prototype and the performance was evaluated on different fruit rotation speed. The juice loss observed was 3.73% (220 rpm) and 15.74% (362 rpm), respectively. The average peeling time/fruit was in the range of 8–15 sec. After peeling, the approximate weight fraction of peeled fruit (58%), peel (37%) and juice (5%), respectively were obtained. This composite peeling-cum-juice extractor machine can find its applicability in cottage fruit processing industries as well as for the domestic juice sellers.

Composite peeler-cum-juice extractor for sweet orange and kinnow

Multi-purpose polyhouse solar dryer for chillies: A polyhouse solar dryer for drying chilli, was developed. It protects chillies from unprecedented rains and reduced 50% of drying time as compared with conventional drying. Polyhouse dried chillies had better colour retention value as compared to conventional drying. The percent of discoloured pods is less (3–4%) as compared to 13–15% in conventional drying. The product is free from aflatoxin infestation. The cost of drying is very low (₹ 17/q of ripened pods) compared to mechanical dryers. Polyhouse can be used throughout the year December to April—drying; May to June—coriander production; July to October—nursery raising.

Multi-purpose polyhouse solar dryer for chillies –ANGRAU (Bapatla)

Processing of millets for enhanced shelf-life: Millets including sorghum are endowed with nutraceuticals such as antioxidants, minerals and vitamins, further they have low glycemic index. The major impediment in consuming millets is the presence of antinutritional compounds and low shelf-life of products. Process protocols were developed to enhance shelf-life and nutritional availability of processed millets like kodo and sorghum using submerged fermentation, where tofu whey based LAB culture was used for fermentation. A processing line was developed, comprising a batch type fermenter, pneumatic-conveyor-dryer, flaking machine, flakes conveyor, dryer, mini boiler, and hot water tank. The shelf-life of fermented

Automated packing line for spherical horticultural produce

Activities of a fruit pack-house involve washing, sorting based on colour, blemishes and estimated weight and packaging in appropriate packaging material. An automated packing line for spherical horticultural produce was developed, which can carry out real time sorting of spherical horticultral crops on the basis of three weight categories and colour. The packing line is attached with a water jet washer and perforated cylindrical LDPE heat sealing packing unit. The overall capacity of the machine is about 200 kg/h (assuming average fruit weight 120 g). The colour and weight based real time sorting efficiency of the machine is 92 and 88% respectively. Colour and weight based sorting algorithms are individually programmable to accommodate variety of spherical fruits like oranges, sweet lime, apple, etc.

Automated packing line for spherical horticultural produce

Pilot plant for minimal processing of cut vegetables

The processed cut vegetables are gaining popularity among the urban consumers. Currently, the cut vegetables available in supermarket are processed manually and their shelf-life is limited due to inappropriate processing conditions and lack of hygiene during manual handling, more so, the process is labour intensive and time consuming. A pilot plant for minimal processing of cut vegetables was developed using adopted/developed machinery with a capacity of around 100 kg/h. Machinery like a vegetable cutter, cauliflower floret cutter, washing-cum-treatment tank, ozone generation system, basket centrifuge, UV chamber and belt conveyors were developed for production of minimally processed fresh cut vegetables (carrot, cabbage, cauliflower) with a capacity of around 100 kg/h. Process-protocol was developed for treatment of cut vegetables in ozonated water, surface moisture removal in a basket centrifuge, packaging and UV treatment of packaged products that increases the shelf-life as compared to traditional chlorine treatment. The cut vegetable processed through the developed pilot plant can be stored up to around 9–12 days under refrigerated conditions and 2–3 days under normal room conditions. The process utilizes no harmful chemicals and hence effects of harmful chemical residues are eliminated. Pilot plant is suitable for establishing an enterprise in peri-urban areas of vegetable production catchment.

Pilot plant for minimal processing of cut vegetables

sorghum and pearl millet flour could be increased by 2.5 times or more when stored in sealed 100 µ LDPE pouches at 25°C and by following the developed fermentation and packaging protocols.

Mobile fish vending trolley for hygienic fish marketing: Hygienic fish marketing is an important issue. The trolley is mounted on paddle-operated cycle rickshaw and costing ₹ 52,780. The trolley can carry 100 kg fish. The vending unit is fabricated using fibre reinforced plastics (FRP), which reduces the weight, requires lesser draft for motion and enhances the ergonomics. 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 pull on rickshaw. The gross weight of the gadget including fish, ice, water, rickshaw and other utilities is 320 kg.

Process protocols developed

Spray-dried groundnut milk powder: In India, groundnut is mainly used for oil extraction or consumed in roasted form prompting a need for diversification to further increase its value and utility. Different dairy analogues like groundnut milk, groundnut flavoured beverage, groundnut milk paneer and curd from groundnut kernels were made to diversify the uses of groundnut. But, groundnut milk has very limited shelf-life and also adds to the increased transportation cost of carrying the liquid milk from one place to another. Groundnut milk powder, like dairy milk powder, can reduce product perishability as well as storage and transportation costs. The spray drying of groundnut milk was optimized. Spray dried groundnut milk powder can be safely stored in both the packaging materials for 12 weeks, and metal tin is marginally better than aluminium foil packaging. The reconstituted milk from groundnut milk powder showed favourable score (7.15/9).

Value-addition

Sorghum upma mix: Sorghum *upma* mix was developed using fermented, steamed and flaked sorghum grain. The shelf-life of the ready mix is about 3 months, when packaged in 100 micron thick LDPE sealed pouches, and stored at 25°C. The uncooked sorghum *upma* mix contains about 3.2 g moisture, 8.3 g fat, 11.7 g protein, 6.8 g minerals, 2.3 g crude fibre, 67.8 g carbohydrate in 100 g ready mix and has an energy value of 393 kcal. The product had an overall sensory score of 7.8.

Masala sorghum mix: *Masala* sorghum dry mix was prepared by mixing dried sorghum flakes, dried vegetables, skim milk powder, roasted defatted soybean flour and condiments. The sorghum flakes were prepared using whole sorghum grain. The shelf-life of the ready mix is about 3 months, when packaged in 100 micron thick LDPE sealed pouches, and stored at 25°C with an FFA value of 0.073% at the end of storage. The uncooked *masala* sorghum contains about 6 g moisture, 1 g fat, 10.2 g protein, 5.5 g minerals, 3.2 g crude fibre, 74.2 g carbohydrate in 100 g ready mix and has an energy value of 346 kcal. The product has 21% antioxidant activity. Sensory studies showed that the product is liked by both female and male respondents with an overall sensory score more than 7.5.

Ready-to-eat fruit puree for undernourished children: Process for ready to eat papaya puree (strained food) targeted as complementary food supplement for babies and children (aged 9 months and above) was developed. The optimized process includes fruit sorting, washing with lime, steam blanching, addition of sugar and cooking at about 82°C, followed by deaeration and sterilization in sealed container. Processed and packaged product can be kept for 3 months under refrigerated storage condition. Developed strained food is rich in vitamin

Ready to eat fruit puree for undernourished children

C (96 mg/100 g), calcium (35 mg/100 g), magnesium (70 mg/100 g) and fiber (1.7 g/100 g). Calorific value of products is 98–100, which is comparable to commercial first baby food having net calorific value of 91.

Soy-based fortified food bars for undernourished children: A protein rich formulation of composite cereal bar was developed based on soya and cereals like wheat, rice, sesame and mungbean. The developed soya composite cereal bar contains cocoa powder, coconut milk, skimmed milk powder, butter and sugar having protein and fat contents are 18–19% and 24–25%, respectively. Compressed protein bar with acceptable sensory quality, peroxide value, FFA content and microbial stability, has a shelf-life of 3 months, when packed in polypropylene and 4–5 months in metallized packing stored at ambient temperature as well as 37°C.

Protein rich soy based fortified compressed food bars for undernourished children

Nanocellulose polymer based PVA composite film: The trend towards banning of plastics comes in the wake of growing awareness on environmental threat associated with disposal of plastic waste. Many biopolymers were developed but these have poor mechanical, thermal and barrier properties; rendering them unsuitable for packaging films. Combining these biopolymers with green fillers could address the property-performance gap between renewable and synthetic polymers. The process protocol was developed using nanocellulose (NC) as a reinforcement for development of biodegradable PVA-NC composites with improved functionality. Tensile strength of composite films loaded with 2 and 5% nanocellulose improved significantly by 25% and 50.7%, respectively, as compared to pure PVA film. Reinforcement of nanocellulose up to 10% also showed marked increase in water vapour barrier properties; reducing the WVP values by 14–29%.

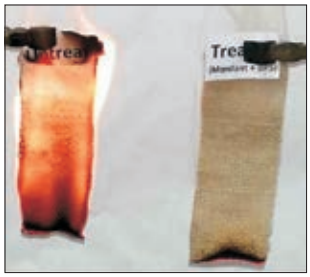
Seedling tray from nano-lignocellulosic biomass based composites: Nano-lignocellulosic (NLC) biomass was extracted from the banana fibres and cotton stalks by a combination of beating and refining processes. NLC was mixed with the non-woven mat of banana fibres and molded into nursery seedling trays in a hydraulic press. The lignin content in the biomass acted as a binding agent while the NLC gets compacted to form a stable structure of the mold. The strength was imparted by the presence of cellulosic fibres. The nursery seedling trays could be used for growing the seedlings for a period of two weeks. Also, the produced structure is bio-degradable as no synthetic resin is used. Use of biomass from banana pseudostem and cotton stalks adds value to the farming by-produce.

Seedling tray from nano-lignocellulosic biomass based composites

ECF bleaching protocol for banana pseudostem fibres: Banana fibre, obtained from the banana pseudo-stem, is an underutilized natural fibre available in significant quantities. The banana fibre contains cellulose, hemicelluloses, lignin and other woody material in its constituents. Banana fibre after extraction is brown due to the presence of lignin and other impurities, which has to be removed through bleaching process to use the fibres for applications in textiles, paper making etc. Generally, the fibres are subjected to bleaching with hypochlorite or hydrogen peroxide but leads to release of harmful elemental chlorine and absorbable organic halides into environment. To address these issues, an elementary chlorine free (ECF) bleaching protocol was developed for bleaching of banana fibres through which the banana fibre is bleached into whiter fibre with 93% and 87% higher whiteness index (CIE 2000) compared to the hydrogen peroxide and hypochlorite bleached fibres respectively. The developed protocol can be used for producing quality paper with required brightness properties. The process can also be used for banana based textile materials for producing whiter fabrics.

Removal of colour from reactive dye bath effluent: The effluent generated after dyeing of textile materials contains more than 20 ppm of residual dye. An activated carbon based process was developed to remove the dye. Under this process, the effluent containing 20 ppm residual dye was passed through the activated carbon column. The iodine value of activated carbon used for this process was 404. By this process, the residual colour of the reactive dye effluent was completely removed. The treated water is then reused for dyeing of cotton fabric along with a control dyeing using freshwater. The k/s value of the dyed fabric using treated water was 16.2, whereas the fresh water dyed fabric showed k/s value of 18. The result indicated that no significant difference between the treated water and freshwater in terms of colour coordinates. The activated carbon based process can be used for removing the residual colour of the reactive dye effluent and the treated water can be reused for dyeing.

Fire retardant jute fabric using natural extract: Fire retardant treatment of textile substrate is important, as it is directly related to human health and other hazards. Natural fibres based textiles like jute, flax, ramie, banana, silk, etc. readily catch flame in an open atmosphere. Banana pseudostem sap (BPS), an agro-residue, was successfully used for flame retardant treatment of jute fabric. It is an environment friendly, natural and sustainable material



Fire retardant jute fabric using natural extract

produced from the renewable source. It is a by-product obtained during the extraction of fibres from the banana pseudostem. The BPS was applied in the unbleached, bleached and dyed jute fabrics in alkaline condition by pad-dry-cure process. After application, the fabric not catch flame and its limiting oxygen index value improved notably from 22 in the untreated sample to 30–34 in the different treated samples. The maximum average rate of heat emission in the untreated and banana sap treated fabrics were 76.0 and 69.4 kW/m², respectively.

Manual plastic mulch, drip laying-cum-retrieval machine: This machine can lay the standard width (1.2 m) of plastic mulch in opened furrow. Plastic mulch of less than 1.2 m width can also be laid with it. After laying, the mulch is covered with soil. Facility of laying inline drip pipe/tape beneath the plastic mulch is also provided in the machine. It also marks (punching) small holes on the laid mulch. The overall dimension of the machine is 2.00 m × 1.7 m × 1 m. Actual field capacity of the machine is 0.059 ha/h which is almost 10 times faster than manually. Average draught required to pull the machine was 32.2 kg.

Off-season okra under different type structures and mulch conditions: Performance of hybrid variety (GJO-H4) was evaluated inside the structure. The fruit yield (22.4 tonnes/ha) was significantly higher inside the net-cum-polyhouse. Lower weed intensity and highest water saving (28.75%) was found under silver black plastic mulch. Maximum water-use efficiency (71.58 kg/ha-mm) was under silver black plastic mulch inside the net-cum-polyhouse, while it was minimum (0.54 kg/ha-mm) in no mulch condition in open field environment. Maximum net profit of approximate ₹ 8 lakh/ha can be obtained for off-season okra cultivation inside the net-cum-polyhouse under silver black plastic mulch. B:C ratio was 2.61

Storage of ber: A new handling-cum-storage box was designed for improving the consumer appeal and acceptability. The box was made using three ply corrugated fiber board material laminated on outer side with proper ventilation for proper exchange of gases. The top cover of the box contained a transparent window slit showcasing the freshly packed ber fruits. The designed box could hold 750–800 g of fresh ber fruits. Freshly harvested mature green ber fruits (Kaithli) was found to be successfully handled and stored for four days under ambient conditions. A labelling provision was made on one side of the box which gives the basic information, viz. variety of ber, net weight, date of packing etc.

Virgin seed oil of pomegranate: ICAR-NRCP has standardized extraction protocol for virgin seed oil from pomegranate seed—a by-product after juice extraction, with 29% oil recovery in shortest duration of 2 h.

Aonla based value-added products: ICAR-CISH has developed vit C (144 mg/100 ml) and antioxidant (2.07%) enriched aonla based spiced squash having tangy taste. On the demand of industry CISH has developed low calorie (12 kcal/100 ml) aonla-fennel RTS drink. Sugarcane juice blended with aonla juice was preserved successfully for a period of one year. The vit C and total phenolic content in stored juice were 69 mg/100 ml and 237 mg/100 ml, respectively. Aonla blended sugarcane vinegar was prepared with 5.4 acidity as acetic acid and 112 mg/100 ml total phenolics. Probiotics are health-friendly microflora, which exert beneficial effect. CISH has developed probiotic drink from aonla, bael and jamun. Nutritionally rich healthy herbal chew formulations having medicinal properties were prepared having jamun, aonla and dill as one of the ingredients.

Instant protein rich tomato soup mix: The whole tomatoes were blanched at 100°C for 2 min, sliced and placed in gelatinized starch for 10 min at 40°C. Subsequently tomato slices were dried in cabinet dryer at 50–55°C to reduce the final moisture to 1–2%. The formulation of instant protein rich tomato soup consisted of dry blending of 15–20% WPC-70, 10–15% corn flour, 15–20% modified starch, 2–5% onion powder, 0.5–20% garlic powder, 20–30% tomato powder, 4–6% table salt, 0.5–1.5% black pepper, 0.5–1.0% cumin powder, 4–6% flavour enhancer, 50–100 ppm red colour, 3–8% sugar, 4–8% black salt and 0.5–1.5% dextrin white.

Potato-based products: Developed potato based gluten free cookies having 50–80% potato flour. Besides, developed potato starch-based table ware. The strength of tableware was quite good.

Particle boards from cassava by-products and starch: Cassava stem based particle boards were prepared with urea formaldehyde as resin, oxidised starch as well as starch succinate as binders, and glycerol and water as plasticizers. The particle boards have the following characteristics: Density 851 kg/m^3,

Manipuri black rice (*Chakhao Poireiton*) bran for extraction of anthocyanins and development of functional pasta

Black rice, a special variety of rice, is deep black in color, contains antioxidant namely anthocyanins, which is commonly found in dark-hued fruits and vegetables. In India, it is mainly grown and consumed in Manipur where it is known as *Chakhao*. The anthocyanin extraction in this variety was carried out by solvent extraction method with assisted technologies. The anthocyanin content varied from 1.15 to 1.60 g cyanidin-3-glucoside equivalent/100 g bran with different pretreatments, type of solvent, extraction time and temperature. The total phenol content and DPPH (%) inhibition activity varied from 2.4 to 3.9 g/100 g bran and 35.3 to 88.9%, respectively. Development of pasta using black rice bran was carried out. Pasta samples supplemented with 15% black rice bran were the most acceptable. The nutritional value of pasta with 15% black rice bran expressed 10% protein, 2.93% fat, 1.57% mineral content. The anthocyanin content of pasta with 15% rice bran was 165.29 mg/100 g. The free fatty acids were within permissible limit. The antioxidant activity showed increasing scavenging activity with increasing bran level.

moisture content 8.2%, total colour difference 39.7, maximum water absorption 96.5% after 24 h of soaking, and thickness swelling after 2 h soaking 24%. Cassava stem based particle boards made using starch succinate as the binder have density 856 kg/m^3, moisture content 9.54%, total colour difference 37.6, maximum water absorption 93.54% after 24 h of soaking and thickness swelling after 2 h soaking 12.18%. It can be used for interior applications.

Thermoplastic cassava starch composites based biodegradable films and foam type packaging products: Thermoplastic starch sheets were prepared from cassava starch modified with cross-linked cassava starch and starch octenyl succinate. Under optimized conditions of temperature (130°C), pressure (34.74 bar) and concentration of glycerol (41.46%), sheets with density 1,301 kg/m^3, total colour difference 34.45, net expansion index 51.38%, solubility 8.65% and hygroscopicity at 9.9 g/g at 75% relative humidity, were obtained with octenyl succinate starch. Thermoplastic starch sheets made with cross linked cassava starch at 140°C, 130 bar pressure and 40% glycerol had a density of 1,619 kg/m^3, total colour difference of 34.32, expansion index of 21.05%, solubility of 1.58%, and hygroscopicity of 13.65 g/g at 75% relative humidity. It can be used for packaging disposable articles.

Freeze-dried turmeric solubles: Curcumin, the yellow pigment, is the active ingredient of turmeric, has poor bio-availability in human body due to its insolubility in water. To make the curcumin available in the soluble form, the process of freeze drying was adopted wherein the juice from fresh turmeric was extracted, filtered to remove the fibrous particles, frozen and then freeze dried till complete moisture was removed.

Studies on production of freeze dried turmeric soluble using four varieties of turmeric—IISR Prabha, IISR-Pragathi and Chintapalli. The recovery of freeze dried turmeric solubles varied from 4.6 to 5.8%. The curcumin content from different varieties of freeze-dried powder varied from 1.93 to 4.75%. Studies on the bioavailability of curcumin from the turmeric solubles are in progress.

Extractability of curcumin in vegetable oils: The bioavailability of curcumin in human body is expected to be higher when dissolved in oils. A study was taken up to extract curcumin in edible oils such as virgin coconut oil and olive oil. The procedure for extraction of curcumin into the vegetable oils was standardized. The results indicated that about 70–80% of curcumin was getting extracted into oils with respect to that in acetone. Virgin coconut oil enriched with curcumin at the rate of 1 g/200 ml oil is highly potential even when stored for 60 days and hence can be consumed for its medicinal and antioxidant activity. The health benefits of virgin coconut oil due to the presence of desirable fatty acids lauric acid, myristic acid, palmitic acid and oleic acid would be an added advantage. The bioavailability of virgin coconut oil enriched with curcumin in animal system is in progress.

Dishware from banana fibre

A technology was developed to produce eco-friendly and biodegradable dishware from banana fibres extracted from the pseudostem. The fibres were cleaned and beaten to produce the pulp and the same was compressed under high temperature and pressure to produce the moulded product. No binders or additives were used in this process as the lignin present in the fibres act as the binder during high temperature compression moulding. The dishware produced had sufficient strength for holding the food items and acceptable aesthetic look. The developed technology is being taken up by one of the CIRCOT incubatee for establishment of a green-field factory for production of eco-friendly dishware.

Milk

Fortified milk and yogurt: Iron fortification using casein hydrolysates-iron complex in milk and yogurt was an effective strategy to increase the iron, its bioavailability and reduction in fat oxidation without sacrificing the sensory attributes and affecting shelf-life of the product.

Following digestion of goat casein under *in-vitro* simulated gastrointestinal conditions, the low molecular weight peptides were evaluated for DPPIV inhibitory activity. The fraction with maximum activity subjected to MS/MS and five potential DPPIV inhibitory peptides identified from beta casein (K.YPVEP.F, K.YPVEPF.T, N.LHLPLP.L, N.LHLPLPL.L, L.HLPLPL.L) and one from κ-casein (I.NNQFLPYP.Y).

Improving milk protein content: Goat milk protein is drawing considerable interest due to availability of different bioactive peptides, which have nutraceutical applications. Goat milk is also being used for treatment of different disease, allergy and heat stress condition. Therefore, the milk proteome analysis is required for future industrial application with respect to human health and nutrition. Casein haplotypes in association with protein content of milk in different goat breeds/ geographical regions were determined and specific milk protein variants for application to human health and nutrition identified.

SDS-PAGE genotyping presented αs_1 (CSN1S1), αs_2 (CSN1S2), β-casein (CSN2), k-casein (CSN3) and whey protein β-LG and α-LA were observed in different breeds (Barbari, Jamunapari, Jakhrana, Gaddi, Ganjam, Sirohi and Black Bengal goats) and indicated the presence or absence of certain genetic variants in different individuals. Milk protein variation analysis at DNA level in different breed were analyzed. The individual animal can be selected based on CSN1S1 AA gene variant for increasing protein content in goat milk.

Flavoured whey beverages: Flavoured whey beverages were prepared to utilize the whey produced

from *channa* making process upon admixing the camel and buffalo milk. Upon acidification during chhana production, the whey obtained became acidic and slightly sour in taste. Addition of 25% for pomegranate and 20% for watermelon were found the best level to enrich the flavour as well as nutritional quality. It was acceptable up to 12th day upon its refrigerated storage. Thus, naturally flavoured whey beverage had optimum sensory characteristics and excellent health-promoting nutritional qualities and antioxidant properties

Probiotic lactic acid bacteria: Three isolates from camel milk (Cam 31, 41 and 42) were evaluated for probiotic properties and all the strains passed the preliminary tests (acid tolerance, bile salt tolerance, deconjugation of bile salt proteolytic activity, surface hydrophobicity, etc.). Genotypic characterization was also done for all isolates and the majority of the identified isolates were *Lactococcus lactis*, *Lactobacillus plantarum* and *Enterococcus lactis*. The periodical fermentation pattern of camel milk was also studied.

Mithun milk: Mithun milk samples were analyzed to determine the levels of conjugated linoleic acid (cis-9 trans-11+trans-9 cis-11 CLA) and other fatty acids (C4 to C24 all *cis* and *trans* forms). The total fat content in mithun milk varied from 4.22 to 15.89% with a mean value of 8.90±0.63%. The level of CLA varied from 2.83 to 23.99% with an average of 10.07±1.09%. The average level of saturated fatty acid (SAF), monounsaturated fatty acid (MUFA) and polyunsaturated fatty acids (PUFA) were 72.89±1.77, 24.79±1.71 and 2.32±0.22% of total fatty acids, respectively. The omega-3 fatty acids and omega-6 fatty acids were 0.63±0.14 and 1.76±0.25 µg/g milk.

Meat

Meat species identification: Species identification is one of the important aspects of molecular meat traceability. A method for detection of pork was developed by designing a novel set of primers targeting mitochondrial D loop gene.

Primers specific for cattle, buffalo and pork gave positive amplification for their respective species while no amplification could be seen in other closely related meat animal species. AL–LAMP technique was applicable for species authentication even in meat samples treated at 121ºC for 30 min. Technique could detect adulteration of 0.2% of the meat. Technique was also validated in meat products commercially available in the market. Technique takes only 3 h to complete.

Species authentication of fresh and processed pork products: Adulteration of pork with other meat is a possibility and needs to be checked for protecting consumers trust and halal authentication. Another urgent need for authentication of fresh and processed pork is that wild boar which are related closely to domestic pigs are protected species under Wild Life Act, 1972. A loop-mediated isothermal amplification (LAMP) technique was developed, which enabled amplification of the targeted gene at constant temperature and result can be interpreted easily based on the colour change in the solution. The technique is simple and can be done easily with simple instruments by semi-skilled person.

E-Varaha An information system for safe pork production: Different images of body temperature of the normal and diseased pigs were taken at different times by using infra-red thermal camera. Different images of body temperature of pigs were taken at pre-slaughter and post-slaughter level for examining pig and pork quality. Preliminary work proved the usefulness of IRT images for discriminating disease from normal pigs. A synthetic disease-specific symptom knowledge base is also created. A web-based decision support system (DSS) on different diseases of the pig was developed to arrive at a decision that pig can be converted into consumable quality pork.

Small scale pig slaughter units: A cost-effective (₹ 5 lakh) unit for rural pig slaughter house (for 5–6 pigs/day) was designed and a model unit was established at Rani Market in collaboration with Gram Panchayat, Rani, Guwahati; Assam. The model offers provision for electrical stunning, elevated carcass dressing, hygienic fabrication and packaging of pork.

Mithun meat: The dressing percentage of mithun meat is 51.65±1.29. Among the edible offals, liver, heart, kidney, spleen consisted of 1.22±0.09, 0.416±0.01, 0.19±0.02, and 0.23±0.02% of the live weight, respectively, whereas skin/hide contributed 6.49±0.56%. The proximate analysis of mithun meat revealed 71.18±0.95% moisture, 22.24±0.64% protein and 0.595±0.14% fat suggesting that mithun meat is leaner as compared to other bovine species. The calorific value (kcal/100 g) of mithun meat is 113±3.93 and cholesterol 34.93±3.93 mg/100 g. The degree of marbling (intramuscular fat) of mithun meat, judged by exposing the rib-eye area on the 12th rib of the carcass on the basis of a standard photograph of USDA

SUCCESS STORY

Technologies Transferred

- Sugar tolerating lactic culture for preparation of misti doi (Misti doi culture-15 freeze dried ampoules).
- Whey jaljeera drink.
- Whey mango drink.
- DNA based method for differentiation of cow, buffalo, sheep, goat and camel milk.
- Arjuna herbal ghee.
- Bajra lassi.
- Milk protein enriched iron fortified bajra biscuit.
- Detection of buffalo milk in cow milk using hansa test serum.
- Strip based test for detection of maltodextrin in milk.
- Misti doi with fast acidifying high sugar tolerating lactic cultures.
- Strip based test for detection of neutralizers in milk
- Strip based test for detection of hydrogen peroxide in milk.

Accelerated retting of jute

A better and user friendly technology for improved retting of jute was developed. The powder formulation contains microbial growth supplement, which enhances the initial microbial population of retting water, which in turn accelerates the rate of retting. Accelerated retting technology, aids in reduction of retting time from 18 to 22 days to only 10–12 days besides additional 50 kg/ *bigha* fibre yield and up to two grade enhancements over the conventional retting process. This resulted in a four-fold increase in net profit/ha from ₹ 10,575 through conventional retting to ₹ 32,500 by adopting accelerated retting of jute. Therefore, this technology, in the imminent future could prove to be a viable and lucrative alternative to the conventional jute retting and help in reviving the jute industry in the context of doubling the farmers' income within 2022.

Advantages

- Accelerated retting is an effective and remunerative process of jute retting to double the farmers' income within 2022.
- The jute grades improve through increasing the strength, fineness, colour and reducing the defects
- Fibre quality improved by 1–2 grades and thus per quintal effective income increases to the jute growers.
- As compared to conventional retting, there is no additional impact on environment through accelerated retting.
- There is no impact on water and soil and the retting residues enriches the soil.

marble scoring guide by visual appraisal, showed a moderate to slight marbling.

Smart packaging nano-sensor for meat safety: Smart packaging sensors detect the freshness of meat during storage. A strip-type sensor for detecting volatile amines released from chicken meat during refrigeration storage was developed. The strip was made of nitrocellulose membrane coated with anthocyanin from red cabbage, 1% silver nanoparticles and 0.1% titanium oxide. The color of the sensor changed from dark pink to whitish light pink during the storage period. The rate of discoloration increased as the concentration of volatile amines released increased during the progressive storage period.

Superchilling cabinet for storage of meat: A superchilling cabinet was developed with respect to temperature and humidity to optimize the superchilling conditions of dressed carcass or meat to improve their quality and storage stability. Carcasses were stored at superchilling temperature and were analysed for pH, water holing capacity (WHC), cooking yield, thio barbituric (TBA) value, instrumental color (lightness -L*; redness - a* and yellowness - b* value), % metmyoglobin, shear force value, total plate count (TPC) and coliform count on 0, 4 and 7th day for chilled, 0, 7, 14, 21, 28, 35th day for superchilled and 0, 14, 30, 60, 90, 120th for frozen carcass. The pH, TPC and coliform count were decreased initially in superchilled storage and then again increased from 28th day of storage. WHC, cooking yield, a* and b* value, shear force were significantly ($P<0.05$) decreased throughout the storage period, whereas L* value, TBA value and % metmyoglobin were significantly increased.

Microbiological quality assessment of pork: Food borne illness is a serious threat to public health around the world. The contamination of food may occur throughout the food chain from farm to industry and from market to kitchen. *Staphylococcus aureus* is commonly found in pigs which may also be present in contaminated pork and pork products. An assay for simple and cost-effective detection of *S. aureus* from pork was developed by using LAMP assay.

PM tenderization of breast meat from spent hen: For effective utilization of tough meat from poultry post-mortem tenderization was optimized at refrigeration (4±1°C) temperature. The electrophoretic patterns of the myofibrillar proteins indicated 6 important changes due to action of enzymes, viz. the protein of MWt near 110 kDa disappeared 24 hr post-mortem though it was distinctly visible at 6 hr and fairly visible at 12 and 18 hr. Similarly, two proteins of approximately 29 and 30 kDa first appeared immediately after post-slaughter, and then band clearance increased up to 6 hr, but on subsequent ageing for 12–24 hr the bands disappeared. The 110 kDa protein could be α-actinin, which is a substrate of calpains. The bands were observed at 43 and 65–70 kDa due to the presence of proteins actin and tropomyosin, but additional bands predicted at 33 and 35.4 kDa might be due to protein α-tropomyosin and troponin T, respectively. In general, during post-mortem ageing all the cytoskeletal proteins along with few regulatory and myofibrillar proteins started to disappear or degraded into other forms due to action of calpains. The SDS-PAGE showed degradation of protein bands of breast muscle during ageing at refrigeration temperature (4°±1°C)

Functional turkey meat loaf utilizing adult turkey: Processing technology and formulation for functional turkey meat loaf was standardized utilizing tough meat from adult turkey. For processing of meat loaf, sprouted blackgram dal, rosemary, α-tocoferol acetate (vit. E) and fructo-oligosaccharides (FOS) were mixed with other ingredients. The emulsion was filled in aluminum molds and cooked for 50 min. Different physico-chemical quality parameters were assessed. The product was well accepted by the sensory panel members.

Wool and fibre

Yak hair based high value textiles: The yak hair fibre was succesfully used for making novel warm garments. Different jute-yak fibres blended textiles were developed in jute processing machineries. Natural thermal insulation property of both the jute and yak fibres, excellent dimensional stability and strength of jute fibre were improvised in a single product for improved overall properties of the warm cloth. Yarn made from fine as well as coarser yak fibre in blending with jute fibre is used to produce shawl, suiting fabric and high value jackets, which are much comparable, even sometimes better than the commercial woolen cloths. The thermal insulation value of the jute-yak

fibres blended cloth of areal density of 200 g/m^2 is 1.0 Tog (Tog is an unit of thermal insulation as per ASTM) as compared to 0.8 Tog of commercial woolen cloth of similar areal density. Commercial exploitation of yak fibre would create an environment of economic maneuvering to yak herders living at much harsh and cold climatic regions.

Yak hair based high value textiles

Furs: Furs were collected from Soviet Chinchilla, New Zealand White, Grey Giant, White Giantbroiler rabbits after the slaughter in the experimental abattoir. Furs were chrome tanned and processed as per the standard methods. Different fur products like ladies purse, hand bag, baby purse, gloves, cap and many unique handicrafts were made from it. The processing cost of one rabbit fur comes to ₹ 20/piece. The finished products fetch much higher price in the markets. The rabbit fur processing could be a good source of employment to rural youth and women.

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11. Agricultural Human Resource Development

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 3 Central Agricultural universities (CAUs) under the National Agricultural Research and Education System (NARES) 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.

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

Governance and quality assurance

Accreditation of agricultural universities: Quality assurance in higher agricultural education is being pursued through accreditation. For improving educational standards and assuring an acceptable institutional quality, the accreditation of AUs along with their colleges and academic programmes is being done by National Agricultural Education Accreditation Board (NAEAB) established by the Council with well defined guidelines. The NAEAB has been strengthened by establishing four regional Centres in North, East and North-East, South and Western regions at IARI New Delhi, CRIJ&AF Barackpore, IIHR Bengaluru and CIFE Mumbai respectively.

To make accreditation process more objective, new guidelines namely, "Guidelines for Accreditation of Higher Agricultural Educational Institutions in India have been developed and implemented in this year.

Ranking of agricultural universities: In line with the National Initiative on Ranking of Indian Institutions, Ranking of Agricultural Universities has been initiated with a larger objective to improve ranking of Indian Universities in World University Rankings. The ranking process is being done annually and top three universities are honoured on ICAR Foundation Day held on 16 July. It is expected that the process of ranking would help agricultural universities to self-assess themselves on the quality and enhance their abilities.

While evaluating the agricultural universities, the emphasis has been given on parameters such as students' performance, academic excellence, faculty profile, 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. Based on the evaluation, 63 agricultural universities were ranked and the top three universities, viz. First ICAR-National Dairy Research Institute, Karnal; Second ICAR-Indian Agricultural Research Institute, New Delhi; Third Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, were honoured on ICAR Foundation Day Award Ceremony held on 16 July 2018.

Student READY

Experiential Learning: This is one major component of 'Student READY' programme, where hands-on skill-oriented training to undergraduate students is imparted. Fifteen new modules were established during the year. New modules were supported in various profitable areas, viz. processing of tea, fruits and vegetables processing for value addition, bee keeping and honey production, fabrication of green houses/ polyhouses, production of bioagents and biopesticides, protected cultivation of high value horticultural crops, commercial floriculture, goat farming, etc. Presently 441 Experential Learning Units are working across the agricultural universities.

Rural Awareness Work Experience (RAWE): This is another component of 'Student READY', where 14,210 students were exposed to the rural settings through Council's support. This exposure of students

"Guidelines for Accreditation of Higher Agricultural Educational Institutions in India" have been developed and implemented in this year. The guidelines are available in public domain at—
https://icar.org.in/sites/default//files/guidelinesforaccreditationfinalbook.pdf

helped them gain competence and confidence for solving problems related to agriculture and allied sciences. All these activities of students were under the supervision of faculty. The students were also exposed to agri-industry in the region and even outside the region and gained tremendous experience through in plant and industrial attachment.

Teaching, research and capacity building

Niche area of excellence: Capacity building and creating excellence in specific cutting edge areas, support of ₹ 4.50 crore to 11 ongoing and two new centres of Niche Area of Excellence (NAE), viz. on Development of Alternate Models and National Standards for Quality Control of Veterinary Vaccines and Diagonostics at IVRI, Izatnagar; and Antibiotic Resistance–Animal Human Interface at GADVASU, Ludhiana, was provided during the year.

The NAE programmes are being supported in the important focussed areas, viz. molecular breeding in rice for stress tolerance, reduction of spongy tissue in mango, production of seedless kinnow, detection of toxins in milk, pet food with probiotics, zoonotic diseases, technology enhanced learning, etc.

Significant achievements under some programmes were:

- Digital courses were designed, turning the facility into a viable revenue–generation model. Technology enhancements to the TELAgE facility added better digital content quality and MOOC on Teaching Management was offered, besides managing MOOCs with online certification (for the first time). The facility is used for consultancy assignments and offering customized programmes for massive number of clientele. An initiative on MOOC was offered to enhance the teaching competencies of the teaching faculty or those aspiring to be faculty.
- Successful development of three Nutraceutical products for use in dogs with specific GI disorders based on probiotic and polyphenols (PPE and JAE). Alginate-based encapsulation was effective in terms of shelf-life and maintenance of *in-vitro* viability of the probiotic bacteria.
- New vectors for propagation of *Listeria monocytogenes* were identified. Mite species *Ornithonyssus bacotii* can transmit *Orientia tsutsugamushi*; an etiological agent for Scrub typhus in the region and Karp strain of *Orientia tsutsugamushi* as a major circulating genotype among rodents of the region was identified first time. In-house listeriolysin-O (LLO) based ELISA was developed for serodiagnosis of listeriosis.
- Epsilon toxin of *Clostridium perfringens* cloned for use as vaccine candidate.
- Optimized strip-based sensor for detection of pesticide residues in milk under field condition.
- Hybrids between Kinnow and Mukaku Kishu were developed and identified using polymorphic SSR markers. Hybrids were also developed from the crosses- Jattikhatti × X-639, Jattikhatti × Sour orange and Volkamer lemon × Cleopatra mandarin.
- Two virulent isolates of *Phytophthora* were selected based on the earliest and severe symptoms expression.

'Kinnow' × 'Mukaku Kishu' hybrids identified through SSR markers

Mass multiplication of *Phytophthora* isolates (a) and screening of rootstock genotypes (b)

- Foliar application of potassium nitrate @ 1% and GA @ 100 ppm were most effective with respect to maximum induction of post-harvest vegetative flush, high flowering intensity and increased yield per tree.

Foilar application of Paclobutrazole for hastening of flowering in Alphonso mango

- The centres organized 12 long (>10 days) and short (1–10 days) duration training programmes/ awareness workshops/ camps/ workshops leading to capacity building of 154 faculty and 20 students. Faculty (516) was trained online through MOOC online cetification, and 85 candidated were trained in video production exercise.
- One patent on 'Rapid spore enzyme based miniaturised assay for detection of pesticide

Training Programme under NAE, MAFSU, Nagpur

residues in milk' was published and technology on strip based sensor was transferred.

- The ITS2 sequence of fourteen species of mites have been deposited in NCBI gene bank. The centres generated recombinant proteins and peptide specific antibodies.

Centre for advanced faculty training/ summer/ winter schools and short courses: During the reporting period, 120 programmes comprising 70 summer/winter schools for 21 days and 50 short courses for 10 days were organized at various ICAR institutes and SAUs. The skills, knowledge and capacity building of 2,640 faculty were enhanced.

The 40 Centres of Advanced Faculty Training provided training to about 1,576 scientists/faculty members from the National Agricultural Research and Education System through 63 training programmes in cutting edge areas of agriculture and allied sciences. All the training programmes sponsored by Agricultural Education Division were monitored through workflow based online management system in the form of a Capacity Building Program vortal that provides information on all training programmes, submission of training proposal and evaluation, availability of e-books/lecture notes of a training and reports besides several other features.

Attracting talent

All-India entrance examination for admission to UG: The 23rd Undergraduate Examination for admission to 15% seats of degree programmes in agriculture and allied subjects, other than veterinary sciences, including the award of National Talent Scholarship/ JRF/SRF (NTS) was conducted on 19 August 2018. The examination attracted 73,548 applications, out of which 48,446 candidates appeared and 1,506 candidates were finally recommended for admission in 45 AUs. All the candidates, who joined a university outside their State of domicile, were awarded National Talent Scholarship.

All-India entrance examination for admission to PG: The examination was conducted on 18 August 2018 for admission to 25% seats in PG programmes at 51 accredited AUs, including award of ICAR-PG scholarship. Out of 23,015 candidates, 2,252 candidates were finally recommended for admission. Non-PG scholarship candidates who join the Master degree programme are eligible to get NTS (PGS) for two years, subject to fulfilment of prescribed terms and conditions.

All-India competitive examination for Ph.D. admission and award of Junior/Senior Research Fellowship: The examination was held on 18 August 2018 at 22 centres across the country and 3,460 candidates appeared out of which 389 candidates were finally recommended for Ph.D. admission in 43 accredited AUs.

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, were awarded on the merit-cum-means basis.

National Talent Scholarship (NTS): This year 5,172, UG and 2,203 PG students were provided merit based support through National Talent Scholarship, through ICAR, All India Entrance Examination (AIEE) NTS.

ICAR Fellowships for Post-Graduate Students: During the reporting period 1,149 and 332 students were awarded ICAR-PG Scholarships and ICAR-JRF/ SRF(PGS) for Master's and Doctoral studies, respectively, in different disciplines of agriculture and allied sciences.

Globalization of agricultural eEducation

International Fellowships

Netaji Subhas-ICAR International Fellowships: With the objectives to develop competent human resource and showcasing the strengths of National Agricultural Research and Education System (NARES) and to create a pool of scientist-envoys for enhanced future co-operation, Netaji Subhas ICAR International Fellowships are offered for pursuing Ph.D. programme at Indian agricultural universities (AUs) and overseas universities for Overseas and Indian candidates, respectively. The amount of fellowships for Indian and overseas candidates is @ US$ 2,000 and ₹ 40,000/ month, respectively.

During this year, 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 their Ph.D. study including 23 Indian candidates at overseas universities and 7 foreign candidates at Indian SAUs/ICAR-DUs.

India-Africa Fellowship Programme: India-Africa Forum Summit III (IAFS-III) ensued allocation of 500 seats under Special Agricultural Fellowships for African nationals to conduct higher degree programme from Indian Agricultural Universities. A total of 156 applications (108 PG; 48 Ph.D.) of African nationals from 13 countries (Botswana, South Sudan, Kenya, Tanzania, Nigeria, Eritrea, Ghana, Malawi, Egypt, Zimbabwe, Uganda, Mozambique and Ethiopia) were recommended in session 2018–19. Out of which 88

(62 PG; 26 Ph.D.) candidates were provisionally selected and 26 (21 PG; 05 Ph.D.) have joined. IAFS I (2010–14) programme has been summed and 188 African nationals successfully graduated from 36 Indian Agricultural Universities.

India-Afghanistan Fellowship Programme: Under India-Afghanistan fellowship Programme, 124 applications (10 Bachelor's, 107 Master's and 7 Doctoral) were screened during academic year 2018–19. Out of which, 75 candidates (7 Bachelor's, 63 Master's and 5 Doctoral) were provisionally selected and 33 (3 Bachelor's, 28 Master's and 2 Doctoral) candidates have joined so far.

Promoting Excellence

ICAR National Professor: ICAR operates National Professor Scheme with the twin objectives to promote excellence by recognizing outstanding scientist 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, 6 National Professors were in position. Their areas of specialization are Crop Sciences (4), Natural Resource Management (1) and Economics, Statistics and Management (1).

The salient achievements are:

- Spatial distributions of total nitrogen (N) in soils of Punjab showed that majority of the soils were in low N category. Soils under rice–wheat had lower concentration of total carbon and were characterized by preponderance of recalcitrant forms compared to maize–wheat and cotton–wheat systems. Mulching in maize ameliorated the adverse effects of conventional and deep tillage on total organic C and soil biological activity.
- Study indicated that heat events (defined as maximum temperature being 3°C or more than the normal temperature consecutively for three or more days) in India have become more frequent and intense between 1966 to 2011. Heat stress reduces wheat yield by about 3.3%. The negative effect, though, not large has accentuated over time. Irrigation produces significant adaptation benefits, but its effect has slowed down.
- Poor transport infrastructure, asymmetry in information restrict farmers from accessing remunerative markets allowing rent seeking by informal buyers, i.e. local traders and middlemen. The policy should focus on improving efficiency of agricultural markets and their outreach by investing in transportation infrastructure that reduces cost of trade for both farmers and traders. Market information systems need to be developed to reduce asymmetry in information between farmers and traders. Finally, the financial institutions need to improve their outreach to smaller farmers to reduce their dependence for credit on local traders and input dealers who often tie it with output sale and extract rent by paying less than the market price.

Per cent deviation in producer price of wheat from the MSP

	Actual	Improved market access
Local traders	–10.0	–5.4
Mandies	–3.3	–2.7
Input dealers	–11.7	–5.0
Others	–7.2	–2.7

- An insecticidal gene, trypsin inhibitor was identified and isolated from wild type chickpea, *Cicer reticulatum* and cloned in the cloning vector (pGEMT). A promoter sequence of a high expressing gene in pod wall of chickpea was identified and isolated. Screening of putative transgenics is in progress.
- MTU1010 × *O. rufipogon* and *Swarna* × *O. rufipogon* crosses were generated up to BC4F2 by genome-wide genotyping and backcrossing to develop CSSLs. 152 BC4F2 lines of the first cross showed significant difference from the parent MTU1010 for at least one of the seven traits. In BC2F2 of the same, 49 QTLs were identified for thirteen yield and seven photosynthesis related traits.

ICAR National Fellow: There are 25 positions of National Fellows across National Agricultural Research and Education System. During the period under report, 22 National Fellows were in position and they carried out research work in horticulture (3), animal science (7), fishery science (5), natural resource management (3), agricultural engineering (2) and economics, statistics and management (2).

Salient achievements are as follows:

- Co-developed first Canola mustard hybrid, RCH 1, and promoted to AVT1 in Zones 2 and 3. Genetic resource for determinating plant growth habit was transferred to major centres. Genotyped 194 (derived + 92 natural *B. rapa* inbred lines) and completed GBS of 93 introgression lines (*E. abyssinicum* × *B. juncea* and *D. tennuesiliqua* × *B. juncea*). Cytoplasmic indexing of 75 released mustard varieties was done. Marker trait associations were identified for four domestication traits.
- Five shRNA molecules, each of fatty acid synthase (*FASN*) and *acetyl-coenzyme A carboxylase* A (*ACACA*) genes were evaluated for transient RNAi silencing in chicken hepatocyte cells where knockdown efficiency varied from 99% in shRNA2 to 94% in shRNA3 for *FASN* gene and 93% in shRNA4 to 76% in shRNA2 molecules for *ACACA* gene indicating their role in

development of knockdown chicken for production of low fat poultry produce such as meat and egg.

- Gene reporter assay was successfully standardized with Mx promoter of rainbow trout. IRF-3 promoter of snow trout was characterized and the nucleotide sequence determined which revealed the presence of one interferon stimulated regulatory element (ISRE). Snow trout IRF3 promoter was cloned in a reporter plasmid and gene reporter assay standardized.
- A recombinant Invariant Surface Glycoprotein (65 kDa) was cloned, expressed and purified with optimum concentration in the heterologous expression system and was found as a potential, reliable antigen candidate for development of ELISA and Lateral Flow Assay for sensitive and rapid detection of antibodies against *Trypanosoma evansi* infection in equines.
- GRIS (Germplasm Registration Information System), a first of its kind in the world, was developed to make registration of plant germplasm completely online.
- The generated recombinant proteins of NKEF and LHH1M of rohu were found to be antimicrobial in nature against *Aeromonas hydrophila* and *Staphylococcus aureus,* by zonal inhibition method. LHH1M possessed a novel antimicrobial region of 13-mer (AK13) in the protein sequence.
- The prevalence studies based on clinic-parasitological examination of goats brought for slaughter from different areas of Jammu region revealed considerable level (21%) of warble fly infection in the goats. Molecular studies based on PCR-RFLP of cytochrome oxidase subunit I gene (COI) validated the occurrence of *Przheval skianasilenus* fly in the region and abolished the taxonomic ambiguity of the fly. To identify the immunogenic molecules in the larvae of goat warble fly somatic antigen of the larvae was characterized by SDS-PAGE.
- *Small area estimation under a nonparametric generalized linear mixed model:* This methodology was applied to produce reliable and representative district-level estimates of the head count ratio (i.e. poverty indicator) for rural areas of Uttar Pradesh using Household Consumer Expenditure Survey (2011–12) carried out by NSSO and the secondary data from the Population Census (2011). These estimates and their spatial distribution would be useful for various Departments and Ministries of Government of India as well as International organizations for their policy research and strategic planning. They would also be useful for budget allocation and intervention of targeted welfare for below poverty-line households.
- RNA isolation from buffalo spermatozoa was standardized. The buffalo spermatozoa contain approximately 5–10 fg of RNA. Workflow for the analysis of spermatozoal RNA-seq data for finding fertility signature transcripts was standardized. Cattle spermatozoal transcripts profiling revealed that expression patterns of genes from few chromosomes vary according to the fertility status of the bulls.
- *Genome data mining to unravel molecular basis of thermotolerance and adaptation to diverse environments in native cattle and buffaloes:* To evaluate the effect of heat stress across various temperature humidity index, efforts were made to generate systematic phenotype data related to thermo-physiological, hematological, biochemical and cellular changes in cattle breeds, viz. Sahiwal, Tharparkar, Gir, Rathi, Kankrej, Karan Fries, Holstein Friesian, and buffalo breeds, viz. Murrah and Banni.
- Cyprinid herpesvirus-2 (CyHV-2) was isolated with a high virus titer of 107.8±0.26 $TCID_{50}$/ml in a highly permissible fibroblastic cell line, FtGF developed from the caudal fin of goldfish, for producing vaccine, which is much higher than any earlier reported titer for CyHV-2 in other studies worldwide.
- Marine biopolymer, Carrageenan was extracted from the red seaweed *Kappaphycus alvarezii,* by hot alkaline water treatment and characterized by FTIR spectroscopy. Method was developed for the entrapment of anthocyanin in chitosan nano-carriers for nutraceutical applications as an effective strategy to enhance their *in-vivo* bioavailability and *in-vitro* stability. Oral supplementation of anthocyanin loaded chitosan nanoparticles exerted potent antihyperlipidemic property and antiulcer activity in experimental rats.
- Labile soil carbon pools were found higher even in degraded mangrove system compared to rice–paddy in Sundarban, West Bengal, owing to relatively less anthropogenic disturbance and higher litter deposition. Moreover, mangrove ecology showed sign of GHGs sink due to salinity and inter-tidal interference.
- Protocol was standardized for the minimal processing of pineapple, tender jackfruit, matured jackfruit and ripe jackfruit.
- Novel viruses associated with diarrheal infections in pigs were identified and characterized. An enzyme linked immunosorbent assay was developed for the detection of rotavirus infection in poultry.
- Crop evapotranspiration was estimated year-round at IARI farm. Diurnal and seasonal changes in soil water and temperature at multiple depths were monitored. Pedo-Transfer Functions (PTFs) for soil water retention were developed and validated. Sentinel-1 active microwave data was explored to map surface soil moisture.
- Cloned CENH3 coding sequence from *Allium cepa, A. sativam*, *A. fistulosum* and *A. tuberosum.*

Coding region of CENH3 from genomic DNA, promoter and terminator elements from *A. cepa* were also cloned. N-Tail multimer of *AcCENH3*, expressed in *Escherichia coli* was designed and purified for antibody production. EMS mutated M_1 population of *A. cepa* var Bhima Super was also generated.

- Developed encapsulation system comprising two fluid nozzle with heat jacket, thermostat controlled quartz heater and spray chilling unit to encapsulate food and feed ingredients using high melting fat as matrix material.
- Nutritional intervention study on feeding of calcium enriched biscuits to school going children was carried out. Millets based jaggery and buttermilk beverages were optimized on the pilot plant scale. β-carotene enriched sweet potato chips were developed which had 2.7 mg/100 g β-carotene. Two MoUs were signed with ICDS and NHMS, Government of Madhya Pradesh wherein multi-nutrient biscuits, Nutribar, soy-butter, extruded snacks, etc. were included for distribution in the schemes implemented by Government of Madhya Pradesh.
- For heat stress related cellular pathway analysis, protocols were developed for immune fluorescence/western blotting studies for various heat shock proteins. Samples were collected from pigs and goats reared in Asom and Rajasthan. The production records of the pigs reared at ICAR-NRC on Pig were collected for screening with respect to expression of selected genes related to thermotolerance or adaptability.
- Over-writing the fruit fly memory with respect to preferred host cues over non-host cue was established in mango fruit fly, *B. dorsalis* using γ-octalactone and β-caryophyllene. Role of microbes in niche partition between mango fruit fly, *B. dorsalis* and guava fruit fly, *B. correcta* was revealed. Red ant *Oecophyllas maragdina* volatiles repelled female *B. dorsalis* from laying eggs. Antennal transcriptomics of melon fly and fruit sucking moth was carried out to understand genes underlying the semiochemicals induced behavior in insects.
- Comparing the data generated by ^{137}Cs method with actual measured data, it was observed that the prediction erosion rate in slightly eroded plot was nearly 94% accurate. It was also observed that there is close relationship between ^{137}Cs and soil organic carbon (SOC) content of the soil.

Competency enhancement

Emeritus Scientist scheme: To tap brain and skill bank potential, a total of 60 Emeritus Scientists are currently appointed. The aim of this programme is to complete the work in hand for its fruitful conclusion, utilize their talent in teaching specialized courses and use their experience in addressing nationally important issues in different ICAR-Institutes and SAUs.

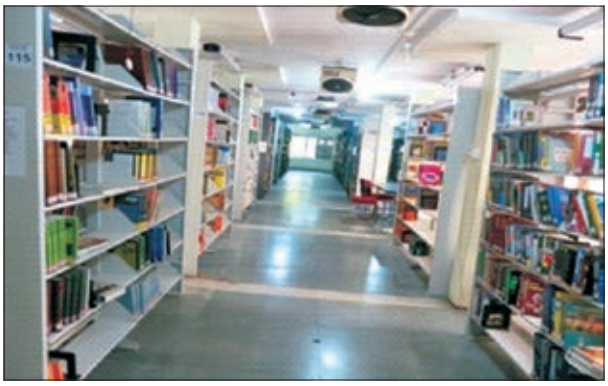
Salient achievements are as follows:

- Benzimidazole resistance was detected by egg hatch assay (EHA) and larval development assay (LDA). Ethanolic extract of neem leaves at 25 mg/ml inhibited conversion of 99% L1 larvae to L3 indicating efficacy against larvae in LDA. Ethanolic extract of fruits of baibirang (*Embellia ribes*) @ 20 mg/ml concentration inhibited hatching of L1 larvae from eggs up to 70.1%.
- Results on physical, mechanical, gravimetric and aerodynamic properties of kodo and kutki millet revealed linear increase/decrease w.r.t. moisture content. Application of Peleg model confirmed the suitability of the equation for describing the water absorption kinetics within the studied temperature range.
- Special instruments on awareness-knowledge, attitude towards gender, gender sensitive activities for planning, monitoring and evaluation of extension under ATMA and KVK and its perceived impact on farmmen and farmwomen were developed.
- Out of 3.77 million ha area in sodic soil in the country, Uttar Pradesh alone accounted for 1.35 million ha (36%). The highest production loss was estimated in wheat (2.35 million tonnes) followed by rice (1.27 million tonnes). Total monetary losses in all crops were ₹ 73,420 million in Uttar Pradesh, that has the largest sodic land in the country.
- Indigenous soil fauna of natural forests were successfully mass produced with greater diversity in soil, coco-peat, FYM by using household kitchen, terrace garden waste, etc. These fauna were introduced to organic farming, INM farms and terrace garden. The introduced fauna established successfully compared to without introduced plots of same situations.
- Combination of the *Trichoderma harzianum, Metarhiziu mansopilae*, *Beauveria bassiana* (2×10^6 CFU/ml) with the pesticides Mancozeb (0.2), Tebuconazole (0.2%), carbendazim (0.2%), Imidacloprid (0.01%) through FYM (1:20), seed treatment, and drenching twice with bioagents was effective against root and stem rot and white grubs (groundnut) and wilt and aphids (cumin).
- Genotypes of *Hadjod* along with botanicals for bone healing were collected from healers and identified. Successive extraction of *Hadjod* powder and botanicals collected from healer was done and compared with healer sample. Secondary metabolites/ compounds were isolated. Out of three, one molecule was characterized as b-sitosterol using spectroscopic techniques. Experiments were conducted on Wistar rats for evaluating the bone healing properties of each extract as well as isolated secondary metabolites. Two extracts gave a good response for bone healing properties during animal experiments

(CT_HU value range: Control: 605.8; Ethyl acetate extract: 847.8; Alcoholic extract: 921.3).

Library strengthening

The Library Strengthening grants to the tune of ₹ 31 crore were utilized to digitize, strengthen and modernize the university and college libraries services. University libraries and colleges were automated through KOHA and other softwares. Installation of KOHA was supported in 56 libraries. The Web-OPAC through e-KIOSK helped students and faculties to locate the books and journals etc. Self check in/ check out Kiosks were made available to library users. University library provided Web-OPAC to all component colleges, KVKs and research station, and IDEAL facility was made available. As many as 20 Agricultural Universities implemented the RFID technology in the library for enhanced security and library in house operations such as self check in and check out and stock verification. Text/ reference/e-books/ encyclopedias etc. were added. The support from Council under this component, helped the agricultural universities to enrich their resources by adding about 267,381 print books, 90,096 e-books, 363,034 e-journals, and 531,573 print journals across universities. The AUs also installed more than 2,500 new computers to enable easy access to the various resources. Under e-Granth, the KrishiKosh and IDEAL were supported.



Strengthened facilities at the Library

At present KrishiKosh has more than 30 million digitized pages in more than 125,000 digital items (volumes) like old books, old journals, reports, proceedings, reprints, research highlights, training manuals, historical records. More than 75,000 thesis are submitted at KrishiKosh by various SAUs/ Institutions and value addition was done by making theses full Text searchable. Agrotags were integrated for semantic search. At present, 65 State Agricultural Universities / Deemed University under ICAR are the partners in KrishiKosh repository. The KrishiKosh repository was viewed by 178 countries worldwide with more than 4,095,452 users access this repository during the reporting period. Mobile Application for KrishiKosh (version 2) was developed and was downloaded by more than 3,000 users. It is a 24 × 7 online availability of huge NARES content/ knowledgebase on a digital platform.

Infrastructural and curriculum development support

The support under this component continued during the reporting period for renovation and refurbishing of old existing structures, with emphasis on improving the condition of student hostels across Agricultural Universities (AUs). Support of ₹ 341.52 crore was provided under the component strengthening and development of AUs during the year. In 2018–19, infrastructure pertaining to student amenities has been strengthened with support for 29 new student hostels, teaching facilities enhanced with support for 62 smart classrooms and 14 new examination halls. Three new auditoriums and two educational museums are also being supported in various AUs.

Across the country, AUs are being supported to design and implement comprehensive Quality Improvement Programs, to bring about overall changes in capacity building of faculty, revision of course curricula, learning materials, learning processes, learning outcomes, assessment and monitoring systems, to ensure that the quality of higher agricultural education and learning is improved. Smart classrooms, with most up to date audio visual aids, enabled effective delivery of course curriculum, ensuring enriched learning experience.

Computer lab for students

PG Laboratories upgraded with Council's support

Boys hostel, SKUAST, Jammu | Girls' hostel, Dr YSPUHF, Solan | Girls' hostel, JNKVV, Jabalpur

Central instrumentation facilities have been encouraged and equipped preferentially across AUs. The upgradation of UG and PG laboratories improved both PG student research and practicals. Communication labs helped in improving the language skills of the students as per requirements. For increasing awareness in latest techniques and research in cutting edge areas, support was provided for student and faculty amenities/ tours/capacity building and participation in seminars, symposia, workshops, trainings, etc. Practical manuals were developed in various subjects.

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

New initiatives by Agricultural Education Division

- Ranking, Grading of the university based on score card and accreditation to be linked with the financial support.
- The amount of scholarships and number of students availing these scholarships have been enhanced.
  - Number of ICAR PG Scholarships enhanced from current 475/year to 600/year and the fellowship amount for the same enhanced from ₹ 8,640/month to ₹ 12,640/month/student.
  - It was also recommended that all Ph.D. admissions in Deemed to be Universities of ICAR including Indian Agricultural Research Institute (IARI) may be made through AIEEEA examination conducted by the Council. Hence, number of JRS/SRS-PGS Scholarships increased from the present 202 to 300 from the year 2018–19.
  - Junior/Senior Research Scholarship-PGS brought at par with DST Fellowships. Therefore, it is proposed that the amount of scholarship may be enhanced from current ₹ 15,000/month during the first two years and ₹ 17,500/month in the third year of Ph.D. to ₹ 25,000/month for the first two years and ₹ 28,000/month in the third year of Ph.D. including Veterinary Sciences discipline.
  - The amount of National Talent Scholarship for Undergraduate (NTS-UG) enhanced from existing ₹ 2,000/month to ₹ 3,000/month.
  - The amount of National Talent Scholarship for Post Graduate (NTS-PG) enhanced from existing ₹ 3,000/ month to ₹ 5,000/month.
  - The amount of scholarship under Merit cum Means is proposed to be enhanced from existing ₹ 500/month to ₹ 1,000/month at par with the amount awarded by other Ministries.
  - The amount of scholarship under Post Matric scholarships for SC/ST enhanced from ₹ 300 month to ₹ 1,000/month at par with the amount awarded by other Ministries.
  - The internship allowance for final year students of B.V.Sc. and AH enhanced from existing ₹ 400/ month to ₹ 3,000/month per student for the period of maximum six months at par with 'Student READY' programme of ICAR.

Strengthening and quality assurance of higher agricultural education through active coordination: The annual Vice Chancellors' meet is conducted to actively review, refine and strengthen various programmes implemented by the Education Division of ICAR. For maintaining uniformity in governance and financial management System, comptrollers of the agricultural universities were sensitized on 15–16 June 2018. The agricultural universities were requested to appoint the nodal officers specifically for streamlining the utilization of funds from Education Division and timely submission of various reports and UC/ AUCs. The annual meet of nodal officers was held on 4–5 May 2018, Port Blair, for smooth coordination of all the activities. The annual meeting of coordinators of Experiential learning programme was held on 25–26 May 2018 at Dr YSPUHF, Solan, for effective implementation of the modules supported by the Council.

Librarians from across the AUs were invited for two-day workshop-cum-meet on 2–3 July 2018, JAU, Junagarh. The librarians were informed about the support under the scheme for digitization and connectivity of libraries, available e-resources, new demand submission proforma, format for the submission of annual impact report, in addition to the presentations by the librarians of the well-developed automated libraries.

ICAR-National Academy of Agricultural Research Management

Capacity building programmes (54) organized during

the reporting period, benefitted 2,495 trainees, which also includes 988 Massive Open Online Course (MOOC) participants. The flagship programme of the Academy popularly known as Foundation Course for Agricultural Research Services (FOCARS) was organized twice—once in July 2017 and another in January 2018, and had 84 newly appointed ARS scientist probationers. The two Foundation Courses for Faculty of Agricultural Universities (FOCFAU) which were designed in the same line of FOCARS, but for one-month duration had 102 participants. In-house and externally funded contract research projects were 16 in number each. The Academy was able to take two consultancy projects. MoUs were signed with Indira Gandhi National Forest Academy (IGNFA), Dehradun; Administrative Staff College of India (ASCI), Hyderabad; and Tata Institute of Social Sciences (TISS), Hyderabad.

NAARM is one of the consortia partners of 'Farmers FIRST' initiative launched by ICAR. The Academy was involved in the capacity building activity and organized several workshops. A unique workshop and first of its kind—'Let's listen to Farmers'—was also organized to collect feedbacks directly from the farmers. Two hundred delegates including about 143 farmers from 25 states participated in this workshop.

The Academy houses Centre for Agri-Innovation (CAI), which provides hand-holding support to the agri-business incubators by inter alia developing modules, guidelines and other forms of learning materials. Till date, 36 incubatees have been inducted and out of that 13 have already graduated.

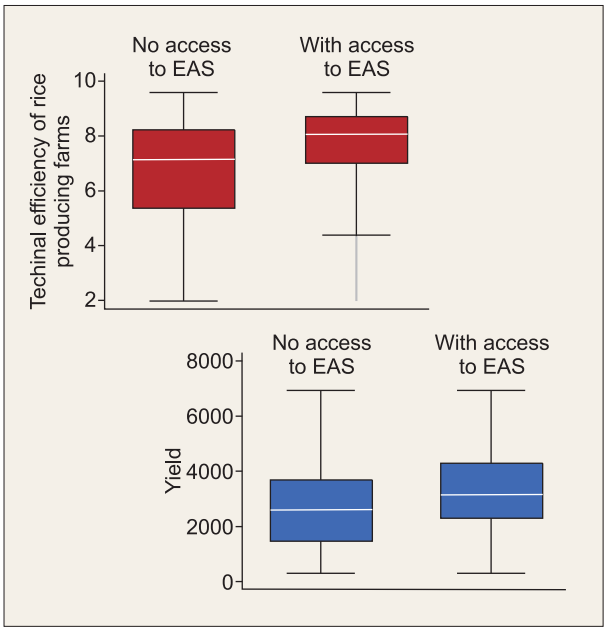
❑

12. Social Science

Agricultural economics and policy

Market linkages and price triggers in onion: Among the 'TOP' (tomato, onion and potato), which are identified as price sensitive commodities, onion remains the vulnerable commodity with instability of 49.3% during 2011–16. Maharashtra is the biggest onion-producing and marketing state in the country. Maharashtra, Madhya Pradesh and Bihar are the *rabi* dominating states while Karnataka, Andhra Pradesh, Rajasthan and Gujarat *kharif*. In Maharashtra and Madhya Pradesh, *mandi* remains the most important destination for selling onions. The response of major consuming and producing markets owing to price shocks in producing markets is given in Box 1. Lasalgaon, Bengaluru and Solapur remain the most influential producing markets causing the change in consuming markets besides their own influence. Pimpalgaon and Bengaluru are the most important markets influencing Indore, Lasalgaon, Mahuwa, Patna and Pimpalgaon besides their own influence. Pimpalgaon and Lasalgaon are the most important primary markets dealing with *rabi* onion. Bengaluru dominates in *kharif* onion supply and transmits the signals accordingly. Thus, market surveillance needs to be given a priority to control any imperfections and malpractices arising due to advance signals. Market intelligence can help objectively examine the extent of price influences as markets are highly co-integrated with each other and price signals are transmitted from one market to the other.

Access to extension and advisory services and rice productivity in Eastern India: Improving agricultural productivity has always remained as a key strategy for achieving food security and rural development agenda. A study was done to assess the access to Extension and Advisory Services (EAS) and its effects on technical efficiency and productivity of rice producing farms in Eastern India. The study area



Technical efficiency and productivity of rice farms with reference to EAS access

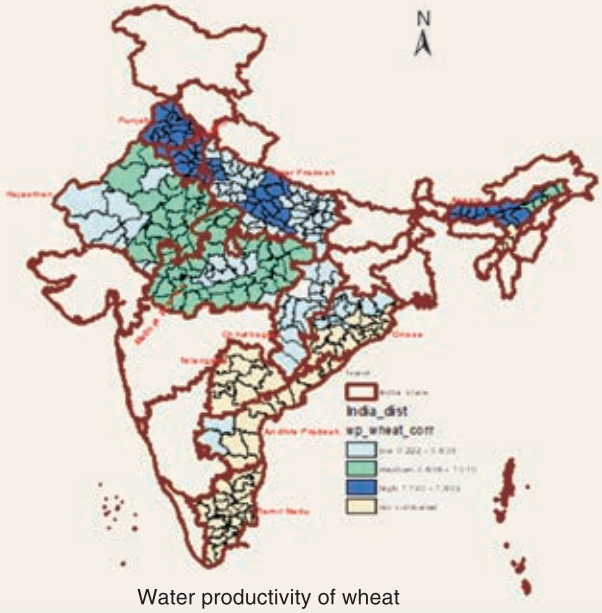
Price influence among major onion producing and consuming markets

Zone	Major onion producing states	Major onion markets	Producing markets								Consuming markets			
			Bengaluru	Indore	Lasalgaon	Mahuva	Patna	Pimpalgaon	Pune	Solapur	Chennai	Delhi	Kolkata	Mumbai
Central	Madhya Pradesh	Indore												
North	Bihar	Patna												
South	Karnataka	Bengaluru												
West	Maharashtra	Lasalgaon												
	Maharashtra	Pimpalgaon												
	Maharashtra	Pune												
	Maharashtra	Solapur												
	Gujarat	Mahuva												

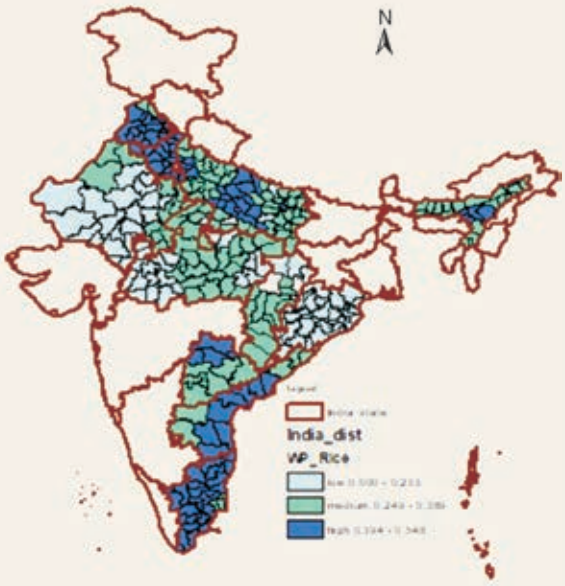
Only positive response and other influencial markets have been considered. Major response | Least response | Not responsive

Estimation of water balance, footprints, crop water productivity of rice and wheat in India: A disaggregated analysis at agro-climatic zones level

Water balance across agro-climatic zones of 11 selected states in India was estimated and water footprints and crop water productivity of major cereals, viz. rice and wheat were mapped using secondary data. The water footprints of a crop is divided into green (rainfall) and blue (irrigated) components. The findings showed that western dry region of the country is facing highest irrigation water deficit requiring immediate attention shift in cropping pattern towards less water requiring crops. Total virtual water contents are higher in eastern region, blue virtual water contents are significantly low as compared to irrigated north-western states. Water productivity of wheat is ranging from 0.2 to 1.8 across the zones. Scarce rainfall zone (Andhra Pradesh), North central plateau (Odisha) and arid western zone (Rajasthan) are the least water productive while North bank plain zone, lower Brahmaputra valley zone (Asom) and western plain zone (Punjab) are most water productive in wheat. However, in rice, the maximum productivity is limited to 0.55. The highest water productivity in rice was noticed in central Barak valley zone of Asom, high rainfall and hill zone of Tamil Nadu and western zones of Punjab, while the least water productive zones was Bundelkhand of Madhya Pradesh. The study advocates to incentivize farmers based water productivity of the crops in these regions. It can serve as a powerful advocacy tool that can support policy development, decision-making and for developing sustainable crop plans.



Water productivity of wheat



Water footprints of paddy

included Bihar, Odisha, Uttar Pradesh (Eastern part) and West Bengal. The findings indicated that 22.74% of rice farming households in the selected region had direct contact with different EAS sources. Out of this, 7.61% of rice farming households had access to public sector EAS, 10.11% to private sector EAS (Agri-business firms and input dealers) and 5.01% to both types of EAS. The study on effects of EAS access on rice productivity indicated that there was a significant difference in yield of rice between farms that had access to EAS and those who did not have access to EAS. As productivity increase can be achieved through technological progress as well as efficiency, a stochastic frontier production was estimated with the inclusion of EAS variable in it. The access to EAS, irrespective of the source, reduced the technical inefficiency of farms (through best use of existing technologies or inputs). Average technical efficiency of farms with EAS access was 9.34% higher than the farms without access to EAS. It helped in educating farmers regarding the efficient use of available technologies or inputs, which is further translated into improved productivity of rice. Hence, there is a need to improve access to EAS in the region to further reduce the agricultural productivity gap.

Organic product value chains (ginger): India attained first rank in producing ginger of 0.655 million tonnes (30%) out of global production of 2.15 million tonnes in 2014–15. Among all spices, ginger is the main cash crop supporting the livelihood and improving the economic level of many ginger growers of north eastern region. Ginger is grown in almost all the states of the region but the leading states are Meghalaya, Mizoram and Arunachal Pradesh. A large number of tribal farmers still practice the traditional methods of cultivation, which are generally eco-friendly, less expensive, and utilize organic inputs, local resources, knowledge and labour. The total area under this crop in NE region was 43.54 thousand ha and production was 275.35 thousand tonnes. The north-eastern states account for about 26.61% of total area and 24.82% of the total ginger production of the country.

Micro-irrigation in Indian agriculture: Coverage and impact: *Pradhan Mantri Krishi Sinchayee Yojana* (PMKSY) launched in 2015–16, led to increase in total area under micro-irrigation to 8.6 million ha (Mha) in 2016–17. Rajasthan having the highest area under micro-irrigation and leading in adoption of sprinkler

Changes in cropped area and yield of crops after adoption of sprinkler irrigation

Crop	Cropped area (ha)		Difference	Average yield (q/ha)		Difference
	Adopter	Non-adopter		Adopter	Non-adopter	
Kharif						
Groundnut	3.71		–	30.5		–
Gwar	3.36	2.37	0.99 (41.8)	13.54	11.74	1.80*** (15.3)
Moth	2.70	2.70	0.0	11.48	8.80	2.68 (30.5)
Bajra	2.64	1.16	1.58** (149.1)	11.76	8.33	3.43** (41.2)
Moong	2.90	1.80	1.10 (60.2)	9.90	7.24	2.66** (36.7)
Rabi						
Wheat	1.97	1.26	0.71 (56.3)	34.00	32.05	1.95*** (6.1)
Rapeseed and mustard (R&M)	2.36	2.22	0.14 (21.3)	21.35	19.01	2.34*** (12.3)
Gram	4.0	1.13	2.87 (254.0)	17.85	12.47	5.38 (43.1)

Source: Computed from field survey, 2017–18; ***, significant at < 1%; and **, significant at < 5%. Figures within the parentheses show percentage differences.

irrigation contributed about 33% of sprinkler irrigated area in 2016–17. This study analysed the farm level impacts from the Bikaner district of Rajasthan.

Farmers adopting sprinkler system cultivated relatively higher area than their counterparts, and varied across seasons and crops. The increase in cropped area for *rabi* crops varied from 21% in rapeseed and mustard to 254% in chickpea. The increase in chickpea area is attributed to assured irrigation, which is critical for crop growth and good harvest. In *kharif* crops, highest increase in cropped area was observed in *bajra* (149%), followed by *moong* and *gwar*. Adopted farmers started growing high value crops like fenugreek (*methi*) and isabgol for better returns. Yield on adopted farms also increased significantly. Among *rabi* crops, highest increase in yield was for chickpea (43%), followed by R&M (12%) and wheat (6%); while in *kharif* crops, yield increase was highest for *bajra* (41%), *moong* (38%) and *gwar* (15%). The yield obtained on adopted farms was statistically significant than that achieved on non-adopted farms

Structural transformation, regional disparity and institutional reforms in agriculture: The pace of diversification within agriculture was studied in 17 major states for the period 1991–2016. The share of allied sector in total agricultural output was used as a measure of change and the norm of absolute values (NAV) indices were used for this purpose. NAV is measured as half of the sum of change in share between the initial and final years for a given state. The results showed higher level of diversification in Jammu and Kashmir, Tamil Nadu and Andhra Pradesh, with the indices ranging between 0.15 and 0.20. On the other hand, allied sectors contributions were low in West Bengal, Himachal Pradesh, Madhya Pradesh and Asom, i.e. the indices for the states were lesser than 0.05. Despite output growth, the share of agriculture in total output and employment continued to decline. More importantly, there had been an absolute decline of around 55 million agricultural workers, which include farmers and labourers between 2004–05 and 2015–16. Considerable decline in farmers was noted in Uttar Pradesh, Tamil Nadu, West Bengal, Bihar and Rajasthan. Decline of agricultural labourers was notable in Karnataka, Madhya Pradesh, Maharashtra, Odisha and Andhra Pradesh. This withdrawal, together with higher wages in nonfarm sector and the employment guarantee programme MGNREGS, has raised the farm wages significantly. Wage growth has accelerated to 7.6% a year in agriculture during 2005–16, from 3.5% during 1981–2005. The trend could have implications on working expenses in agriculture, resulting in reduced profits. This provides a scope of mechanization in agriculture that would offset the demand for labour.

Classification of various agro-climatic zones with respect to different indices

Components of development	Status of agro-climatic zones		
	Low	Medium	High
Infrastructure security index	2, 3, 5, 7	1, 4, 8, 6, 9, 11, 14	10, 12, 13
Nutritional security index	5, 11, 12, 13	3, 4,6, 7,8 9, 10	1, 2, 14
Economic security index	4, 7, 10, 13	1, 2, 6, 8, 9, 11, 12	3, 5, 14
Environmental security index	4, 6, 9, 13	2, 5, 7, 8, 10, 11, 12	1, 3, 14
Agricultural security index	1, 2, 11, 13	4, 7, 8, 9, 12, 10, 14	3, 5, 6
Sustainable livelihood security index	4, 5, 7, 8	1, 2 6, 9, 10, 11, 13	3, 12, 14

(1) Western Himalayan Region, (2) Eastern Himalayan Region, (3) Lower Gangetic Plain Region, (4) Middle Gangetic Plain Region, (5) Upper Gangetic Plain Region, (6) Trans Gangetic Plain Region, (7) Eastern Plateau and Hills Region, (8) Central Plateau and Hills Region, (9) Western Plateau and Hills Region, (10) Southern Plateau and Hills Region, (11) East Coast Plains and Hills Region, (12) West Coast Plain Hills Region, (13) Gujarat Plains and Hills Region, and (14) Western Dry Region.

Adaptive capacity index (ACI) of Himalayan and Gangetic Plain zones

Agro-climatic zone	Adaptive capacity index
Western Himalayan Region	0.2876
Eastern Himalayan Region	0.5671
Lower Gangetic Plain Region	0.3258
Middle Gangetic Plain Region	0.4369
Upper Gangetic Plain region	0.5413

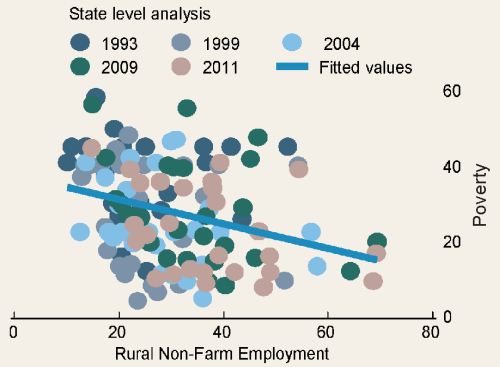
Sustainable livelihood security index for different agro-climatic zones: Changing contours of climatic conditions are posing serious risks to livelihoods of rural poor and small landholders in India. An integrated approach to adaptation strategies is needed, which can encompass farm level adaptation, institutional adaptation, technological adaptation and social adaptation for mainstreaming into developmental framework. Moreover, decentralized mechanism forms an effective pathway for sustainable resource-based planning and adoption of location-specific policy interventions. Using district level data, the study attempted to assess the impact of changes in temperature and rainfall on productivity of major crops for both *kharif* and *rabi* (1966–2011), evaluate adaptive capacity and livelihood sustainability across 14 of 15 agro-climatic zones (excluding Island region) delineated by the erstwhile Planning Commission. A Sustainable Livelihood Security Index (SLSI) was constructed for measuring relative livelihood sustainability of different agro-climatic zones. SLSI was developed using 37 indicators, segregated into five components of development; infrastructure, nutritional, economic, environment and agriculture. Under each component, zones are classified into three different clusters, namely, low (0–25th percentile), medium (26th–75th percentile) and high (76th–100th percentile). The calculated SLSI revealed that zones 4, 5, 7 and 8 need immediate policy interventions to secure livelihoods.

Further, a higher adaptive capacity of a society and the ecosystem may have a positive influence on the adaptation to stresses, and understanding current levels of adaptive capacity may ultimately contribute to improved adaptive management of resources. Moreover, the study identified critical agro-climatic zone-wise major constraints responsible for deceleration in agricultural growth and output. Premised on these barriers, the study illustrated some region-specific adaptive capacity indicators and attempted to estimate the adaptive capacity index (ACI) for the agro-climatic zones of Himalayan and Gangetic Plain Zones. The calculated ACI revealed that Eastern Himalayan Region (EHR) has higher adaptive capacity, whereas Western Himalayan Region (WHR) has lowest adaptive capacity.

Both SLSI and ACI will help ascertain the current development status of the 14 agro-climatic zones and 637 districts, *inter alia* prioritization of adaptation strategies, and policy interventions for augmenting livelihoods and resiliency of vulnerable regions.

Structural change in rural employment and poverty

Rural non-farm employment (RNFE) plays a key role in reduction of rural poverty. The linkage between farm, non-farm and poverty in rural India was studied using different rounds of employment and unemployment data and consumption expenditure data collected by National Sample Survey Organization (NSSO) for the period 1993, 2000, 2004, 2009, 2011. The existing literatures on linkages are inconclusive on what is the major path, which lead to reduction of poverty in rural area. The forward and backward linkages between farm and non-farm sector and its linkages with poverty were explored. The study explored linkages and pathways using Structural Equation Modelling (SEM), which revealed that there exists both forward and backward linkages in farm and non-farm sector, but the backward linkages were weaker. The preliminary results showed that RNFE is a major contributor for reduction in poverty in rural areas.



Rural Non-Farm Employment and Poverty

Agriculture and ecosystem services: The linkages between the production systems, natural resources, environment and social system have now become more prominent to reduce environmental footprints of agricultural development. In particular, understanding of agriculture-ecosystem interactions and trade-offs is essential for considering agriculture and ecosystems in a holistic manner and corrections of those processes, which contribute to negative environmental footprints. An effort was made to collate evidences on ecosystem services, assess role of research and development (R&D) in enhancing them and mainstreaming ecosystem services in the development processes.

Understanding the ecosystem services provided by agriculture, is complex as the interaction between agriculture and its ecosystem is bidirectional. However, these interactions and contributions to ecosystem services vary considerably because of wide diversity in agricultural ecosystems, arising mainly due to differences in cropping systems and environment. Therefore, purpose of the analysis should be to reward ecosystem services and take suitable measures to reduce the dis-services. Understanding of these issues becomes easier when multi-functionality characteristics of agro-ecosystems are taken into consideration and economic, ecological and social dimensions are given due emphasis. Technological interventions to enhance

these ecosystem services are listed below.

Interventions for enhancing ecosystem services

Interventions	Enhanced ecosystem services	Institutional aspect
Sand dunes stabilization	**Provisioning service** • Fodder, fuel, timber **Supporting and regulating services** • Soil fertility, soil erosion control, water conservation, carbon sequestration • Net sown area increase	• Need for partnership with different stakeholders
Conservation agriculture	• Improved soil health • Reduced weather risks • Reduced chemical load • Saving of irrigation water • Lower GHGs emission	• Technologies like micro irrigation, and precision nutrient management • Subsidy on farm machines used for conservation agriculture
Soil and water conservation / watershed management	• Nitrogen accumulation • Phosphorus accumulation • Sediment control	• Holistic systems approach • Institutions for collective actions of all the stakeholders • Technology-driven management system
Biological amendments	• Enhancement in plant growth and nutrient uptake, nodulation and yields; improved soil fertility	• Production and distribution of bio-fertilizers and other agriculturally important micro-organisms

Once the role of ecosystem services is established, it is appropriate to pay to farmers and rural communities *in lieu* of ecosystem services provided by them. This requires development of an institutional mechanism, which is responsive and inclusive in terms of participation of all the stakeholders. The structure of a mechanism may differ depending on the nature of service, but an effective partnership of government, farmers and other stakeholders is necessary for fair distribution of payments. In some cases, like carbon sequestration, a trading mechanism can be designed and implemented at the national, regional or global levels. In others, rewards based on certification of farm practices on area basis or price support could be an option to begin with.

Can wheat crop beat the heat?: The wheat crop is more sensitive to higher temperatures three months prior to harvest, especially at anthesis and grain filling stages (February–April). Trend in heat stress and its consequences on wheat production were examined using a long-series of district-level panel data and also evaluated effects of adaptation measures that farmers follow to minimize its adverse effects on yield. Heat events (defined as maximum temperature being 3°C or more than the normal temperature consecutively for three of more days) in India have become more frequent and intense over-time that is between 1966 and 2011. The probability of occurrence of two or more heat events is uncommon, and also the probability of a heat event to last for a prolonged period, say more than 10 days, is rare. Much of India is prone to heat stress, but the north-western region, where wheat is a dominant crop, is more exposed to heat stress. Heat stress reduces wheat yield by about 3.3%. The negative absolute effect, though, not large has accentuated over time because of rise in yields. Irrigation produces significant adaptation benefits, but its effect has slowed down. In view of the rising heat stress in the plausible future climate scenario, these evidences suggest greater research efforts towards breeding for heat-tolerance, efficient management of scarce water resources, and promotion of innovative crop management practices to improve crop's resilience to heat.

Infrastructure, information and producer prices: Poor transport infrastructure and asymmetry in information restrict farmers from accessing remunerative markets and create opportunities for rent seeking by informal buyers, i.e. local traders and middlemen. An analysis of data from the survey on *Situation of Agricultural Households in India* conducted by the National Sample Survey Office in 2012–13 showed that smallholder farmers are more dependent on local traders and input dealers as outlets for their produce (paddy and wheat) because of the higher transportation cost in relation to the volume of sale, and lack of information on the market conditions. Small farmers also avail inputs and credit from them against their commitment of sale of produce as collateral. In general, the prices that smallholder farmers receive from informal channels are lesser than the minimum support prices. The larger and more-informed farmers, on the other hand, sell most of their produce to government agencies and to licensed traders and commission agents in the regulated markets and they receive higher prices from sales to them. Further, farmers also receive lower than the government-set minimum support prices from sales to traders and commission agents in the regulated markets. Nonetheless, infrastructure and information play in empowering farmers to bargain better price terms from informal as well as formal market channels. The effect of information on producer prices is relatively

stronger compared to that of road infrastructure. However, when access to roads is combined with access to information, the effect on producer prices becomes stronger. These findings have important implications for agricultural policy. The policy should focus on improving efficiency of agricultural markets and their outreach by investing in transportation infrastructure that reduces cost of trade for both farmers and traders. Improvements in markets need to be accompanied by development of market information systems to reduce asymmetry in information between farmers and traders. Finally, the financial institutions need to improve their outreach to smaller farmers to reduce their dependence for credit on local traders and input dealers who often tie it with output sale and extract rent by paying lesser than the market price.

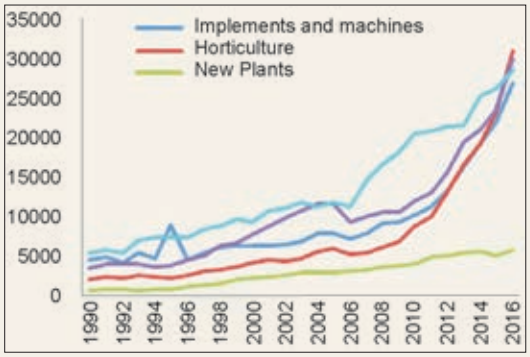
Statistics and computer applications

Education portal: Education Portal-ICAR (https://education.icar.gov.in) is a single window platform for providing vital education information/ announcements/ event schedules/e-learning resources from Agricultural Universities across the country to the rural youth in an easy and fast way on their doorsteps. Portal is being used by Education Division, ICAR for data management of Annual reports, financial sanction and release of funds on the basis of online demand and relevant data submitted by Universities.

It also provides link and covers vital information of Agricultural universities for the benefits of students; Provides information about Courses (Bachelor, Master and Doctoral), Facilities, Student Strength, Faculty Strength and Scholarships; Provides Admission Announcements uploaded by universities under "Notifications" at the central place. Provision for generation of Unique Student ID (USID) by the universities/colleges is displayed university-wise under the link USID. It will ensure the uniqueness corresponding to the student records in various academic processes and associated online systems. Provides access to Academic Management System developed by ICAR-IASRI and operational at Deemed and Central Universities of ICAR. Portal also provides links to other resources/sites important in the arena of Agricultural Education.

Technology foresight in agriculture

In the last decade (2006–16), 7.4 lakh patent applications were filed by 40 major countries under various sub-categories in agriculture. Maximum number of patents were filed under the category of chemicals and fertilizers, followed by animal husbandry, horticulture and new plant materials. In the last decade, the compound growth rate of cumulative patent filed in agricultural sector in India was 12.5%, which was higher than the growth rate of global total (11%). The growth rate of China was almost double (25%) than that of India in the same period. India should also increase investment in R & D, reform economic policies and state support for patent filing to be globally competitive in agricultural sector.



Global patents trends in agriculture

Pashu-prajanan (Animal-Reproduction) and sukar-palan (Pig-Farming) mobile applications: IVRI-Pashu-Prajanan (Animal Reproduction) App, is targeted to impart knowledge and act as a ready reckoner for the Graduating Veterinarians, Field Veterinary Officers and Livestock Entrepreneurs about reproductive diseases/disorders in cattle and buffaloes and measures to treat and control them. Presently, the app provides information in eight languages, viz. Hindi, English, Punjabi, Bengali, Assamese, Gujarati, Tamil and Malayalam. The App is available on Google Play Store for free.

Skukar-Palan (Pig Farming) App was developed to impart scientific knowledge and skills to the Graduating Veterinarians, Field Veterinary Officers, Developmental Organizations and Entrepreneurs for promoting commercial pig farming. This is an educational App providing information on about all the aspects of scientific pig farming. The App also provides information about various centres in the country from where the entrepreneurs can procure pigs/piglets of specific breeds. The App additionally provides support for development of commercial pig farming projects of various sizes. Further, it will also help the livestock entrepreneurs to market their pigs and piglets. The Pig Farming App is a complete guide for the

establishment of a pig farm on scientific lines in the country. This App is developed for Android platform. It is available on Google Play Store for free. Presently, the app provides information in Hindi and Punjabi.

Estimates of poverty incidence at district level: Information about the incidence of poverty is a crucial parameter of the population for policy analysis and decision making. A poverty map showing the spatial inequality in distribution of poverty incidence in different districts of Bihar was produced. This type of map is a useful aid for policy planners and administrators charged with taking effective financial and administrative decisions that can impact differentially across the region.

R package or AoptBDTVC: It was developed to implement the algorithms for construction of A-optimal BTIB, GDT, BBPB and weighted A-optimal BTIB designs. The package is available on **cran.rproject.org/web/packages/Aoptbdtvc/index.html**.

Applications: A web based application for obtaining first and second order orthogonal Latin hypercube (OLH) design-constructed using the proposed method of construction was developed. Methodology for the construction of OLH designs with good space filling property was developed. Several new designs obtainable from the methods of construction were also obtained. A module was deployed for obtaining Latin Hypercube (Orthogonal/Nearly Orthogonal) design with good space filling property.

For Forecasting of spatio-temporal time series data using Space Time Autoregressive Moving Average (STARMA) model, STARMA-Genetic Algorithm (GA) and STARMA-Particle Swarm Optimization (PSO) models were developed and found to be better over the existing models. An improved STARMA model was developed by including spatial heterogeneity among locations using inverse distance weightage derived from Euclidean distance of Riemannian great circle; this performed better as compared to univariate ARIMA and classical STARMA models. Formulae for two step ahead out of sample forecasts of STARMA model was derived analytically by recursive use of conditional expectation.

Wheat yield data of Araria district in Bihar was fitted using usual Regression, LASSO, GARCH, and GARCH using weather variables. GARCH using weather variables provided a better fit to the volatile yield data under consideration. Forecasts were carried out for yield data of wheat along with weather variables. ARIMAX model was used with weather indices as the exogenous variables. ARIMAX provided an improved forecast in comparison to usual ARIMA and regression methodology.

HRGPred: A software for prediction of herbicide resistant genes (**http://webapp.cabgrid.res.in/hrgpred/**) was developed. The evolvement of herbicide resistance is a major cause of concern for sustainable agricultural production. As far as target site resistance is concerned, seven classes of target proteins have been reported so far. A computational tool HRGPred, that can be used for predicting the genes encoding for the seven categories of target proteins, was developed. HRGPred will supplement the wet-lab experiments for annotation of herbicide resistance genes.

GSAQ: An R package was developed for Gene Set Analysis with QTLs (**https://cran.r-project. org/web/packages/GSAQ**). The GSAQ approach provides a valuable platform for integrating the gene expression data with genetically rich QTL data.

Improved recognition of Heat Shock Proteins (ir-HSP): Heat shock proteins (HSPs) are one of the largest groups of molecular chaperones that assist in correct folding of partially folded or denatured proteins, establishment of proper protein conformation and prevention of unalterable aggregation of damaged proteins. HSP have received a considerable attention of the researchers. This server was developed for prediction of HSPs, their families and sub-types of DnaJ proteins. The ir-HSP achieved higher accuracy as compared to the existing approaches, and thus believed to supplement the existing efforts for annotation of protein sequences.

Prediction of nitrogen fixation genes (http://webapp.cabgrid.res.in/nifPred/): Biological nitrogen fixation, an important biogeochemical process, plays a major role in conversion of atmospheric nitrogen to ammonia. The nifPred is the computational tool for identification of nitrogen fixing proteins, viz. nifH, nifD, nifK, nifE, nifN and nifB.

Pearl millet drought transcriptome database (http://webtom.cabgrid.res.in/pmdtdb/): It catalogues the information related to assembled contigs or transcripts, DEGs, the pathways in which these are involved, detailed SSR markers, and variants. Web pages are developed for browsing the database along with the queries by user in client tier.

Transcriptome database of seasonality associated genes in *Labeo rohita* (http://webtom.cabgrid.res.in/lrsatdb/): It catalogues tissue wise transcripts/contigs, putative SSRs, SNPs, Indels, transcription factors, miRNA targets representing two reproductive phases (IGA and PSR) of the carp fish.

Wheat drought root transcriptome: An online relational database of wheat drought transcriptome was developed which catalogues differentially expressed genes, miRNAs, transcription factors, KEGG pathways along with markers (SSRs, SNPs and InDels). This genomic resource can be accessed at **http://webtom.cabgrid. res.in/wdrotdb/**.

Guidelines for estimating post-harvest losses of agricultural products: Three guidelines for estimating post-harvest losses of fruits and vegetables, meat and milk and fish were developed, and FAO, Rome, accepted these. Field testing of these guidelines will be done in Mexico, Zambia and Finland/Philippines. Classroom and field training was imparted to the nodal officers and enumerators for field testing on post-harvest losses of fruits and vegetables (primary data collection) in Mexico and of livestock products (meat and milk) in Zambia. Pre-testing of questionnaires was done for

both the commodities before starting the data collection work in respective countries. Data collection is being carried out using CAPI method. Food Loss Index (FLI) for India has also been obtained as one of the objectives of this study.

Estimation of area and production of horticultural crops: Suitable sampling methodology for estimation of area and production of horticultural crops was developed, tested and validated. The study was carried out in Andhra Pradesh, Tamil Nadu, Maharashtra and Himachal Pradesh. Data Entry software and Data Analysis software were developed to implement this methodology. The survey needs to be conducted in all high productive districts within a State and no survey is required in less productive districts. The estimates of area and production for less productive districts may be obtained using suitable models. Area under the crop is the key factor in estimation of production and hence needs to be estimated more accurately. It is advisable to issue the necessary instructions to the Patwaris/ Talhattis/Village Accountants through District Magistrate/Collector for recording crop-wise area under fruits/vegetables. Recording of crop-wise area under fruits/vegetables will solve the problem of area estimation and in turn will lead to the more reliable estimation of production. This will also reduce the cost of survey for area estimation and save the time significantly.

State level estimates of crop area and production (reduced sample sizes): Suitable sampling methodology was developed for obtaining State level estimates of area and production based on reduced sample size. Study was conducted in Asom, Odisha, Uttar Pradesh, Karnataka and Gujarat. The project was initiated for precise estimation of crop area and yield at district level from a sample size of less than 2% of the total number of villages in a state. The proposed methodology and the sample size proved to be sufficient for crop yield but where there is some problems while construction of the frame and few other non-sampling errors, it increased the Standard Error of the estimates to certain extent for crop area estimation. A data entry software was also developed to digitize the survey data collected under this study. The software is a standalone software which works offline. A Mobile Assisted Personal Interview (MAPI) software was also developed for collection of survey data using android smart phones. The MAPI software was implemented successfully in two districts of Uttar Pradesh and one district of Gujarat. Development and implementation of MAPI software under the project was very efficient.

Women empowerment

ICAR-Central Institute for Women in Agriculture (ICAR-CIWA) is the prime research institute mandated to carry out research exclusively on gender issues in agriculture. The institute implemented several institutional research projects, which generated gender related information and knowledge, which have the potential of benefiting different stakeholders including farm women.

Extension systems, grass-root institution and capacity building: For engendering agricultural research and extension, technologies/ methodologies (547) were collected from different ICAR Institutes, SAUs, and AICRP on Home Science centres. Out of the above, 138 technologies were found suitable for farm women, which were further categorized both state-wise and discipline-wise. More than 100 different agriculture related problems of farm women were identified to create an expert system. Gender sensitive materials were also collected to develop gender-sensitive lab to sensitize various stakeholders for engendering agricultural research and extension. The portal was further restructured and updated with the latest publications and 189 technologies/ methodologies related to women in agriculture. A dynamic database on technologies for farm women was developed.

An attempt was made to map livestock and gender and study the role of institutions in livestock development in Eastern India. The district-wise analysis of indicators of gender and livestock revealed that there were 198.1 million females in eastern states (34% of India) and out of which 66.9% are agricultural workers. The region has 40.1% of cattle of India, 18.1% buffalo, 38.7% goats and 49.3% pigs. The eastern states have varied indicators related to gender among the states and also the indicators related to women in agriculture. Similarly, the livestock development also did not show a uniform pattern and the preferred livestock species are different in different states.

Livelihood and socio-economic policy of food and nutritional security: For enhancing the livelihood of farm women with emphasis on doubling farmers' income, activities were carried out in Khorda and Puri districts of Odisha. Field level studies were taken up for identifying the gendered scope of doubling family income and an action plan was developed. Technological support in the form of critical inputs and drudgery reducing farm tools were provided to the stakeholders along with advisory services. A cluster of farm women

was mobilized from seven villages in Nimapara block of Puri district for the formation of farm women Producer Company for enterprise development on mushroom cultivation.

An attempt made to identify status of malnutrition in Odisha, clearly showed much lower haemoglobin level and BMI of respondents in Semla, Umerkote block. To enhance the protein consumption of the selected farm families, a high yielding variety of black gram (var. PU 31) was introduced in the village for cultivation during the *rabi*.

Technology assessment and refinement: To increase the livelihood of farm women, small-scale mango orchards and to ensure their participation, intercropping of pineapple and cucurbitaceous vegetables in inter-row spaces of mango orchard were introduced in a participatory action mode. Different capacity building programmes were also conducted in farmers' fields. Exotic fruit crops like apple, ber and dragon fruit were introduced and planted in mango orchards at the Institute's experimental field for evaluation.

Three peri-urban areas of Odisha, i.e. Jagatsinghpur, Cuttack and Puri were selected for peri-urban dairy farming. Over the last two decades, milk production in Odisha has increased from 5.8 lakh metric tonnes (LMT) in 1994–95 to 19 LMT (2014–15).

The farm women were given hands on training on stocking procedure of fingerlings, application of lime for maintaining the pond water quality, supplementary feeding of the stocked fishes etc.

An initiation was made to promote gender equity through family poultry production. The effect of dietary substitution of maize with cassava root meal on production performance and egg quality of Vanaraja laying hens were studied. There was no significant effect of different protein levels on hen-housed egg production (HHEP), egg weight, and egg mass/ day and feed efficiency during the entire experimental period.

Distribution of fingerlings of small indigenous freshwater fishes to homestead pond owners

Study carried out to identify the goat rearing practices, revealed that the management practices of goats are regulated by women and marketing linkage, benefits of government policies and goat schemes are controlled by men only. However, major expenditure from the selling of goats is made by joint decision of men and women. Field trial of 4 months duration showed significant improvement in growth rate of male kids by feeding supplemental protein through groundnut oilcake along with mineral mixture.

Agricultural Research Data Book (ARDB) 2018

The ARDB-2018, the twenty-first in the series was published. It has 173 tables on different aspects like 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). It contains National level data, state-wise data on area and production of seven food grains including rice, wheat, jowar, bajra, maize, pulses, oilseeds; area and production of five fruit crops, viz. mango, banana, sweet orange, apple and papaya; area and production of three vegetable crops, namely, 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.

Drudgery and vulnerability: For reducing the drudgery of farm women in field preparation activities. The prototype of the disc type ridger was developed. An integrated floating cage aquageoponics system (IFCAS) for small-scale women pond holders was designed, which can be used in ponds without adversely affecting the natural pond environment

For empowering women farmers through the promotion of gender friendly farm equipment and to reduce the women's drudgery in paddy, *ragi* (millet) and vegetables based farm operations, one block from each district (Koraput and Mayurbhanj in Odisha) was selected for suitable intervention. Demonstration of the farm tools and implements was organized for familiarizing with the operation, repair and maintenance of tools. The SHGs were provided a range of support such as on-farm skill demonstration by experts, refresher trainings at the cluster level, interactive session with scientists, and advisory on troubleshooting, etc.

Farm demonstration

Achievements of AICRP on Home Science

The AICRP focused on gender mainstreaming and empowerment of rural women, drudgery assessment and mitigation, nutritional security and dietary approaches for addressing non communicable diseases, parenting and reproductive health, sustainable livelihood security of rural families through locally available natural resources and capacity building of agrarian families to adopt different IFS models for facing climate related issues and digitization of knowledge products for rural families.

For prevention of diabetes, 112 region-specific food items were developed having low glycemic index (GI) and 40 recipes were modified with low GI ingredients and higher amount of fibre. Two multigrain RTU mix per centre were developed for the management of over-nutrition and undernutrition among farm women.

Paddy thresher, vegetable sapling transplanter were introduced in paddy and vegetables production system. Grain picker was also intervened. Workstation for jaggery processing unit, collection tool for drying bagasse and trolley for transporting bagasse were introduced to the women involved in jaggery production to reduce drudgery and work efficiency of farm women.

Extension systems, grass-root institution and capacity building/ livelihood and socio-economic policy

Farm women knowledge groups (FWKGs) were formed under the Extension and Communication component to empower farm women on climate change.

Studies were undertaken on underutilized identified plant sources for functional finishing of textile fabrics for antimicrobial/ insect repellency and/or UV protection for comprehensive use of underutilized natural fibres and sustainable livelihood of farm families. Fibre extraction protocol from 10 different sources was standardized, and 57 plant sources were selected for the application of herbal functional finishes from different agro-climatic areas (ten centres) for utilization of renewable plant sources and agro waste for herbal functional finishes. An attempt was made for popularization and product diversification of ethnic crafts on textiles with ICT application.

Intervention packages were developed to improve levels of psychological well-being, reproductive health knowledge and maternal and child health knowledge of rural women. Knowledge level on reproductive health, maternal and child health and psychological well-being of the respondents were studied in ten centres. Knowledge level on reproductive health revealed that average knowledge on reproductive health was found among majority of women from the centres like Hisar (97.7%), Pantnagar (63%), Udaipur (40.66%), Parbhani (95.66%) and Dharwad (56%). Only in Hyderabad (38%), maximum percentage women were having poor reproductive knowledge whereas in four centres that is Palampur (100%), Jorhat (76.92%), Ludhiana (68.6%) and Tamil Nadu (65%), women were having good knowledge on reproductive health. Regarding the knowledge of maternal and child health among the respondents, it was observed that women from half of the centres, Jorhat (83.69%), Palampur (100%), Ludhiana (77.3%) and Tamil Nadu (52.67%) possessed good knowledge followed by Hisar (87%), Pantnagar (91%), Udaipur (81.66%) and Parbhani (100%) where they had average knowledge. Surprisingly women from Hyderabad (39%) and Dharwad (54.3%) had poor knowledge about maternal and child health.

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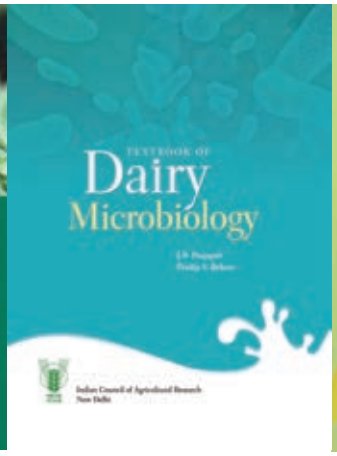
13. Information, Communication and Publicity Service

The Directorate of Knowledge Management in Agriculture is mandated for quick, effective and cost-effective delivery of agricultural information to all the stakeholders in the agricultural sector. With the changing time the Directorate is modifying its methods to showcase the technologies, policies and other activities of ICAR through different media, viz. print and electronic mode. ICAR website and network connectivity across ICAR institutes and KVKs is designed, maintained and updated by the Directorate. Public relation and publicity support to the council and its constituents across the country is provided by the Directorate. DKMA is part of the showcasing of impact analysis of the Farmers FIRST project through print as well as social media.

Knowledge and information products

The Indian Journal of Agricultural Sciences and *The Indian Journal of Animal Sciences* the flagship monthly research journals of the Council, are available in open-access mode (hhttp://epubs.icar.org.in/ejournal). The in-house journals like *ICAR Reporter* and *ICAR News* are also posted on ICAR website, Special issues of the *Indian Farming* were brought out on Arid Agriculture (Sep 2018), World Food Day 2018 (October 2018), and Weed Management (November 2018). The special issue of *Indian Horticulture* was on Arid Horticulture. During the year under report, three special issues of *Kheti* were brought out, viz. 70 years of *Kheti*; Doubling of farmers' income; and Small millets. Popular magazines of ICAR were reoriented to make these demand-driven and competitive. To share the agricultural knowledge and information through value added information products in print, the DKMA has brought out 10 books in English and 3 books in Hindi. More than 140 textbooks are in process under UG/PG Level textbooks programme for the Agricultural Universities, as these are written as per the syllabus of the V Deans' Committee Report. 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. Trainings on 'Online article processing', 'Technical writing', 'Role of Reviewer in quality research journals', 'Book writing' and 'Success Stories' were conducted. One month training programme on Publication Production Management was organized. Students were exposed to all publication aspect like editing, proof reading, typesetting, printing and production, sales and marketing in the training programme.

The e-books were also brought out and copies of the electronic CDs were distributed among farmers in the meetings and rallies of the Union Minister for Agriculture and Farmers Welfare. The ICAR web page 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://epub.icar.org.in/ejournal. The Directorate has facilitated



online access to 2,000 journals from a single subscription in more than 123 libraries under CeRA project of NAIP. During 2017 Business Unit has achieved the target of ₹ 65 lakh through sales of ICAR publications. Business Unit participated in major agricultural and science related events for distribution of ICAR publications and showcasing ICAR publications to agricultural community.

Social media

The ICAR website was updated on regular basis, 1,375 new pages were created, and total number of page-views 13,292,897 from 221 countries visited the website from across the globe; the top five countries include India, United States of America, United Kingdom, Union Arab Emirates, and Nepal. DARE website received GIGW certification in 2018. The website is updated regularly. *E- Krishi Manch*, a web based public utility, is a public-connect platform for stakeholders in more efficient, quick and simple manner by direct approach. This website has 5775 registered users. ICAR facebook page https://www.facebook.com/InAgrisearch/ has 170,730 likes and 171,147 followers. On an average one post is uploaded to ICAR facebook page every day. ICAR twitter handle https://twitter.com/icarindia has 36.5 K followers. On an average one tweet is posted every day. Till date, 1,865 tweets have been posted. 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. ICAR YouTube channel has 184 videos and 29,898 subscribers.

Agricultural Knowledge Management

Agricultural Knowledge Management Unit (AKMU) of Indian Council of Agricultural Research undertakes management and maintenance of ICT infrastructure which includes Gigabit-speed wired and wireless network in premises of ICAR at Krishi Anusandhan Bhawan-1, Krishi Anusandhan Bhawan-2 and National Agricultural Science Centre Complex. An e-Publishing system developed and implemented in-house is hosted in secure network center of ICAR at KAB-1, Pusa Campus, New Delhi. The e-publishing system is used by readers, authors and research reviewers globally from 184 countries, 24×7, through Internet for accessing and publishing research in ICAR's research journals. Two new online journals namely *Journal of Sugarcane Research* and *Journal of Community Mobilization and Sustainable Development* were hosted online on the e-Publishing portal http://epubs.icar.org.in/ejournal, a unified gateway of research journals of ICAR. Presently a total of forty research journals are hosted. Other important activities undertaken by AKMU were: Management and maintenance of web-based e-Publishing system of ICAR; Development and hosting of "KM portal" with features like updation "High Cost Research Equipment and Service facilities" details by all ICAR institutes, updation of "contact details" online by all institutes/Universities/AICRPs and updation of "e-Transaction details" online by all ICAR Institutes; Technological backstopping provided to thirty six professional agricultural societies' for e-Publishing of their journals using online e-Publishing system developed and maintained by AKMU, ICAR.

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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, National Innovations in Climate Resilient Agriculture (NICRA), Pulses Seed hubs, 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

Technology assessment and refinement is one of the main activities of KVKs to identify the location specificity of agricultural technologies under various farming systems. The details of technologies assessed and refined in different locations are as follows:

Assessment: A total of 3,354 technologies of various crops were assessed in 2,981 locations by KVKs through conducting of 24,976 trials on the farmers' field under different thematic areas, namely cropping systems, drudgery reduction, farm machineries, integrated crop management, integrated disease management, integrated nutrient management, integrated pest management, integrated weed management, processing and value addition, resource conservation technologies, seeds and planting materials production, storage techniques besides varietal assessment for cereals, pulses, oilseeds, fruits, vegetable crops and commercial crops.

In livestock, 656 technology interventions across 842 locations covering 6,818 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 cow, buffalo, sheep, goat, poultry, pig, and fish.

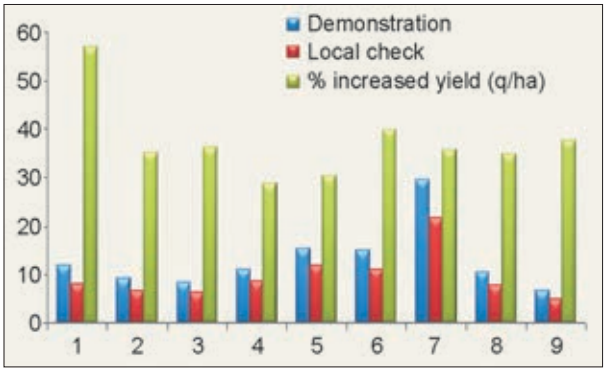
Under enterprises category, 1,562 technologies were tested at 1,709 locations through 9,911 trials. Out of which, 616 technologies were assessed exclusively related to rural women through 5,269 trials in 868 locations. Major thematic areas under enterprises were drudgery reduction, processing and value addition, health and nutrition, energy conservation, small-scale income generation, storage techniques, household food security, organic farming, agroforestry management, mechanization, resource conservation technology. The major enterprises included were mushroom cultivation, vermi-compost production, processing of fruits and vegetables, nutritional garden and rural craft.

Refinement: Total 88 technological interventions were refined across 68 locations by laying out 442 trials in the farmers' fields under different thematic areas, viz. integrated crop management, integrated disease management, integrated nutrient management, integrated pest management, integrated weed management, resource conservation technologies, farm mechanization, post-harvest technology and varietal evaluation. The major crops included are cereals, pulses, oilseeds, fruits and vegetables.

Besides, 18 technological interventions in 21 locations were also refined through 166 trials on livestock, poultry and fisheries under the thematic areas, viz. disease management, evaluation of breeds, feed and fodder management, nutrition management and processing and value addition. Under enterprises, 11 technological interventions in 10 locations refined through 48 trials of which 5 technological interventions were women specific under the thematic areas like health and nutrition, processing and value addition, and mushroom cultivation.

Frontline demonstrations

Cluster frontline demonstrations on pulses: Indian Council of Agriculture Research, New Delhi initiated National Level Cluster Frontline Demonstration (CFLD) on Pulses to demonstrate the production potential of new pulses and oilseed varieties and the related technologies. CFLDs on pulses were conducted on 29,350 ha area in the country involving the major



Overall yield advantage of CFLD pulses over local check

Performance of Green gram var. IPM2-3 : Zone-II (Jodhpur)

Demonstration on Lentil var. IPL-81: Zone-III (Kanpur)

pulses, i.e. *kharif* pulses pigeon pea (3,673 ha), blackgram (3,320.37 ha), green gram (2838.17 ha), horsegram (218.00 ha), rajamsh (79.2 ha), *rabi* pulses, i.e. chickpea (6,842.35 ha), lentil (4,895.46 ha), fieldpea

Chickpea ICM technology with var. NS-1 and NBoG-49: Zone-X (Hyderabad)

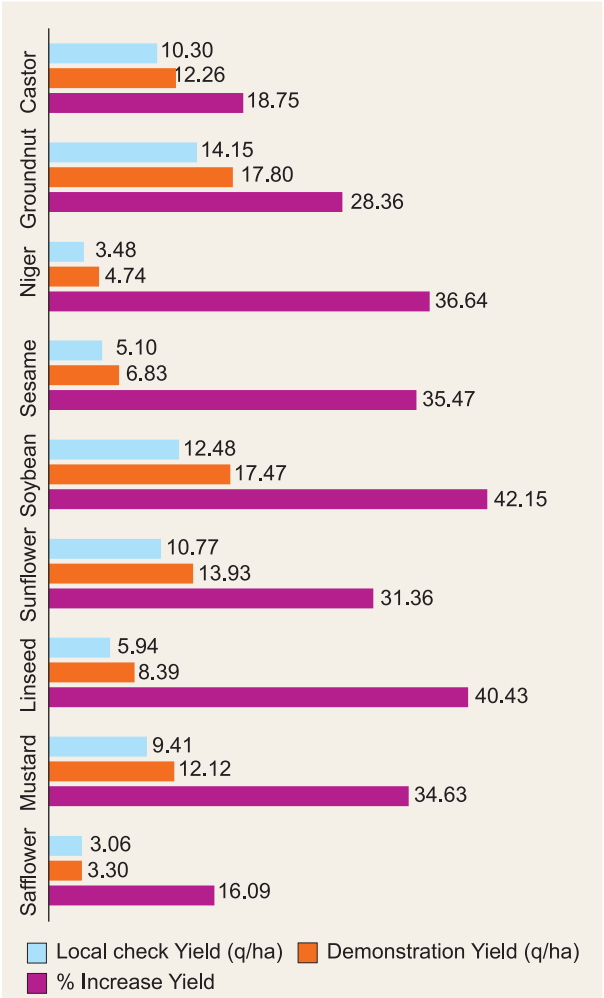
Full package for Cowpea: Zone-XI (Bengaluru)

(1,680 ha), greengram (1,180 ha), blackgram (720 ha), pigeonpea (70.00 ha), rajmash (238 ha), lathyrus (120 ha) and summer pulses greengram (2,497.80 ha), blackgram (977.60 ha), cowpea (30 ha).

On national level the yield advantage in pigeonpea was recorded highest the (56.80%), followed by field pea (39.51%), lathayrus (37.47%), greengram (35.98%), lentil (35.32%), blackgram (34.91%), rajmash (34.64%), chickpea (30.01%) and horsegram (28.33%).

Cluster frontline demonstrations on oilseeds: During the year, 26,481.25 ha area was covered with the CFLDs on oilseeds across all the zones including 9,879.48 ha area in *kharif* season, 14,072.17 ha area in *rabi* season and 2,529.6 ha area in *summer* season. In total area of CFLDS on oilseed 26,481.25 ha in the country different oilseed crops were grown; *kharif* oilseed—groundnut (3,193.3 ha), sesame (2,532.18 ha), niger (1,010.8 ha), castor (120 ha), soybean (2,963.2 ha), sunflower (60 ha); *rabi* oilseed—mustard (9,739.89 ha), groundnut (1,850.2 ha), sesame (383 ha), linseed (1,490.075 ha), sunflower (456 ha), safflower (43 ha), niger (60 ha), castor (50 ha); and summer oilseeds—groundnut (1,119.6 ha), sesame (1,059.2 ha) and sunflower (350.8 ha).

On national level the yield advantage in oilseed crops was recorded highest in Soybean (42.15%),



Yield advantage of oilseeds in 2017–18

Raised bed line sowing of mustard (*top*) and sunflower (*bottom*)

followed by linseed (40.43%), niger (36.64%), sesame (35.47%), mustard (34.63%), sunflower (31.36%), groundnut (28.36%), castor (18.75) and safflower (16.09%). This was due to improve technology interventions and skill developed of the farmer.

Frontline demonstrations on crops other than oilseeds and pulses: Demonstrations (68,440, other than CFLDs), on 199 crops covering an area of 20,382 ha were organized. Gender-specific technologies for women empowerment (1,077), were also demonstrated.

Cereals: In rice, wheat, maize and barley 28,991 demonstrations were conducted, covering an area of 9,970 ha. The highest increase in yield was obtained in buck wheat (37.5%), followed by maize (22.1%) and wheat (20.5%). Rice demonstrations resulted in (15.5%) more yield.

Millets: FLDs (2,636) were laid out covering an area of 833 ha, achievied yield increase of 54.3% in minor millets over local check of kodo millets (52.5%).

Pulses (other than CFLDs): FLDs (5,399) were conducted covering an area of 1,965 ha—greengram (1,165) in 561 ha followed by chickpea (1,075) and blackgram (697). The yield increase was 33.16% in cowpea followed by pea (33.1%) and pigeonpea (32.2%).

Oilseeds (other than CFLDs): Total 5,070 demonstrations were conducted covering an area of 1,604 ha. The more number of 1,211 demonstrations were on mustard followed by groundnut (823), soybean (602) and sesame (550). Safflower yield showed an increase of 56.8% followed by groundnut (47.7%).

Commercial crops: Demonstrations on cotton (1,083), jute (496), sugarcane (428) were conducted in an area of 770 ha. The yield increase was 20% in cotton, 19% in jute and 15% in sugarcane.

Enhancing production and productivity of blackgram through integrated disease management

Blackgram was grown in 29,200 ha area in the Sagar district in the year 2014–15 but heavy infestation of Yellow mosaic disease and poor management curtailed its production to 278 kg/ha. The farmers used locally available mixed seed of T 9 with 30–40 kg DAP as basal application of, and spray of trizophos on insect/ disease appearance. KVK Sagar, made farmers aware of YMV resistant variety IPU 94-1/ PU 30/ PU 31, timely weed management, seed treatment, and management of white fly. These interventions helped farmers harvest 718 kg blackgram/ in comparison to 349 kg in farmers' practice. Most of the farmers convinced with the improved technologies, increased area in blackgram by 87,000 ha in the district in the year 2016–17.

Fodder crops: Demonstrations (2,858) on berseem, maize, sorghum, napier grass, etc. were conducted on farmers' fields covering an area of 468 ha. The yield increase in oats was 23.6%, berseem 24.8%, fodder sorghum 28.3%, fodder maize 18.3%, and lucerne 54.77%.

Horticultural crops: Demonstrations on vegetables (14,656), fruits (2,785), flowers (511), spices and condiments (2,827), plantation crops (468) were conducted in 5,489 ha area. The yield increase was 31.6% in vegetables, 25.7% in fruits, 23.6% in flowers, 27.3% in spices and condiments, and 36.4% in plantation crops over the farmers' practices. Demonstrations (66) were also conducted on medicinal plants in farmers' fields in 30 ha.

Hybrids: Demonstrations (14,695) on hybrids of cereals, oilseeds, pulses, fodder crops, commercial crops and horticultural crops. were laid out in an area of 3,450 ha. In cereals 6,148 demonstrations were conducted in 1,988 ha. Demonstrations on hybrids of oilseeds were conducted in 1,015 ha with yield advantage of 35%, while 6,034 demonstrations were conducted on vegetables, fruits, flowers and spices in 718 ha area. In hybrid cotton, 1,292 demonstrations were conducted in an area of 496 ha with yield increase of 27.2%. Hybrids of fodder crops were demonstrated at 144 locations with an average yield increase of 27.8%.

Farm mechanization: Demonstrations (7,711) on improved tools and farm implements including drudgery reduction technologies were laid out covering an area of 6,122 ha.

Livestock and fisheries: Demonstrations on dairy animals, sheep and goat, including chicken, quail, turkey and duck, piggery, rabbit etc., were carried out in which 17,310 farmers benefited. In the demonstration on fisheries, 2,329 fish farmers benefited.

Other enterprises: Demonstrations on 33 allied enterprises like mushroom cultivation, apiary, sericulture, value-addition, vermicomposting, nursery etc., were conducted involving 20,138 farmers.

Capacity development

Farmers/ farm women, rural youth and extension personnel (14.98 lakh) were trained on various aspects through 50,934 training programmes.

Types of capacity building programmes

The KVKs of India organised 42,340 need based capacity building courses benefiting 11.91 lakh participants while the respective number of courses organised and participants was 5,381 and 2.42 lakh for sponsored trainings and 3,213 and 65,309, respectively, for vocational trainings.

Farmers and farm women: Training courses (40,738) on various technologies benefited 11.87 lakh farmers and farm women out of which 7.74 lakh (65%) participants were from other classes while 4.13 lakh (35%) were from SC/ST category. These courses targeted productivity enhancement and cost reduction of field crops, horticultural crops, plant protection, empowerment of rural women, livestock production and management, soil health and fertility management and other. Out of these training courses 32.46% were organized on-farm while rest (67.54%) were organized off-campus.

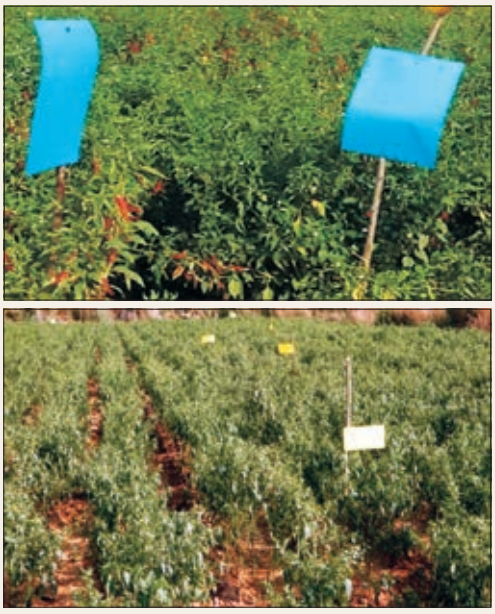
Rural youth: Training courses (6,262) for the skill development were organized for 1.64 lakh participants, out of which 59,557 (36.26%) were the young women during this year. These trainings were conducted mainly on-campus (63.36%).

Extension personnel: Capacity development of 1.21 lakh extension personnel was carried out through 4,211 courses and proportion of female participants in these programmes was 25.32%. Different extension functionaries working both in government and non-government organizations were included. The trainings mainly focused on agricultural technologies aimed at enhancement of crops productivity, integrated pest management, integrated nutrients management, group dynamics and farmers' organizations, management of

Management of viral complex in chilli

Chilli, one of the important vegetable and commercial spice crop, is grown in 22,436 ha in Khammam district. Chilli crop is attacked by pathogens and heavy losses are caused due to viral diseases, viz. Gemini, CMV and PBNV. The Gemini virus is transmitted through whitefly, peanut bud necroses virus by thrips and CMV through aphid. Among them, Gemini virus and PBNV are the major viruses in the viral complex. Scientists of KVK, Wyra, demonstrated virus complex management module in the farmers fields by seed treatment installation of yellow and blue sticky traps, removal and destruction of virus infected plants and need based application of pesticides for control of sucking pests. In treatment plots farmers are getting 61 q/ha of dry chilli as against 53 q/ha in farmers' practice. Farmers realized a net profit of ₹ 137,950/ha in the treated plots as against ₹ 94,550/ha in farmers practice.

Out of 22,436 ha of chilli area in the Khammam district farmers are adopting these practices in 15,500 ha. Almost 90% of the chilli farmers are practicing installation of yellow sticky traps and spraying of neem oil.



Chilli crop demonstration on virus complex management

Success Story

Water-reed-cum-fish farming: A case of success story in Imphal East district

Shri Maibam Nabakishor Dong of Yairipok Top Chingtha, Imphal East district, an enthusiastic and progressive farmer, was cultivating only paddy on his 2 ha of land. He was upset due to low return from paddy cultivation. KVK Imphal East, identified the integrated farming system of water reed-cum-fish farming. He started the activity as a participating farmer in KVK, Imphal East's technology demonstration programme under the project "National Initiatives on Climate Resilient Agriculture–Technology Demonstration Component". Net returns in the first year was ₹ 71,984.40. From second year onwards, the net return would be ₹ 96,384/year/0.25 ha which turns out to be ₹ 3,85,536/ha/year.

Shri Maibam Nabakishore Singh was very happy by the good harvest of water reed-and-fish leading to increase in his income. He appreciated the technological support and the information given by KVK Andro, Imphal East. Farmers from different parts of the district and also from the state have shown keen interest for taking up such farming system and accordingly, horizontal spread of the technology has taken place at 7 new locations.

farm animal, rejuvenation of old orchards, women and child care, livestock feed and fodder production, protected cultivation technologies and information communication technology (ICT) applications. Very high proportion of trainings for extension personnel were organised on-campus (63.58%) compared to the off-campus (36.42%).

Sponsored training programmes

Sponsored training courses (5,381), having a specialized focus, were organized for 2.40 lakh participants, and women participation was 29.37%. The sponsored programmes mainly focussed on women empowerment, processing-cum-value addition, protected cultivation, farm machinery, fishery management, nutritional security, fisheries, animal nutrition management and drudgery reduction of women.

Extension programmes

The KVKs organized 5.68 lakh extension programmes through advisory services, diagnostic and clinic services, celebration of important days, exhibitions, exposure visits, ex-trainees sammelan, farm science club conveners' meet, farmers' seminar, farmers' visit to KVK, field days, film shows, group meetings, kisan ghosthi, kisan melas, lectures delivered as resource persons, mahila mandal conveners' meetings, method demonstrations, plant/animal health camps, scientist' visit to farmers' field, self-help group meetings, soil-health camps, soil-test campaigns, workshops and others. Latest technologies related to agriculture and allied sectors were disseminated among 139.67 lakh participants of which 135.92 lakh farmers and 3.75 lakh extension personnel. Further, KVKs gave wider coverage of technology dissemination through 2.26 lakh extension activities in the form of TV programmes, radio talks, CDs/DVDs, extension literature, newspaper coverage, popular articles, research articles, training manuals, technical bulletins, leaflets, folders and books/ booklets for the benefit of a large number of farmers, extension personnel and other stakeholders.

Production of technological products

At the KVKs, technological products like seeds and planting materials of improved varieties and hybrids, bio-products and elite species of livestock, poultry and fish, were produced benefiting 37.23 lakh farmers in the country.

Seeds: During the year, 1.77 lakh q 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 19.98 lakh farmers.

Planting materials: In all, 365.53 lakh quality planting materials of elite species of commercial crops, vegetables, fruits, ornamental, medicinal and aromatic crops, plantation crops, spices, tuber crops, fodder and forest species were produced and provided to 4.75 lakh farmers.

Bio-products: Bio-agents (70.96 q), bio-pesticides (381.70 q), bio-fertilizers (12,307.17 q), vermicompost, mineral mixture etc., were produced and supplied to the extent of 264.74 q benefiting 12.13 lakh farmers.

Livestock, poultry and fish fingerlings: Improved breeds of cow, sheep, goat, buffalo and breeding bull were produced and supplied to 7,638 farmers. Different strains/breeds/eggs of poultry birds (chickens, quails, ducks and turkey) were provided to 26,199 farmers. Improved breeds of pigs were provided to 372 farmers. KVKs also enabled 19 farmers to establish small rabbit rearing units by providing 38 rabbits. A total of 154.91 lakh fish fingerlings were produced and supplied to 3,890 farmers.

Success Stories

Low cost bottle trap for the management of fruit flies: In Himachal Pradesh, *Bactrocera cucurbitae* (coquillett) and *B. tau* (walker) are the most serious pests on cucurbits. Fruit flies cause huge 35–80% economic losses in different areas of the state. The effective management of the pest was possible only through mass trapping of the male fruit flies (male annihilation technique-MAT) followed by need based bait application technique (BAT). As the traps capture only the males, hence traps need to be installed on community basis on larger areas for longer durations preferably 2–3 years, for desired results.

In cucurbits, installation of fruit fly traps @ 25 traps/ ha along with BAT (jiggery + malathion) application thrice increased fruit yield by 20–30% in cucurbits while in tomato yield advantage of technology was 16–18%. Installation of fruit fly traps reduced number of insecticidal applications from 6 to 3, reducing not only labour costs but also saving time and money. The trap has become very popular among the farmers within a short span of three years, and KVK, Mandi, sold around 20,000 traps earning ₹ 15.0 lakh. Thus, this technology has now been widely adopted in the district. The technology resulted in additional revenue of ₹ 24,000/ ha (based on results of FLDs and farmers feedback) owing to additional marketable yield and reduction of pesticide applications (at least 2–3 applications) apart from intangible benefits on account of reduced pesticide load in the environment. Overall, the technology has been adopted in about 250 ha cucurbit growing area in the district, resulting in direct additional returns of ₹ 6,000,000 (250 ha × ₹ 24,000)/

Low cost bottle trap for the management of fruit flies

Success Story

Self employment through pig farming

With the increasing pressure on land, pig rearing could offer economic, food and social security to the resource poor families. Piggery is the most potential source of meat production and more efficient feed converter after the broiler. Apart from providing meat, pig is also a source of bristles and manure.

Shri Ranjod Singh, 28 years old, from Lauhgarh village of district Ambala, Haryana is B.Tech. He contacted KVK Ambala, for training on commercial pig farming in 2016. KVK Ambala provided 10 pure Large White Yorkshire piglets for his farm. Presently, he is maintaining 25 sows, 20 gilts and 2 boars along with piglets at his farm. He also developed an IFS unit Pig-cum-fish farming at his farm. The cost of fish feed reduced by the use of pig dung in the pond. Due to high cost of feed, the pigs are being maintained on kitchen waste, vegetable (cauliflower, carrot, potato etc.) and sugarcane press mud (Maili/jugary) during the seasons.

Shri Ranjod Singh earned a net profit of ₹ 5.15 lakh in a year 2016–17 and ₹ 45,000 and ₹ 5,000 from sale fish and pig manure, respectively. This success achieved distinctly over a short period of time. Mr. Singh has also developed and loaded a video of his farm on youtube. The development of the pig farming system model by Shri Ranjod Singh has not only been beneficial to him in terms of productivity but it has also influenced other unemployed rural youths of the neighboring areas to establish such venture. His ventures promoted economic stability and sustainability and are an example for locals to emulate.

year. Apart, benefit of about ₹ 1,000,000 was realized on account of reduction in pesticide applications (2 application @ ₹ 2,000/ha, i.e. 250 × 2,000 × 2).

Backyard poultry rearing: During last few years, backyard poultry farming boosted the socio-economic status particularly of poor women farmers with very low initial investment in the rural areas. The production performance of poultry birds reared under backyard system was not up to the mark due to unavailability of good poultry germplasm, unavailability of quality feedstuff, high incidence of diseases and attacks of predators. KVK Dhenkanal, Odisha, helped through improved poultry breeds (RIR, Vanraja, Hit-CARI, Shyama, Gramapriya, Kroilers), use of low-cost mud-based portable housing, little supplementation of locally available feedstuffs along with calcium and zinc. Vaccination against Ranikhet disease and fowl pox were done in backyard poultry rearing system.

OFT on blackgram variety (IPU 94-1) with weed management

It resulted into high body weight (4–5 kg) compared to non-treated (2–2.5 kg), increased egg production by 322%, monetary saving in low-cost housing by ₹ 1,260 and increased net income of ₹ 9,800 from ₹ 3,800/year from a 20 bird unit. This technology is being adopted by many backyard poultry farmers in Odisha.

Agricultural Technology Information Centre

A total of forty-seven Agricultural Technology Information Centres (ATICs) are serving as single window delivery system in the country by providing technology information, advisory services and technological inputs to the farmers. During the reporting period, 6.26 lakh farmers visited ATICs for obtaining solutions related to their agricultural problems. ATICs provided information related to various aspects of farming to 4.28 lakh farmers, both through print and electronic media. Farmers (3.65 lakh) received 32,282 q disease free seeds of various crops, 13.15 lakh number of planting material, 21,783 poultry birds and 4,748 q bio-products through ATICs. Besides, 12.86 lakh farmers were benefited from technological services by the ATICs. The prominent technological services provided by the ATICs were agri-veterinary services (2.86 lakh), Soil Health Cards (25,225), Kisan Call Centre (99,460), Kisan Mobil Advisory (67,457), Kisan Credit Card Services (65,486) and Special Extension Programmes (132,371).

Technological backstopping for KVKs

The Directorates of Extension (DEs) of the SAUs/CAUs (56) being the pivotal points of technological backstopping for KVKs, organized 527 capacity development programmes for updating the technical knowhow of the 20,899 KVK participants in the country. In addition, Agricultural Technology Application Research Institutes (ATARIs) also upgraded technical knowhow and skills of 13,715 participants from KVKs through 176 training programmes. DEs facilitated technological backstopping and delivery at KVKs level through 2,974 training programmes, 771 field days, 476 group meetings, 298 *Kisan Melas* and 231 Technology Week celebrations. Furthermore, monitoring

Diversification in vegetable and strawberry production

Shri Ashutosh Panday has grown different vegetables in such a way as to ensure year round production. He produced potato, beans, capsicum, cowpea and coriander to catch off season market. He started the cultivation of strawberry in 0.25 ha area and gets the good market price and more profitable than previous crop cultivation. In 2017 he had grown strawberry in 0.4 ha area in own land and some other neighbouring farmers have also started the cultivation. He harvested 5 tonnes/acre strawberry fruits and sold ₹ 100 to 200/kg on the basis of market and demand. He cultivated the potato and bean in broad bed and each bed two row of potato and beans seed were planted. He obtained the potato yield of 140 q/acre and green beans yield 50–55 q/acre. He also produced coriander.

Crops	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	Benefit: cost ratio
Strawberry	450,000	1,250,000	800,000	1.78
Potato	86,500	210,000	123,500	1.42
Beans	90,000	246,600	156,600	1.74
Veg. cowpea	56,000	150,000	94,000	1.67

The main intervention of Buxar KVK, was providing of good quality planting material of strawberry and their storage and marketing. High value crops, viz. potato, beans and vegetable cowpea production gave higher return due to more demand for hotels and local market. Strawberry cultivation is more profitable and giving opportunity to more employment generation and attraction of rural youth in smart farming.

of interventions (500), *rabi* and *kharif* campaigns (248), animal health camps (279) and technology exhibitions (1,168) were also used by the DEs for showcasing the technology backstopping and enabling technology delivery through KVKs. Officials of these directorates made 3,431 visits to the KVKs on various occasions to review and monitor the technology dissemination process at KVKs in the respective operational areas. The DEs also undertook the technological backstopping by delivering 2,603 lectures, 266 TV talks, 272 radio talks and 1,983 news items in newspapers.

National Innovations in Climate Resilient Agriculture

Technology packages that have proven potential to impart resilience to crop and livestock production systems were demonstrated in 151 villages of 121 vulnerable districts by KVKs under the Technology Demonstration Component (TDC) of NICRA. During the year, 14,616 demonstrations were carried out under natural resource management covering 8,671 ha; 18,752 demonstrations on crop productions technologies covering 5,985 ha; and 14,944 demonstrations on livestock and fisheries technologies. KVKs undertook 2,457 training programmes on climate resilient agriculture covering 34,120 farmers. Extension activities (3,208) were taken up to create awareness on successful climate resilient practices and technologies covering 60,860 farmers. About 38 NICRA villages received a deficient rainfall of more than 20% and another 28 villages received deficient rainfall up to 20%. The distribution of rainfall is erratic in NICRA villages located in the north western, central, eastern parts of the country experienced prolonged breaks during the season impacting the crop growth.

Demonstrations (4,134) were taken up on *in-situ* moisture conservation practices involving 4,356 farmers in the four states. Farmers (1,764) were provided opportunities for critical irrigation in several states of the country. About 1,191 demonstrations were taken up on soil test based nutrient application, 272 demonstrations were conducted on green manuring in medium to high rainfall regions and, wherever, opportunities existed for irrigation. In Punjab and Haryana, emphasis was on zero till planting of wheat in rice residues with happy seeder as alternative to crop residue burning. The efforts of NICRA led to making of 26 villages as residue burning-free villages adjoining the NICRA villages in Punjab and Haryana.

Success Story

Mustard variety RH-749 becoming popular among farmers

Shri Shyam Dhar Singh, of Dudaun village at Bhadohi district, was selected for demonstration of mustard in his field. KVK Bhadohi tried to popularize the mustard variety RH-749 from CCSHAU, Hisar and brought from ICAR-DRMR, Bharatpur under the FLD programme. Shri Singh adopted the balanced dose of fertilizer (N:P:K:S::100:50:0:30) kg/ha in mustard crop as per suggestion of KVK's scientist. The neighboring farmers reported the yield of Var. Varuna was 18.60q/ha whereas the yield of RH-749 was 33.34 q/ha with 79.24% increase in yield. The gross cost of cultivation, gross income, net return and BCR were ₹ 36,154, ₹ 14,428.00, ₹ 107,874 and 3.98 respectively.

This variety is spread in 79 villages of the district in area of approximately 93 ha. The outcome of this demonstration motivated the farming communities to replace their old varieties.

A total of 890 demonstrations were taken up involving 2,227 farmers during the year on drought escaping short duration paddy cultivars such as Abhishek, Sahabhagi, Anjali, Swarnashreya; and flood tolerant paddy varieties for various depths and duration of flooding. For crop diversification with short duration high value crops about 373 demonstrations were taken up involving 1,441 farmers. In eastern India and the north eastern regions demonstration involving 224 farmers were on short duration paddy followed by zero till cultivation and improved planting methods. Resilient intercropping systems were demonstrated frequently in drought prone regions involving 737 farmers. About 738 demonstrations involving 1,706 farmers were taken up for silage making, one of the important interventions taken up for making the fodder available during the lean season in Maharashtra, Telangana, Andhra Pradesh, Karnataka and Tamil Nadu.

Carbon balance studies were taken up for Arunachal Pradesh, Sikkim and Asom, to assess the mitigation co-benefit of resilient practices.

PPV and FRA programmes

PPV and FRA, New Delhi, jointly in collaboration with 11 ICAR-ATARIs launched the programme for creation of awareness among the farmers' and other stakeholders about the provision of Protection of Plant Varieties and Farmers' Right Act, 2001. Total 287 PPV and FRA awareness and training programmes were organized by KVKs. In these awareness-cum-training programmes 66,426 persons participated out of which 63,267 were farmers, 1,351 scientists, 1,030 officials and 778 others. They were sensitized about the provision of Protection of Plant Varieties and Farmers' Right Act, 2001. As the result of these programmes farmers applied for registration of varieties to PPV&FRA. During the reporting period 3,101 farmers' varieties were applied for registration which included 1,163 varieties in cereals, 550 in vegetable, 291 in oilseeds, 505 in pulses, 56 in millets, 72 in fruits, 100 in medicinal, and 102 in other crops.

Farmers FIRST

Farmer FIRST Programme has been implemented at National level successfully in 52 institutes involving ICAR institutes and SAUs under jurisdiction of 11 ATARIs in a participatory approach. Under Farmers FIRST programme various interventions were implemented by partner institutes/ SAUs across the country in five modules, viz. natural resource management, Crop production, Horticulture, Livestock production and Integrated Farming System, in addition to various extension activities. Under NRM, 2,721 demonstrations were conducted involving 13,950 number of farm families. A total of 15,152 demonstrations were conducted covering 32,751 number of farm families under crop based modules. A total of 110 demonstrations were conducted involving 10,610 number of farm families under Horticulture based modules. A total of 5,538 demonstrations were conducted covering 55,646 number of animals among 13,326 farm families under livestock and fodder based modules. Under Integrated Farming System module, a total of 451 units were established involving 2,519 partner farmers. Different extension activities were performed through 569 programmes conducted under Farmer FIRST programme involving 33,818 partner farmers and farm women all over the country. Overall, 24,963 participatory demonstrations were conducted under different modules involving 73,156 practicing farmers and farm women. The results of participatory demonstrations have shown superiority over traditional practices, productivity enhancement, income augmentation, increase of area under usable technologies, employment generation, etc. Adaptation of Climate Resilient technologies also helped in timely management of production and protection technologies and cost reduction. Farmers have accepted utility of mineral mixture on milk yield and general health of the animals was better than before feeding minerals to the milch animals.

Mera Gaon Mera Gaurav (MGMG)

An innovative initiative *Mera Gaon Mera Gaurav* aimed to promote the direct interface of scientists with the farmers to hasten the lab to land process. The objective of this scheme is to provide farmers with required information, knowledge and advisories on regular basis by adopting villages.

MGMG, an innovative flagship programme of ICAR, is operational and being monitored by 11 zones in the country. Total 133 institutions including ICAR institutes and SAU's are working under MGMG programme which is monitored by ATARI at zonal level. Total 1,311 groups were formed by involving 5,091 scientists covering 6,769 villages and benefited 759,275 farmers.

Commercial floriculture bedecks farmers' life

Strengthening production base through area expansion of various flower crops and raising their productivity is the greatest challenge and a good initiative has been made by KVK, Kamrup in this direction. There is a tremendous scope for commercial floriculture in Kamrup district. Till 2005, only 20% of the total demand has been met from the local flowers produced in Kulhati area of Kamrup.

With the active support of KVK, Shri Jiten Das, a flower farmer of Kulhati near Hajo, has emerged to the fore as entrepreneur and could earn an average income up to ₹ 40,000/month by selling mainly marigold, tuberose and gerbera. Within a short span of time, the entire 50 families of Konadiasuburi started cultivating flowers on commercial basis. To sustain this growth KVK, Kamrup, ensured availability of elite planting material within easy reach of farmers, imparting 200 hr advanced training for *Mali*, off season flower cultivation under green house condition etc. Subsequently the impact of the locality gradually spread to the surrounding areas. A survey undertaken by KVK Kamrup, revealed that 12 villages involving 3,200 farm families started scientific flower cultivation and are able to earn ₹ 6,000 to 25,000/month.

Rain water harvesting system

Rain Water Harvesting Units with micro irrigation system established in 201 KVKs across the country have been utilized to organize 645 training courses, 693 demonstrations and for production of 1,283,262 planting material. Further, 113,063 farmers and 10,924 officials visited these units and got acquainted with the rainwater harvesting techniques.

Farmers' innovations

To bring out and share the benefits of farm innovations made and methodologies developed at grass root level by the farmers and rural youth, such innovations and methodologies are documented and validated by the KVKs. In all the zones, ATARIs organized Farm Innovator meetings in which farmer innovators presented and demonstrated their innovations—371 rural innovations by farmers were documented out of which 303 were verified by the KVKs. Thirty-two innovators were recognized and awarded at national and state level, five innovations were commercialized and two innovations were granted IPR during the reporting year.

Farmers innovations documented and verified by KVKs

Thematic area of innovations	Documented	Verified
Farm mechanization	59	52
Horticulture	75	63
Organic farming	32	26
Crop diversification	42	35
Residue management	3	3
Integrated Farming Systems	38	36
Processing and value addition	31	31
Allied enterprises	74	46

Mobile cleaning-cum-grading machine for Kinnow cultivation: Shri Sirbeender Singh of Muktsar, Sri Muktsar Sahib, Punjab designed and fabricated mobile Kinnow cleaning cum grading machine. This mobile machine is taken to orchards for carrying out cleaning and grading operation in the field itself for making entire process cost and time effective. This machine is tractor operated with a capacity of 1–1.5 tonnes/hr. Kinnows are sorted into six grades and cost of the machine is about ₹ 3 lakh and fresh supply of properly graded kinnow fetched higher price in the market. During peak harvesting time earlier he used to employ 5–6 labourers/day each for cleaning and grading of 150 crates (of 20 kg capacity each) of kinnows. This machine helped him in cutting cost of above operations by ₹ 500/tonne of kinnows. This farmer innovation being cost effective, time saving, highly convenient and ensuring fresher fruit supply in the market for getting higher prices has been adopted by large number of local farmers.

Kinnow cleaning-cum-sorting machine

Safed musli peeling machine: Shri Jagdish Chandra Prajapat of Bangreda Mamadev village, Nimbahera Tehsil, Chittorgarh, Rajasthan, has invented a mechanical peeler to remove the skin of safed musli

Grape cultivation for higher profit

Shri Dattatray Bhanudas Chavan is an innovative farmer belonging to village Nandapur, post Nava, district Jalna. He is 39 years and educated up to 12th standard and having diploma in Fruit and Vegetable Production Technology. He has total 50 acres of cultivable land in a joint family of 10 persons out of which 35 acres is irrigated and 15 acres rainfed. At present, he has 20

acres of grapes, 5 acres of pomegranates, 7 acres of pomegranates + papaya intercropping and 3 acres of custard apples. He raised field crops like cotton, pigeon pea and sorghum in rainfed area. He owns 4 bullocks and 22 *desi* cows as a source of organic manures and bullock drawn farming operations. He has all tractor drawn advanced equipment along with atomized irrigation system for horticulture. There is total water scarcity in the area.

KVK has provided continuous technological support for advanced improved varieties, pruning techniques, micro irrigation management, rain water harvesting through adoption of farm ponds, marketing techniques like early and late pruning, etc. Sonaka, Super Sonaka, Thompson, Tas-E-Ganesh improved varieties of grapes were planted. Use of atomization for irrigation and fertigation, electrostatic spray for dipping of grapes was practiced. He used drip and sprinkler irrigation for whole crop husbandry. Rain water harvesting through farm ponds and use in water scarcity period was followed. Innovative marketing of grapes through box and punnet packing with retail and wholesale marketing was adopted. Information technologies like mobile apps, WhatsApp groups, Facebook, internet, etc. were used. Provided free SMS service to the farmers of the village as per crop growth stages.

Average yield of grapes enhanced from 12 tonnes/acre to 15 tonnes/acre due to use of advanced technologies. Economic gain is realized about ₹ 4 to 4.5 lakh acre from grapes. In the last four years, the farmer has been getting average net income ranging from ₹ 60 lakh to 80 lakh/year through his total land.

Safed musli peeling machine

tubers. After acquiring knowledge and skills on cultivation of safed musli, from the KVK Chittorgarh, and motivated by the market availability at Neemach mandi, he started cultivating the crop. The peeling machine has become popular amongst grower of safedmusli in Chittorgarh.

Modified trench former for intercropping in sugarcane: Shri Jabarpal Singh, S/o Shri Kehari Singh, Karanpur Village, Meerganj Block, Bareilly, Uttar Pradesh was cultivating sugarcane crop with traditional method. He adopted the trench method of sugarcane planting with intercrops using the trench opener. The soil removed by the trench opener remained unlevelled leading to 20–25 extra labourers for making seed beds for sowing the intercrop. As it takes time for the rectification of the seed beds, the moisture gets depleted affecting the germination of the intercrop.

The farmer modified the trench opener with adjustable spacing from 120 to 180 cm along with a leveling attachment which makes the seed beds for the intercrops. Timely sowing of intercrops like vegetable pea, potato, tomato, cauliflower, cabbage, lentil and mustard ensured use of the available moisture. Trench method of sugarcane planting tripled his sugarcane yield along with additional yield of intercrop. Now, more than 25% area of sugarcane is under trench farming in Bareilly. Adjustable trench opener provided freedom as per requirement in increasing the space between two trenches from 120 to 180 cm and it saved about 20–25 labour/ha. The leveler adjustment helps to form seed beds on time and enables immediate sowing saving labour, time and conserving soil moisture. This modified adjustable trench opener with leveler was adopted by 150 farmers who visited his farm and the members of his WhatsApp group.

Crop diversification to augment profitability: Mono cropping of strawberry is vulnerable to seasonal price fluctuation. Cropping system should ensure year round income to the farmer. Sri Ashutosh Pandey of NayaBhojpur village, Dumrao Block, Buxar, Bihar, is a strawberry farmer. Owing to non-availability of quality planting material and market risks in disposing the produce he adopted crop diversification by growing different vegetable crops to ensure year around production. He produces potato, beans, capsicum, cowpea and coriander matching the seasonal market demands. This ensured year round income from agriculture. About 1,000 farmers have learnt from Sri Ashutosh Pandey and adopted smart farming of vegetables.

Low cost nutritive flavoured fish feed: High cost of commercial fish feed results in inadequate supply of feed to fishes reducing the yield and quality of fish. Shri Banamali Rout, Digambarpur village, Dharmasala Mandal, Jajpur, Odisha, invented an indigenous technology to prepare low cost nutritive-flavoured fish feed. Multiple layers of polished rice bran, fresh cowdung, mustard oilcake, rice/*dal*/*sattu* mill waste dust and sodium bicarbonate is kept for 6 days with adequate moisture and used as fish feed in ponds using bamboo basket. The cost of production is only ₹ 960 against ₹ 3,500 quintal commercial fish feed. The net profit increased to around ₹ 38,000 from ₹ 10,000/annum. Fish farmers of the district and the neighbouring districts like Bhadrak, Kendrapara, Dhenkanal have adopted the technology and are getting benefitted

Tea processing through indigenous method: Tea is one of the most preferred beverages in Nagaland. Tea processing is an age old technology. Shri Tohovi Chishi, a progressive farmer from Littami village of Zunheboto, Nagaland was inspired to take up tea farming after attending a training programme and planted tea in his backyard. Once his plantation was ready for harvesting, he did not find market to sell his tea. This situation compelled him to come up with an innovative idea of processing local tea through indigenous method. He invented his own technique to produce green tea, organic tea and normal black tea.

Organic green tea: Top three leaves are plucked early in the morning and soaked for 2 minutes in boiling water in a net bag. After cooling in cold water for 2 minutes, the water is drained in a bamboo basket and the leaves are rolled and dried in shade for 1 h and sun-dried until it becomes brittle. The leaves are taken in an airtight jar and kept near a fire place for one month during which, the leaves develop good quality and flavor retaining its green colour.

Organic tea: Top two leaves are plucked early in the morning, shade dried overnight by turning it over three to four times, rolled and sun dried till brittle. The dried leaves are stored in an airtight container near fire place for one month during which the tea develops light brown colour with good quality and flavor.

Organic black tea: Top three to five leaves are plucked early in the morning, shade dried for overnight by turning it over three to four times. The shade dried tea is ground using locally made grinder made of log wood and sieved through bamboo sieving basket. Fine powder is collected and the residue is ground again. The ground tea is spread over a sheet of tarpaulin and covered for one hour during which time it turns red. The powder is rolled, sundried and stored in an airtight container near fire place for one month. The tea retains

Indigenous tools used for making tea

Organic black tea locally made grinder

good quality and flavor with dark red colour. This technology has been accepted, adopted by local farmers, and has also gained good consumer preference.

Bullock drawn fertilizer applicator: Shri NamdeoAnandrao Vaidya, Nimbhora–Bodkha village, Dhamangaon Mandal, Maharashtra, is an innovative farmer cultivating cotton, soybean, pigeon pea, chickpea and wheat round the year. Labour storage for fertilizer application and soil moisture stress in cotton cultivation reduced the crop yield and profit. The farmer innovated a bullock drawn fertilizer drill-cum-hoeing implement by using locally available low cost materials. After successful use in the field, he found that with the help of this implement, one can complete three operations, viz. application of fertilizer, hoeing and making furrow for rain water conservation simultaneously. The simple and portable bullock drawn fertilizer application implement resulted in a saving of ₹ 572/ha on fertilizer application through reduction in labour requirement by 80% and also saved time by 300%. Another advantage was that fertilizer can be applied near root zone and mixed properly in soil, which increased the fertilizer use efficiency.

Drip irrigation technology using brick to mitigate drought in sweet orange: Shri Nayum Patel, Dhawalapuri village, Aurangabad Mandal, Maharashtra, is cultivating sweet orange in rainfed situation. Dry spells of long duration affected his orchard causing loss. Motivated by special campaign to mitigate drought situation by the KVK and other farmers' organizations he decided to make use of the micro irrigation system to save his sweet orange orchard with the limited water resources. To maximize number of trees with minimum available water, he innovated a novel technology of using bricks as a moisture retainer. A hole was made at the centre of the brick and the pressure compensating dripper having discharge rate of 8 litre/h was fixed inserted into the hole. Two bricks were embedded at five to six inch below the soil surface where the active roots are present. The orchard was irrigated for half an hour on alternate days. The bricks acted as water retainers releasing it slowly in the root zone and hence enhancing the water use efficiency. The technology not only saved the crop from intense drought but also fetched an annual income of ₹ 2.40 lakh from 2 acres of orchard under severe drought condition.

Drip irrigation technology using brick to mitigate drought in sweet orange

Long handle lever weeder: Weed management is a major problem in rainfed and garden lands. Shri Duraiswamy, Kumaramangalam village, Mettumarudur (PO), Kulithalai Taluk, Karur district, Tamil Nadu designed a gender friendly implement for weeding in rainfed crops. The weeder is called Balaramweeder and is based on the simple lever principle comprising steel strips and rod. The inclination of the handle and rod fitted with cutting tool is kept at 30° to enable easy forward movement. Square and round pipes are used to reduce weight of the weeder. Two sets of bush bearings are provided to each wheel so as to smoothen the movement. The distance between the tip of the tool and the rear wheel is reduced by 10 cm. The inclination of the handle and tool increased to 39° degree to obtain good result in garden land weeding. In this model both wheels are set up at the back of the cutter. The cutter is attached at the front for convenient weeding. Now the two sets of wheel play as primary and secondary pivoting points for the instrument, and also maintain a constant depth for the cutter. The distance between the tip of the cutter and the primary pivoting wheel is reduced to the minimum. The cutting tool is firmly fixed at an appropriate inclination. With to and fro motion on the garden surface, weeds are uprooted up to a depth of 3 to 5 cm. The weeder can be operated by one person and reduces labour requirement compared to 5 labour requirement in the conventional practice of using hand hoe.

Lever weeder is manual, portable and easy to transport from one field to another as the weight of the weeder is 2.5 kg and can be easily operated by women labour. Cost of weeding is reduced by about ₹ 10,000/acre in Tapioca. Cost of weeder is ₹ 1,700. KVK, Karur tested the long lever hand weeder. Financial assistance of ₹ 3.0 lakh was provided by NABARD under Rural Innovation Fund for development of the weeder. The implement has been displayed in exhibitions at Coimbatore and Trichy. The weeder has been recommended for patent by the Trade and Intellectual Property Department. About 500 farmers have adopted this implement so far.

Silkworm cocoon harvester: Shri Mutteppa, Khanatti village, Belgavi district, Karnataka, developed a user friendly and cost effective cocoon harvester with locally available materials with a capacity of harvesting cocoons from 50 plastic mountages. The cost of harvester and cocoon deflosser is about ₹ 3,000–4,000 each. Shri Mutteppa has been recognized by CSRTI, Mysore, and Department of Sericulture, Karnataka.

Cocoon harvester

X National Conference of KVKs

X National Conference on KVKs was organized at IARI, New Delhi, The sub themes of the conference were Governments' policy and priorities for Doubling Farmer Income; Farmers Producer Organizations Companies, Technologies of agriculture, horticulture, livestock and Fisheries sector for doubling farmers' income; Models of climate smart villages; and integrated farming models.

Crop residue management (CRM)

The Department of Agriculture, Cooperation and Farmers welfare (DAC&FC), Ministry of Agriculture, Government of India has sanctioned a project on crop residue management to ICAR under central sector scheme on promotion of agricultural mechanization for *in-situ* management of crop residue in Punjab, Haryana, Uttar Pradesh and NCT of Delhi, with a total budgetary allocation of ₹ 21.29 crore. This project is being implemented by 60 KVKs belonging to three Zones (ATARI, Zone-I, Ludhiana, Zone-II, Jodhpur and Zone-III, Kanpur). There are 22 KVKs of Punjab, 15 KVKs of Haryana and Delhi and 23 KVKs of Uttar Pradesh, which have been assigned information, education and communication (IEC) component of the central sector scheme. For smooth execution of the project, ICAR-ATARI, Ludhiana, has organised three capacity development programmes of two days each on *in-situ* crop residue management for scientists of 60 KVKs of Punjab, Haryana, Uttar Pradesh and Delhi. Besides this, one stakeholders meet was also organised at ICAR-ATARI, Ludhiana in which more than 150 delegates participated.

Under this project, KVKs were also provided fund for the procurement of machinery required for *in-situ* crop residue management. The KVKs have procured 472 machines of different type used for *in-situ* crop residue management.

KVKs, under the component IEC, have organised various activities to promote *in-situ* crop residue management. Training programmes (337) on *in-situ* crop residue management were organised by the KVKs for the farmers, officials of cooperative societies, owners of Custom Hiring Centres (CHC), etc. in which 8,729 stakeholders participated. For creating awareness about this scheme, 1,185 awareness camps were organised in which 50,744 persons benefitted. KVKs also organised 45 *Kisan Melas* in which more than 1.25 lakh farmers and other stakeholders participated. Demonstrations on *in-situ* crop residue management were laid out on 7,975 ha at 14,217 farmers' field.

Under this project, school and college students were also involved for creating awareness among various stakeholders. More than 32 thousand students' participated in 298 different activities (*Prabhat Pheries*, *Nukkar Nataks* and in various competitions such as painting, essay, debate, etc.) of 185 schools and colleges. Several other activities were also organised under this project for creating awareness amongst various stakeholders such as wall paintings, distribution of extension literature, jingles, etc in local languages.

Specialized programmes

Mobile advisory services: Timely and need based information to the farming community was provided by 627 KVKs by using mobile advisory services. Based on weather forecasts, farmers were alerted and advised on suitable farm operations. Alerts related outbreak of pest and disease incidence and their control measures were also given to farmers. Information related to market prices were also shared with farmers. As many as 175,941 messages sent by KVKs benefited 612.95 lakh farmers on various aspects of agriculture, horticulture and animal husbandry, weather forecast, and pest and disease.

Pulses seed-hubs: Seed-hubs were set-up at 97 KVKs for production of quality seeds of major pulse crops. During the year, 40,077.37 q seeds of pigeon pea, blackgram, greengram, lentil, chickpea, field pea and lathayrus were produced and made available to farmers.

Skill development training in agriculture: KVKs (30) and ICAR institutes (2) organized 32 skill development trainings. Maximum number of trainings were in the job role of Agriculture Extension Service Provider followed by Quality Seed Grower; Seed Processing Workers; Vermicompost Producers; Mushroom Growers; Tractor Operator; Organic grower; Bee Keeper; Broiler Poultry Farm Worker; Community Service Provider; Floriculturist—Open cultivation and Sericulturist; Dairy Farmer—Entrepreneur; Gardener and Harvesting Machine Operator.

Krishi Kalyan Abhiyan-I

Ministry of Agriculture and Farmers Welfare, Government of India, has launched a Krishi Kalyan Abhiyan in 112 Aspirational districts within the country. The subject areas covered under training programmes

Success story

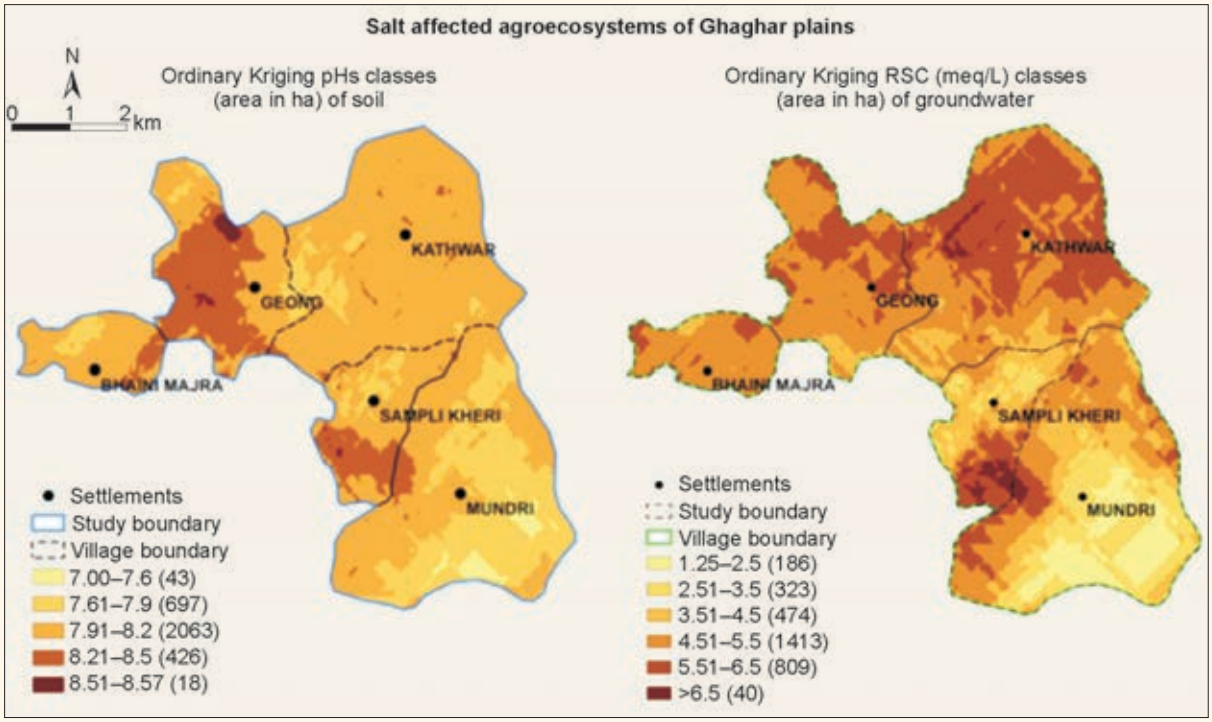
Spatial variability assessment of soil and water quality and soil fertility status in salt affected areas

Grid based (0.5 km × 0.5 km) geo-referenced digital stratified thematic maps delineating soil sodicity (soil pH), residual alkalinity (RSC) in irrigation waters, macro (N, P, K, S) and micro (Zn, Fe, Mn, Cu, B) nutrient status in Farmer FIRST adopted villages (Mundri, Kathwar, Geong, Sampli Kheri and Bhaini Majra) of Kaithal, Haryana were prepared.

Out of total 3,247 ha area under adopted villages, only 10.1% area was found with good quality underground water while 90% area was confirmed with residual alkalinity of variable nature. Maximum (62.7%) area is dominated by alkali waters followed by 17.4% marginally alkali and 9.2% highly alkali in nature. Irrigation water salinity is not a major problem in area, with only 0.6% total area salinity (EC>2 dS/m) affected that too with marginal in nature. Majority (43.6%) of the area is dominated with RSC values ranging between 4.5–5.5 meq/l, being maximum in Bhaini Majra followed by Geong and Kathwar. About 40.1% of total sampled area is affected with sodicity problem having soil pHs>8.2 following the order of Sampli Kheri (54.1%)>Kathwar (40.9%)>Bhaini Majra (40.2%)>Geong (42.6%)>Mundri (33.5%).

Bicarbonate dominated residual alkalinity in irrigation water is the major cause adversely affecting plant growth, soil physico-chemical properties and strongly comprising crop productivity. Precised irrigation water (sodic) management strategies with soil reclamation techniques are the key management issues need to be strongly addressed by holding strong farmers-scientist interface, strengthening farmers participatory research and extension network, suggesting suitable adaptation (salt tolerant varieties) and mitigation (neutralization amendments) strategies to further control degradation (soil sodicity) trends and secure sustainable land management in salt affected agro-ecosystems.

Nitrogen is deficient in whole of arable area while 27.1% area belongs to deficient organic carbon. Phosphorus is in medium to high range while available K status is high. Half of the area is deficient in available zinc. Iron, manganese and copper are in sufficient to high range. B deficiency is prevalent in about 87% of the sampled area.



Soil Health Cards (334) were distributed to the concerned farmers and the same being digitized in the form of an ICT-based user friendly innovative mobile app "Salinity Expert" freely available at https://play.google.com/store/apps/details?id= com.dev.cssri. farmerfirst. These will be quite helpful in assessing the time series change in soil fertility status vis-à-vis decision making support system for balanced fertilization.

were Vermicomposting, Bee keeping, Kitchen gardening, Vegetable cultivation, Mushroom cultivation, Floriculture, IPM in cereal, INM in cereals, Pepper cultivation, Banana cultivation, Passion Fruit cultivation, Coconut cultivation, Paddy cultivation, Goat rearing, Cattle rearing, Value Addition to food products, etc. At many places, the participants in training programmes were provided with necessary inputs related to th training programmes. The intervention has brought confidance in the participants for adopting the technology on large scale.

Out of 112 KVKs, 7 are of Zone-I, Ludhiana; 6 of Zone-II, Jodhpur; 8 of Zone-III, Kanpur; 32 of Zone-IV, Patna; 10 of Zone-V; Kolkota; 9 of Zone-VI;

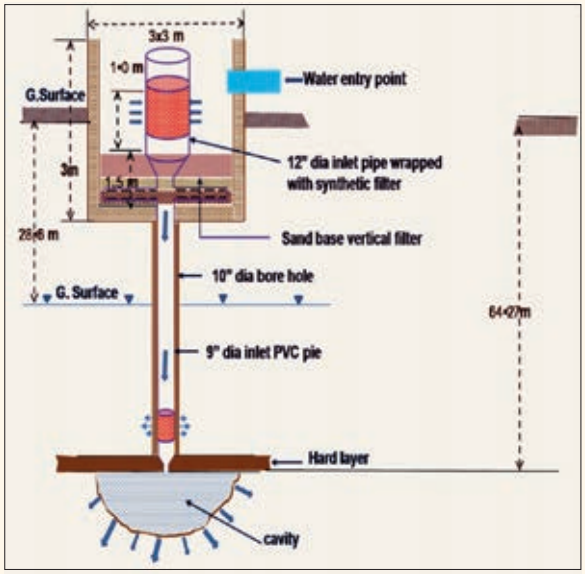
Success story

Managing localized water stagnation and improving groundwater quality by harvesting excess rain water

The average groundwater level in Kaithal block (Haryana) during the last 10 years (2005–15) has gone down by more than double (–1.33 m/year) in 10 years compared to last 40 years average data (–0.61 m/year) owing to excessive pumping to fulfil water requirements of predominant rice-wheat cropping system. Poor quality groundwater causing soil sodicity results in low soil infiltration rate and crop failure due to continuous water stagnation/submergence is a common feature during the periods of intense rains. Such extreme rainfall events are likely to occur more frequently in future due to climate change effects. A total of 6 recharge structures with integrated filtering unit were constructed in masonry chamber. The total cost of each structure was estimated to be ₹ 1200/feet approximately, depending upon lithology of the area.

Flood condition due to heavy downpour

Crop condition after receding of flood volume due to drainage-cum-recharge structure



Recharge structure with integrated filtering unit

Installation of recharge structures managed localized water stagnation vis-a-vis rise in groundwater table (up to 1 m), improved underground water quality with concomitant reduction in residual alkalinity in irrigation water (RSC: 1.5–2.5 meq/l) and enhanced farmers' income by saving submerged rice crop during intense rains. Heavy downpour (150 mm on a single day) immediately after rice transplantation result in complete crop submergence. The installed structure reduced flood volumes through drainage-cum-recharge structure and saved transplanted rice crop in lowest 5 ha area, though low to modest impact was clearly visible in the surrounding areas.

Considering the re-transplantation cost for rice in 5 ha area and 15–25% potential yield reduction under delayed transplanting conditions, the tangible benefit through direct crop saving was estimated to be ₹ 30,000–35,000 in lieu of transplanting (nursery + labour cost) and income loss of approximately ₹ 80,000–90,000 in the absence of recharge structure. The payback period for the localized drainage system to disposed off accumulated runoff volume in low lying area and saving standing crop which otherwise be damaged very badly was estimated to be 2–3 years with the net present value (NPV) of approximately ₹ 1.34 lakh. Benefit-cost ratio of 1.25 and internal rate of return (IRR) of 19% indicated desired economic feasibility of investment on drainage-cum-recharge structure.

Guwahati; 5 of Zone-VII, Barapani; 6 of Zone-VIII, Pune; 18 of Zone-IX, Jabalpur; 8 of Zone-X, Hyderabad; and 3 of Zone-XI, Bengaluru.

Attracting and retaining youth in Agriculture (ARYA)

Under Attracting and Retaining Youth in Agriculture (ARYA), a flagship programme of Indian Council of Agricultural Research, altogether 3,474 rural youths were provided skill development training in entrepreneurial activities through 220 training programme. Among them 2,497 rural youths adopted ARYA enterprises and are running the entrepreneurial activities in sustainable manner by establishing 1,022 micro-enterprise units at village level. The yearly income of the ARYA adopted youths has increased around 30%. The success of the project during a short span of time has created interest among other youths also.

Soil and water testing and Soil Health Cards

Mini soil test kits were provided to all the KVKs to analyze the soil samples and preparation of soil health cards (SHCs). Workshop were organized to train the KVK personnel to handle the kit properly. Soil test campaigns were regularly arranged by the KVKs to make farmers aware of the importance of soil testing and fertilizer recommendation. Feedback was collected by KVKs on the use of SHCs from farmers regularly. Every KVK conducted training programme/workshop inviting farmers and train them how to use the SHCs season-wise and crop-wise as per the prescription (fertilizer recommendation) mentioned in the SHCs. Soil samples (8,33,107) were analysed and 8,79,574 Soil Health Card were distributed among the farmers during the reporting period.

❑

15. Research for Tribal and Hill Regions

NORTH-WEST HIMALAYAS

ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, caters to the agricultural research needs of the north-western Himalayan states of Uttarakhand, Himachal Pradesh and Jammu & Kashmir. The salient accomplishments during the period under report are presented hereunder.

Varieties notified

VL Mandua 379: This finger millet variety with a yield of 33.31 q/ha, was released for Uttarakhand hills and plains. It yielded 18% more than the ruling variety, VL Mandua 352. It is resistant to neck and finger blast.

VL Mandua 379

Doubled haploids in maize: One hundred and twenty nine doubled haploid lines were obtained in *kharif* 2018 from the seeds of 139 doubled haploid plants generated in the previous year. Among these 59 are from crosses involving QPM, 56 are from normal corn and 14 are from sweet corn. Significant variation for important agronomic traits was observed among the DH lines of each cross. Of the 129 lines, 123 exhibited complete within-line uniformity indicating their doubled haploid constitution. The remaining six lines exhibited variable degree for the within-line differences. These lines are under study. The QPM DH lines derived from QPM hybrids, Vivek QPM 9 were screened and 48 out of 50 progenies showed the presence of only one parental allele (VQL 1 or VQL 2). Promising lines were also used as parents for generation of new hybrid combinations. Putative haploid seeds of six crosses generated during *kharif* 2017, were grown during *kharif* 2018 following standard protocol. New induction crosses involving Vivek QPM 9, Pusa Improved VQPM 9, VMH 27, VMH 43 and VMH 45 were also generated.

Diversity of chitinase genes from chitinolytic *Bacillus* spp: A sample of 15 isolates out of 83 was studied for chitinase gene characteristics. Sequence homology study using entire GenBank database by BLASTN search revealed that 10 isolates were 78 to 80% identical to *chiA* gene from *Paenibacillus* sp. FPU7 (Accession no. AB683959). Two isolates (UKCH17 and UKCH77) showed 99% identity to a variety of *B. licheniformis* chitinases and with variable identity (88 to 95%) to other *Bacillus* species (*B. paralicheniformis, B. circulans, B. pumilus, B. subtilis* etc) chitinases. Interestingly, three isolates (UKCH19, UKCH20 and UKCH44) showed 89 to 90% similarity with *B. circulans* chitinase. Multiple sequence alignment of obtained nucleotide sequences showed 40 and 16 single nucleotide polymorphisms (SNPs) in *Paenibacillus* (UKCH19, UKCH20 and UKCH44) and *circulans* group chitinases, respectively. The *licheniformis* sequences (UKCH17 and UKCH77) were identical. Multiple sequence alignment of deduced primary structure (approximately 120 amino acids) showed 8 conserved, 19 semiconserved, 22 non-conserved amino acids substitutions between all 15 sequences covering the three groups. The *circulans* group reported only one semi-conserved amino acid substitution (A to S) despite observed 16 SNPs, whereas, the *Paenibacillus* group reported two conserved (especially in UKCH68), 8 semi-conserved and one non-conserved substitution.

Long-term tillage and irrigation under rice˘wheat cropping system: Identification of a suitable cultivation method with higher energy and carbon efficiency and reducing greenhouse gas emissions (GHGs) is important for sustainability of agriculture. Field experiment was conducted from 2001 to 2016 on a sandy clay loam soil to assess the effect of different tillage and irrigation levels applied at critical growth stages under rice-wheat cropping system. Zero tillage with four irrigations was found suitable for increasing farmers' income and higher energy and carbon use efficiency under rice-wheat cropping system in the mid-Himalayas.

Pedal operated chaff cutter for hilly areas: Keeping in view the acute shortage of quality green fodder during winter, wastage of fodder and straw

Pedal operated chaff cutter

Participatory seed production of rice in different districts of Manipur

resulting from direct feeding and cost of electrically operated cutter, a pedal operated chaff cutter suitable for hills was developed. In this machine, it is easy to feed the straw/fodder in the hopper by the same person who is running the machine while in conventional chaff cutter two persons are required. The output capacity of the machine is about 170 kg/hr for green fodder and 29.4 kg/hr for dry fodder. The machine has 39.2% higher RPM than conventional manual hand operated chaff cutter with 18.1% higher output capacity.

EASTERN HIMALAYAS

Acid soil spectral library for Meghalaya: From the several stratified agro-physical thematic layers (LULC, agro-ecological region, physiography, rock type, geology, slope, elevation, ancillary data comprising climate-rainfall, soil pH, soil carbon content, stock etc.) using SOI topo-sheets at 1:50K, IRS-P6-LISS-III satellite data, ASTER-GDEM, etc. in RS and GIS environment, representative soil sampling locations with maximum spatial variability in soil properties across major land use systems including shifting cultivated areas of hilly ecosystem of Meghalaya were selected. All these maps were transferred into GIS environment, overlaid and used as base map for selecting sites for soil sample and spectral reflectance collections at 1: 50,000 scale (nearly 20 locations per SOI topo-sheets of 1: 50K); a true representative to the inherent variation exists across the sampling site. Collected soil samples (0-15 cm) were pre-processed, characterized following standard procedures for soil reaction (pH), organic carbon (SOC), macro (nitrogen, phosphorus and potassium - N, P, K) and micro (DTPA extractable Fe, Mn, and Cu) nutrient contents. Analyzed soils revealed wide variability in soil properties (e.g. pH varied from 2.51 to 6.4; SOC: 0.16–5.73%) and macro nutrients (available N: <13 kg/ha to >600 kg/ha; P: <6 kg/ha to 48.9 kg/ha; K: <60 to 317 kg/ha). Micro-nutrients, especially DTPA- Fe content reflected wide variation and in many locations across Jaintia Hills, it exceeded critical threshold limits of toxicity by several fold while DTPA-Zn content was very low invariably across the state of Meghalaya.

ELISA kit for detection of CSFV antibody in serum: Classical Swine Fever Virus was isolated from field outbreak samples and the virus was adapted in RK-13 cell line up to passage number 45. The cell culture adapted virus was purified and precipitated with PEG 6000. The precipitated cell lysate was used as antigen to formulate in-house indirect ELISA for the detection of CSFV antibody status in serum samples. Using the standardized protocol for in-house indirect ELISA, 403 serum samples were screened and the result obtained was compared with the result of IDEXX for the same samples.

Antioxidant and anti-hyperglycemic activity of agri-horticultural crops of Manipur: A total of eight agri-horticultural crops were screened for their free radical scavenging and antihyperglycemic activity (α-amylase enzyme inhibitory activity). In antioxidant assay, methanolic extract of pod and seed mixture of tree bean showed maximum antioxidant activity; followed by acetone extract of pigeon pea leaf, acetone extract of tree bean pod, methanolic extract of pigeon pea leaf, methanolic extract of tree bean pod and acetone extract of pod and seed mixture of tree bean. In anti-diabetic assay, maximum inhibition of α-amaylase enzyme was reported with methanolic extract of wild orange pulp (74.83%); followed by tree bean pod (67.39%), Chinese chives leaf (57.14%), hooker chives root (56.84%), mixture of tree bean pod and seed (56.10%), tree bean seed (54.59%), acetone extract of wild orange pulp (54.50%) and methanolic extract of black rice husk (50.62%).

Participatory development of quality seed production practices for seed village concept: The project involving KVKs, NGOs, Self-help Groups and Farmers Clubs under Famers' Participatory Seed Production approach aimed at developing a suitable seed production system for the NEH Region in major crops, was taken up in five districts of Manipur, viz. Imphal West, Imphal East, Bishnupur, Chandel and Churachandpur. Participatory Seed Production of rice covered 48 ha with 60 farmers of rice varieties RC Maniphou-7, -10, -12 and -13 with a production of 525.10 q. An average seed yield of 41 q/ha in pre-*kharif* and 50.4 q/ha from main *kharif* rice were obtained from different districts of the Manipur. Similarly, 124.75 q from 12 ha of labelled seeds of groundnut (ICGS-76) and 1.10 q of maize (RCM 1-76) were produced from 3 ha of farmers' farm land. Selected farmers were properly trained and demonstrated with technologies like isolation, line transplanting, conoweeder and leaf colour chart during the seed production in farmers' field.

ISLAND AND COASTAL REGION

Coastal region

Goa Tambdi Bhaji-1: A local red amaranthus variety was released for the state of Goa. It is highly palatable with plant yield of 14.80 tonnes/ha in 60 days. Seed yield is high (252 kg/ha). The variety is tolerant to rust and responds well to manures.

Goa Bio-1: A promising talc based salt tolerant plant growth promoting bacterium for the paddy cultivation was developed. The organism used is *Bacillus methylotrophicus* STC-4 which has shelf-life of 18 months. It is recommended for paddy, vegetable crops (brinjal, tomato, chilli and cucumber) and black pepper cultivation. The product is eco-friendly, economically viable and sustainable in long term. There is yield improvement of 17% over the farmers' cultivation practice.

Goa Tambdi Bhaji -1

Goa Bio-2: A promising talc based bio-formulation for plant health management of field, vegetable crops and black pepper was developed. The organism used is *Bacillus methylotrophicus* RCh6-2b, which has shelf-life of 18 months. It is recommend for vegetable crops (brinjal, tomato, chilli and cucumber), black pepper, fruit and plantation crop nurseries. The product is eco-friendly, economically viable and sustainable in long term. Application of Goa- Bio-2 reduced the incidence of bacterial wilt in brinjal (50–70 %), soil borne diseases of chilli (40–50%), foot rot of black pepper (80–90%) and mortality in mango nurseries.

Ornamental fish feed technology: Ornamental fish feed is prepared from locally available materials for feeding ornamental fishes which gives better growth performance and colour improvement in fresh water ornamental fishes. It is sinking type pellet which is suitable for rearing fish in community aquarium tanks, FRP tanks and cement tanks and can be used for most of the common freshwater ornamental fishes. The feed can be vacuum packed and stored at room temperature 5–6 months. The fish feed satisfy the requirements of an optimal feed for their ornamental fish culture. Thereby, the fish feed has a potential to increase the total returns to the tune of 20–30%.

Nutmeg pericarp Taffy: Nutmeg Taffy is a product prepared by using nutmeg pericarp or rind. The product stores well at room temperature for about 12 months with simple packing without any synthetic preservatives. The product is commercially acceptable and the process is commercially feasible. Nutmeg pericarp taffy may help earn additional income from the same nutmeg tree besides income from yield of spice products. The patent application has been filed vide application No 201621012414; and was published in Indian Patent Journal.

Islands

Germplasm: Four released noni (*Morinda citrifolia*) varieties, viz. CIARI-Sampada, CIARI-Sanjivini, CIARI-Samridhi and CIARI-Rakshak trees were declared as mother block for DUS characterization of noni by the PPV&FRA, New Delhi. Pepper wood (*Piper ribesioides*), a naturally distributed species in Andaman Islands, was identified as a novel spice crop for the islands. Biochemical analysis revealed its good antioxidant content. Value addition was also attempted in the species. *Myristica andamanica*, an endemic wild nutmeg, was studied for its germination requirements. Occurrence of twin seed and polyembryony were recorded in *Myristica andamanica* for the first time. In turmeric, genotype AT-3 (20.4 tonnes/ha) registered highest fresh rhizome yields which was significantly different from AT-3 (17.23 tonnes/ha), while lowest yield of fresh rhizome yield was found with cultivar AT-8 (9.26 tonnes/ha).Fifty genotypes of chilli collected from Andaman and Nicobar Island, were evaluated and characterized both for quantitative and qualitative traits. Some genotypes exhibited unique characteristics, namely AC-15 (Purple colour), AC-10 (Small conical shape), AC-17 (Blackish green and conical shape), AC-6 (Dark green conical shape), AC-6 (Dark purple), AC-25 (Cylindrical purple green), AC-1(Dark green round) respectively.Twenty genotypes of Ocimum were collected from South and Little Andaman. Among all the twenty genotype AO-7. AO-11 and AO-20 performed best with respect to different quantitative and qualitative observation. Six genotypes of lemongrass were collected from South Andaman. Dextrose (3%) was identified as the best carbon source for *in vitro* shoot multiplication in *Curcuma mangga*. Seed germination pretreatments and substrate were standardized for two endemic species of wild banana, viz. *Musa indandamanensis* and *Musa paramjitiana*. Use of 0.1% KNO_3 as a pretreatment and vermicompost as a substrate was optimum. A nucleus seed garden of 1 ha for released coconut varieties from the Institute, viz. CARI Annapurna, CARI Chandan, CARI Omkar, CARI Surya and one variety of arecanut, viz. Samruddhi was established. Ten germplasm accessions of indigenous tuber crops were collected. Two collections each were made in *Dioscorea* sp, *Tacca* sp and *Colocasia*. A total of 109 accessions are being maintained in the gene bank at the Institute.

First time rice varieties notified for Andaman and Nicobar Islands: Two rice varieties, viz. CARI Dhan 1 and CARI Dhan 5 developed by ICAR-Central

Island Agricultural Research Institute, Port Blair and released by State Variety Released Committee for Andaman and Nicobar Islands were notified during 2017–18.

CARI Dhan 1 (IET 25029): Medium duration rice variety (120 days); plant height 115 cm; 7–8 panicle bearing tillers; and gives 4.0–4.5 tonnes/ha yields in Andaman and Nicobar Islands.

CARI Dhan 5 (IET 16885): Long duration (150 days) variety for saline soils; medium stature (110.0 cm); 9-10 tillers/plant with panicle length of 24 cm; yield ranges from 4.4 to 4.7 tonnes/ha in normal soils and 3.2 to 3.7 in saline soil conditions.

First time rice varieties notified for Andaman and Nicobar Islands

Effect of rooting media in planting material production of marigold: The loose flower, marigold is in high demand in the Island throughout the year. Hence, for fast multiplication, uniform growth and disease free planting material production, two microbial consortia CARI bioconsortia and Arka fermented coco peat were evaluated as rooting media with the control (soil). Wilt incidence was noticed when soil was used as the media and planting material were disease free in both the microbial consortia treatments.

Maximum Sustainable Yield (MSY) estimation of coastal tuna: *Euthynnus affinis* formed the dominant species in landing among the coastal tuna. Most of the tuna catches are exported to mainland India due to low demand in the local market. The fishes in the length class of 33–48 cm contributed more than 50% to the little tuna fishery. The natural mortality rate (N), fishing mortality rate (F) and total mortality rate (Z) estimated were 0.77, 0.32 and 1.09 respectively. Exploitation ratio (E) and exploitation rate (U) estimated was 0.294 and 0.195 respectively. Virtual Population Analysis indicated that the major loss in the little tuna stock up to 30.5 cm was due to natural reasons. The estimated total stock (P) was 10653 tonnes. Estimated standing stock (B) was 6,487 tonnes. The estimated value of maximum sustainable yield (MSY) was 3,535 tonnes.

Health management: Survey on the presence of sero positivity of FMD infection in cattle recorded sharp decline. Out of goat PPR, bovine bluetongue, goat brucellosis, bovine tuberculosis and avian influenza virus, the active sero surveillance was recorded for PPR (53.31%).

Molecular diagnostic technology: Standardization of nested PCR for detection of Orf virus was done. It yielded 235 bp fragment, which was suggestive of presence of Orf virus in clinical samples of goats.

Food safety: Study on antimicrobial resistance in poultry revealed that 40% of *E.coli* isolates were having multiple antimicrobial resistance. This has paved the way for policy decision by Administration for the controlled and recommended usage of antibiotics for antibiotic residue free poultry produce in Andaman and Nicobar Islands.

Herbal egg sanitizer in poultry: *Eupatorium* and *Vitex trifolia* could be potent medicinal plants for the preparation of herbal egg sanitizers in the poultry hatchery to address the issue of health hazards by synthetic disinfectants.

Herbal anticoccidial therapy for poultry: The extracts of *Piper*, *Zingiber spectabile, Cissus quadrangularis* and *Centella asiatica* have anti-coccidial effect against sporulation of oocysts of poultry.

Ethno veterinary medicine for conjunctivitis in poultry: Methanolic extract of *Zingiber spectabile* (leaf) had antibacterial sensitivity towards isolates of conjunctivitis.

Occurrence of parasites: Under the national surveillance programme for aquatic animal diseases, the occurrence of fish parasites in marine and freshwater fishes, were studied. Occurrence of bopyrid isopod parasites namely, *Probopyrus* sp. was reported from freshwater prawns *Palaeomon* sp. and *Macrobrachium scabriculum.* Parasite *Epipenaeon ingens* was reported from marine shrimp, *Peneaus indicus*. Marine fish parasites such as *Serrasentis* sp. and *Caligus* sp. were reported from marine finfish, *Rastrelliger kanagurta.* Parasite, *Lernaenicus* sp. was reported from *Dussumieria acuta*. Further, baseline data were collected from 298 freshwater fish farms, and necessary advices on better management practices were provided to the farmers.

Horizontal dissemination of duckling production technology: The duck is the choice of poultry but major constraint is non-availability of ducklings for farming in time. The concept of "Through farmers to farmers" was programmed. For the first of its kind, mini incubator was introduced in these islands and five farmers were trained to operate mini incubator and its associated activities. In a span of three months,

backward and forward linkage was established by this concept among the farmers by producing hatchable duck eggs and hatching by themselves and distribution of those ducklings to other farmers. With a unit of 20 ducks and 5 drakes, farmers could obtain duck eggs ranging from 200 to 300 in 20 to 30 days. Through cluster approach, the slot was allotted to each farmer to hatch the duck eggs at a time in mini incubator, and 139 ducklings were hatched by the farmers with setting of 290 eggs in three months, which is double the production of ducklings from natural hatching during the period. Hatching performance improved with third batch indicating skill development of farmers on scientific management of duck farming and to handle the mini incubator.

Floriculture based sustainable livelihood model for tropical island condition: Intensive cultivation of tuberose, marigold and jasmine were taken up in polyhouse at farmers' field at Ograbraj and New Bimblitan, South Andaman. Three crops of marigold harvested in both the farmers' field. An average income of ₹ 57,000/year (3 crops/year) was earned through marigold and ₹ 10,000/year through sale of tuberose in the second year after planting. The planting material of *Jasminum sambac* were multiplied through cuttings and about 1,800 saplings were produced in the year. Planting material of marigold (5,000) were produced through rooting of terminal cuttings.

Seeds and planting materials produced : Planting material of black pepper (5,000), cinnamon (2,000), clove (1,000), dragon fruit (1,000), marigold (5,000), arecanut (5,000), ornamentals (500) coconut (500), minor fruit plants (500) and tubers (500 kg), were distributed. Beside 848 Vanaraja chicks; 1,278 Gramapriya chicks; 620 Nicobari fowl; 4,002 Vanaraja hatchable eggs; 7,460 Gramapriya hatchable; 268 Nicobari fowl hatchable eggs were also produced and distributed to the farmers.

TRIBAL SUB-PLAN

Support under Tribal Sub-Plan: Tribal welfare programmes were supported in 17 agricultural universities with financial support of ₹ 23.54 crore. In certain areas, to uplift the economic conditions of tribal farmers, inputs were distributed under this programme, e.g. goats, pigs, spinning machines, honey bee colonies, seeds etc. Various programmes were executed through more than 1,000 training programmes, workshops and demonstrations etc. leading to the capacity building and creating awareness among more than 21 lakh tribal farmers.

Training on modern goat farming at Basing village of Orchha block, District Narayanpur (CG)

Spinning machine for distribution

Rearing of eri silk worm

Eri silk reeling and spinning

The interventions have led to adoption and spread of nutritional gardens in some tribal areas. Tribals were also trained in mushroom production and post harvest processing of mushrooms. The capacity building programmes were also conducted in modernized goat and pig rearing as well as bee keeping. The farmers were made aware

Samples of Eri yarn

Lumsniang—a new crossbred pig variety

The planned crossbreeding program by the institute over a long period with rigorous selection resulted in a crossbred pig variety called Lumsniang with better adaptability in the hill ecosystem, climatic resilient traits, promising growth rate and good mothering ability with higher litter size. It has better adaptability and performance in the hill ecosystem of the north-eastern region of India. Lumsniang have both Niyang Megha (Khasi local pig) as indigenous

germplasm and Hampshire as exotic germplasm. The pig variety had faster growth rate and attained the body weight of 77.5–90.7 kg at the age of 12 months. The post-weaning growth rate was 300–367 g/day with average feed conversion efficiency of 1:4.30. The pig variety had excellent reproductive ability including the early sexual maturity and higher litter size at birth. The life-time productivity of the pig variety traits for average of 6 farrowing/sow, viz. total litter size at birth (51.83±2.70), average litter size at birth (9.13±0.17), total litter weight at birth (44.07±2.29 kg), average litter weight at birth (7.75±0.14 kg), total litter size at weaning (47.17±2.69), average litter size at weaning (8.29±0.20), total litter weight at weaning (446.19±25.43 kg) and average litter weight at weaning (78.46±1.91 kg) were promising.

about benefits of scientific housing of animals, adoption and spread of improved breeds of animals and poultry birds and health care of pig and poultry, production of silk yarn etc. Capacity building programmes and inputs on managing the agro-forestry models, crop intensification through cultivation of short duration summer crops like moong, etc were also conducted for them. Additional income generation opportunities through training in spinning of silk yarn, bee keeping, backyard poultry and bee keeping were provided. Farmers of NEH region were also provided with low-cost polyhouses, mushroom production and vermicompost pits. Trainings were imparted on preparation of mushroom products, samosas, namkin, bhujia and biscuits etc. In Lahaul Spiti district trainings on orchard management were imparted and improved planting materials and implements were distributed.

Land resource inventory (LRI) on 1:10000 scale: Soil maps at 1:10,000 scale were prepared for Manipur, Nagaland and Sikkim. Landscape Ecological Unit (LEU) consisting of landforms, land use and slope is taken as the base map for LRI instead of landforms alone. Contours at 10 m interval and drainage pattern are developed for delineation of slope and landforms using Cartosat digital elevation model. Other remote sensing data like IRS-LISS IV of 5.8 m resolution and those available in public domain are used for land use-land cover (LULC) mapping. Landforms, slope and LULC maps are integrated for developing landscape ecological unit in GIS environment.

Integrated watershed development: Under the Tribal Sub Plan, a watershed was developed at Bernia, a tribal village of Dungarpur district, Rajasthan. A detailed bench mark survey was carried out to assess problems and potentials of the watershed. Scarcity of water and low productivity of both crops and livestock were found the major problems in the area. To improve the availability of water in the village, capacity of existing village poun or nadi was increased from 4,000 m^3 to about 12,500 m^3 by excavation. A conveyance channel 400 m length connecting the pond to farmers field was constructed, which benefited 12 farm families. For drinking water in the watershed area, three rainwater harvesting tankas of 21,000 litres capacity each were constructed.

Further to improve the productivity of *kharif* crops, improved seeds of paddy (Pusa Sugandha-5) and urd bean (IPU-94-1/PU-31) were distributed to farmers with package of practices. Similarly for *rabi* crop improvement, seeds of wheat (Raj 4037/4082) and gram (Pratap-1/RSG-888) along with recommended fertilizers were distributed to selected farmers based on land holdings. In all 22.63, 14.50, 214 and 30.94 q seed of paddy, urd bean, wheat and gram were distributed during 2013-2016 that benefited 175 farm families. Data on *kharif* crop yield showed increase in yield from 5 to 7 q/ha for paddy and 1.5 to 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. Each household in the watershed was provided with solar lantern; and 70 farmers were given seed storage bins. Under horticulture development, 450 seedlings of pomegranate variety bhagwa, 350 seedlings of lemon or kagzi, 500 seedlings of mango Mallika, and 300 saplings of jackfruit were distributed. The survival of various fruit trees varied from 60 to 80%.

For livestock improvement three bucks and seven rams of Sirohi breed were given to the farmers of the watershed; and 15 progenies were produced from the bucks. For human resources development four capacity building programs of 3 days each were conducted on natural resources management, income generation and livelihood security. About 260 farmers including 60 women were benefited.

Kisan Kalyan Abhiyan programme: Kishan Kalyan Abhiyan activities were organized to create awareness in scientific goat practices, vaccination, health camps for goats and other livestock at Raygada district of Odisha, having 55.99% of tribal population. Muniguda block has ST population as well as high goat population. PPR vaccination camps were organized at village Chhelia Naland Nugaon and interactive meet/climate

awareness camp/training at Muniguda, which was attended by more than 250 tribal goat farmers along with veterinary officer of the Muniguda Veterinary Hospital and other dignitaries of the local area. A Goat Production Technology Exhibition was also organised at this place. A kit containing medicines and disinfectants was distributed to each of the goat farmer attending the meeting.

Camel: Animal health cum extension camps were organized in various villages under TSP plan in Sirohi districts. Different inputs like medication for different ailments, concentrate supplements, pelleted complete feed, area specific mineral supplement were distributed for improving milk production and for amelioration of mineral deficiencies under field conditions.

Innovation in tribal farms

Plug nursery: An on-farm training-cum-demonstration on nursery preparation for vegetable crops was organized at Mailot in Kwanu cluster of Jaunsar tribal area of the district Dehradun on 22nd February, 2018. In the training, the farmers were given a demonstration on scientific method of nursery bed preparation. Information on nutrient and disease management in the nursery was also shared with the farmers. In order to acquaint farmers with the modern nursery techniques, the farmers were given demonstration and hands-on training on use of plug-trays for nursery raising. Seeds of tomato and capsicum hybrids, plug-trays, cocopeat and fungicides were also distributed to the farmers. A total of 14 leading vegetable growing farmers of the cluster participated in the programme.

Plug nursery: Seeds of tomato and capsicum hybrids, plug-trays, cocopeat and fungicides were also distributed to the farmers.

Training: Farmers were given training under TSP on—Quality seed production of French bean at Farmer field; *Uchya Parvatiya Phaslon Ki Unnat Utpadan Takniki evam Ekikrat Nashi Jeev Prabhandan* (organized at Malari (3,300 amsl) in Niti Valley; *Sabji Matar ki Vigyanik Kheti* and *Sabjiyon Ki Unnat Takniki*.

Introduction of maize sheller: Shelling of maize in Jaunsar area is an activity that mainly involves female members of the family, and is done manually. A small maize sheller, therefore, got specially designed and manufactured, and introduced in the cluster as an easy means of shelling maize to mitigate this drudgery. Introduction of the maize sheller reduced the time 8–10-fold and has resulted in significant reduction in drudgery. Compared to manual shelling, maize sheller saves 21.4 days per ha which @ ₹ 250/day wage adds another ₹ 2,675 (considering engagement as manual labour for half of the saved time) to the farmer's income

Income generation of women though non-farm activities: A 15-day skill development training program on 'Income generation of women though non-farm activities' was organized at ICAR-VPKAS, Hawalbagh, under Tribal Sub-Plan. The participants were imparted training on tailoring and beauty culture so that they can become self-dependent and contribute to their family income monetarily. The participants were taught the basics of stitching and were provided hands-on training so that they practice it in their respective villages as an income generating activity.

Income generation by women through non-farm activities

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16. Organization and Management

Department of Agricultural Research and Education

The Department of Agricultural Research and Education (DARE) was established in the Ministry of Agriculture, Government of India in December 1973 to coordinate and promote agricultural research and education in the country. The DARE provides necessary government linkages for the Indian Council of Agricultural Research (ICAR), the premier research organization for coordinating, guiding and managing research in areas including crop science, horticultural science, natural resource management, agricultural engineering, animal science, fisheries science, agricultural education and agriculture extension in the entire country. With 112 ICAR Institutions and 74 Agricultural Universities spread across the country, this is one of the largest national agricultural research systems in the world. Apart from ICAR the Department of Agricultural Research and Education has other autonomous bodies, viz. the Central Agricultural Universities (CAUs) at Imphal (Manipur), Jhansi (Uttar Pradesh), and Pusa (Bihar); and 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 the Imperial Council of Agricultural Research, it was established on 16 July 1929 as a Registered Society under the Societies Registration Act, 1860 on the recommendations of the Royal Commission of Agriculture. It was reorganized in 1965 and again in 1973, with its Headquarters located in Krishi Bhawan, New Delhi, with support facilities in Krishi Anusandhan Bhawan I and II and NASC Complex, Pusa, New Delhi. The Union Minister of Agriculture and Farmers Welfare is the President of the ICAR. The Principal Executive Officer of the ICAR is the Director General, who also functions as Secretary, Department of Agricultural Research and Education, Government of India. The General Body of the ICAR Society, headed by the Union Minister of Agriculture and Farmers Welfare is the supreme authority of the ICAR. Its members include; Ministers for Agriculture, Animal Husbandry and Fisheries, and the senior officers of the various state governments, Members of Parliament and the representatives from industry, research institutes, scientific organizations and farming community (Appendix 1). The Governing Body (Appendix 2) headed by the Community Director General, who is also the Secretary, DARE is the chief executive and decision making authority of the ICAR. The Governing Body consists of eminent agricultural scientists, educationists, public representatives and representatives of the farmers. It is assisted by the Accreditation Board, Regional Committees, Policy and Planning Committee, several Scientific Panels and Publications Committee. In scientific matters, the Director General is assisted by 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 82 All India Coordinated Research Projects+Network Research Projects (Appendix 8). The Directorate of Knowledge Management in Agriculture (DKMA) functions as communication arm of the ICAR responsible for delivery of information/knowledge generated by the network of the ICAR and its institutions; and addresses mandate of ICAR through Publications, Information, AKMU, Public Relations Unit and CeRA. The ICAR

promotes research, education and frontline extension activities in 74 Agricultural Universities, which include 63 State Agricultural Universities, 4 Deemed Universities, 3 Central Agricultural Universities, and 4 Central Universities with agricultural faculty by giving financial assistance in different forms (Appendix 9).

ADMINISTRATION

Filling up of vacant posts: During the year, the following posts were filled up under the promotion quota: five Deputy-Secretaries, seven Under-Secretaries, thirteen Section Officers, one UDC and one LDC at ICAR (Hqrs), three Senior Administrative Officers, under Combined Cadre of AO

Financial upgradation granted under MACP Scheme: During the year, 39 eligible officers and staff of ICAR (Hqrs) and Institutes were granted the benefits of financial up-gradation under the Modified Assured Career Progression scheme in accordance with the Government of India (Department of Personnel and Trainings) instructions in this regard.

E-governance in ICAR: E-Governance division was established for smooth implementation and functioning of e-governance activities/initiatives such as e-procurement, implementation of digital office solution, Biometric Attendance System and grievance redressal through CPGRAM etc. The division is monitoring the functionalities and implementation of following e-Governance activities:

ICAR-ERP: The ERP solution for the ICAR was implemented in institutes of ICAR for financial management, Pay Roll, HRMS, Project Management and Supply Chain Management. Some functionality and features were added to the ICAR-ERP Solution such as mail alert to Director for transaction count, bill tracking report and for pending Invoice Transaction, generation of Last Pay Certificate, GPF statement report deployed as per the GPF ledger and developed ICAR GAR Paybill Report. Online Dashboard functionality was strengthened.

E-Office: The digital office solution of NIC was also implemented in DARE and ICAR Hqrs. Around 34.88 lakh pages have been scanned since April 2018 as against the target of 39 Lakhs. Aiming that the ICAR institutes should also strive for paperless office and switch over to more efficient and transparent e-filing system, a decision was taken to implement e-Office in all ICAR institutes by December 2019 in a phased manner.

CPGRAMS: Centralized Public Grievance Redress and Monitoring System, an online web-enabled system, primarily aims to enable submission of grievances by the aggrieved citizens to Ministries/Departments/ Organisations who scrutinize and take action for speedy and favourable redress of these grievances. CPGRAMS was implemented in ICAR Hqrs and its institutes through Subject Matter Divisions of ICAR and regularly monitored.

E-procurement through GeM and CPPP portal: All procurements in ICAR and its institutes are carried out either through GeM portal or through CPPP portal (https://eprocure.gov.in/cppp/). Now, all ICAR institutes have got registered themselves in CPP portal. From April 2018 to till date, 3696 tenders have been floated on CPP Portal and 481 (UPI) tenders were published on ePublish module of CPP Portal from ICAR Institutes.

VOICE: Vigilance Online Integrated Complaints and Enquiry (VOICE) system is now used for monitoring vigilance cases at ICAR (hq).

ICAR-Portal (Institute Information Management System-IIMS): Monitoring cum Information System of Institutes was developed to provide count information of all Institutes and KVKs. It also provides information on AICRP projects, major achievements, RAC/IRC/ IMC/QRT meeting, land assets and RMPs etc. Various MIS reports can be generated form the system related to Institutes, Projects, Budget Utilization, Output, Achievements and Awards etc. Dashboard functionality provides the real time statistics. The portal was opened for all institutes to upload data.

KRISHI Portal: Knowledge based Resources Information Systems Hub for Innovations in Agriculture consisting of six repositories namely Technology Repository, Publication Repository, Experimental Data Repository, Observational Data Repository, Survey Data Repository and Geo-portal developed at IASRI was monitored and reviewed for strengthening the system. The new features added into the system are: Information System on AICRP on Farm Implements and Machinery; Information System on AICRP on Post Harvest Engineering and Technology; Developed Dashboard facility with graphic displays; Added simple and advanced search both in Video/Audio Gallery (Also strengthened it by adding the links of more than 600 more videos.);Quality Research Data Acquisition Guidelines.

Krishi Vigyan Kendra Knowledge Network Portal (http://kvk.icar.gov.in/): 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 new modules added into the system are: Module for DBT Schemes (Training, FLD and OFLD); Module for Krishi Kalyan Abhiyan (KKA); KVK Mobile App for capturing the activities under KKA-II initiative.

INTELLECTUAL PROPERTY AND TECHNOLOGY MANAGEMENT UNIT

Innovation management

Patents: During the period under report 33 new patent applications were filed pertaining to varied sectors of agriculture. Thus the cumulative figure has now risen to 1,078 applications. Indian Patent Office (IPO) had published ICAR's 57 patent applications in this period, which were filed in 2015 (4), 2016 (37), 2017 (15), and 2018 (1). Further, the IPO had granted the 47 patent applications, taking ICAR's cumulative

Drtails of patents granted and filed

Subject	Granted	Filed
Animal Husbandry	Animal concentrate feed mix with curcuma aromatica for reduction of methane; estimation of tannin metabolites in blood serum and cow milk using HPLC; method for producing an effective vaccine against salmonellosis using gamma radiation; mineral mixture as nutrients for small ruminants; portable insulated container for hygienic transport of packaged meat; powered animal feed mixer; process of preparing a spore inhibition based enzyme substrate assay for monitoring aflatoxin in milk.	The indicator impregnated strip for detection of Neutralizers in milk; process for improving riverine buffalo sperm viability and uses; process for manufacture of low-fat *Chakka and Shrikhand*; recombinant non-structural proteins NS1 and NS3 as fusion protein (rNS1-NS3) based immuno-diagnostic assay for bluetongue; RESMI - a composite feed additive for reducing methane emission and improving fibre utilization in ruminants.
Crop Production	Amorphous formulation of entomo-pathogenic nematodes as biopesticide; anti-oxidant and anti-bacterial *di-aryl-indazol-3-ols* and their method of preparation; biosynthesis of zinc oxide nanoparticles; insect oviposition and egg collection apparatus; insect trapping device light trap for managing insects; nano-encapsulated hexaconazole: preparation of liquid pesticidal concentrates of neem meliacin(s).	Composition for managing potato cyst nematode infestation; CRISPR assisted cleavage polymorphism; *Dorsa delta* – an insect attractant trap for mango fruit fly; herbal swabber for revival of coffee stem borer infested plants; *in-vitro* plant acclimatization; novel bio-formulation for potassium fertilizer supplement and process of preparation.
Fish (Aqua/ Marine) Products and Processes	Method of producing *phytase* extracellularly from thermophilic bacterium; process to concentrate anti-inflammatory principles from green mussel *Perna viridis* l. and a product; process to prepare antioxidant and anti-inflammatory concentrates from brown and red seaweeds.	Bacteriophage consortium for biocontrol of luminescent vibrios in shrimp aquaculture; Microbial Consortia for mitigating the nitrogenous metabolites in shrimp aquaculture ponds; product containing anti-hypothyroidism principles from seaweed and a process.
Post-Harvest Technologies	Animal feed crusher; biological softening of lignocellulosic; jute fibre reinforced composite moulded tile and method for producing the same; jute-synthetic blended woven geotextile material; method for isolating aloin by extraction from yellow sap of aloe; method of producing blended yarn from jute and hollow polyester, and method of preparing union fabric and shawl from the said blended yarn; process for dehulling guar seed for refined guar gum split production.	Automatic washer cum singulating system for spherical fruits; CIRCOT Ecofriendly, efficient and rapid burning crematorium; Combine harvester; device for hydroponic culture of plants; iron fortified mushroom and process of producing thereof; simulation and pickup mechanism for bare root seedlings of onion; split cell type metering mechanism for automatic transplanting of vegetable seedlings and the like.

number of granted patents to 259. In this process 42 ICAR institutes were involved to protect their innovations.

To protect the plant varieties, 13 varieties (10 extant and 3 new varieties) were filed at Plant Varieties and Farmers' Rights Authority (PPV&FRA). For applications filed earlier, 30 varieties (23 extant and 7 new) were granted registration certificates during this period; which raised the cumulative figure of registered varieties to 830. The cumulative total for plant variety protection applications rose to 1218.

Other IPR tools used for innovation management at ICAR institutes

IPR Tools	Copyright	Trademark	Designs
Application Filed (Cumulative)	44 (154)	13 (115)	3 (26)
Institute Involved (Cumulative)	11 (27)	13 (31)	3 (6)
Type/Category	Computer Software; Literary/ Dramatic	Word; Device	Prototypes

Other Intellectual Property Rights (IPRs) tools were also used to protect computer software, literary work, products, words, logos, prototypes etc. developed by ICAR institutes in different research and development activities.

Capacity building

ICAR institutes (25) organized 48 awareness generation programs/ interface/ product-specific meets/ workshops/ seminars, wherein 3,495 scientists/ researchers/ business professionals/ farmers/ social workers benefited. These *inter-alia* included:

Agri-business meets: Interaction meet with agricultural machinery manufacturers at India Industrial Fair, Jaipur and Rashtriya Krishi Mela Raipur; interaction meet on export of litchi to middle east countries in collaboration with APEDA; stakeholder meet on pomegranate value chain etc.

Entrepreneurship Development Programmes (EDPs): Beekeeping; coconut value addition; custom hiring of agricultural machinery as an enterprise;

Technology Transfer/Commercialization

This year, 621 partnership agreements were firmed up with 362 public and private organizations and 38 entrepreneurs by 38 ICAR institutes in different Subject Matter Divisions. Out of these 621 partnerships, 64 were IP protected technologies (i.e. for Design/ Patents/Trademark/Copyright/Plant Variety Protection) partnerships. These agreements were signed for 128 technologies of agriculture and its allied sciences. These partnerships, classified according to their subject domain, are as follows:

Subject area	Number of partnerships
Animal based food products	10
Animal nutrition	7
Milk adulteration kits	14
Milk based food products	5
Farm machinery	21
Fish nutrition	3
Fish production and processes	33
Fruit based food products	43
Plant nutrition	40
Crop production technologies	149
Seed planting material	94
Plant protection	180
Post-harvest technology	8
Processes for cosmetic products	4
Textile processing technology	10

cassava-based agro-enterprises; milky mushroom cultivation; and utilizing village incubation centre etc.

Seminars: Entrepreneurship development; entrepreneurship development for sustainability of vegetable processing industries; tissue culture, nursery and value addition in horticulture crops etc.

Training: Capacity building among women self-help group members through inclusive financial literacy for entrepreneurship and innovation; Indian patenting procedures and commercialization; intellectual property rights; IP valuation and tech management; patent drafting, PPVFR Act and farmer's rights; prior-art search; Skill India and Agri-Startups etc.; start-up opportunities based on agricultural engineering technologies.

Workshop: PPV&FR Act, 2001 and Exhibition on Agro biodiversity; horti-entrepreneurship; importance of intellectual property rights (IPR) and its relevance in agriculture; women empowerment through innovation and creativity; intellectual property rights at experimental fish farm and field centre; Start-Up India programme for aquaculture sector etc.

The scientific and technical staff (55) were deputed to attend capacity building programmes to expose them to specific nuances of intellectual property and technology management issues.

Agri-business incubation (ABI): This initiative addresses the much-needed requirements of business incubation for converting agriculture technologies into an attractive commercial proposition. Accordingly, 25 ABI centers were supported/established in various institutes. These ABIs undertaken different activities to facilitate the business environment in the ICAR institutes, which include, Entrepreneurs/Incubators admitted for incubation (377); Entrepreneurs/Incubators graduated (203); Entrepreneur/ Startups Initiated their business (161); New products/ technologies developed under incubation (78); Entrepreneur Development Programme (EDPs) organized (80); Agri-business Development/Awareness Programmes Organized (293), Meeting Organized for Negotiations/Technology Discussions (354). These ABI Centers were visited by 2,556 Technology Seekers/Inventors/Business People/VIP/VVIP/ Foreigners.

Agri-Startup and Entrepreneurship Conclave

Council had organized a two days Agri-Startup and Entrepreneurship Conclave for *Unleashing potential in agriculture for young agripreneures* (UPAYA) on the World Food Day during 16-17 October, 2018 at NASC Complex, Pusa New Delhi. The Conclave was inaugurated by Shri Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmers Welfare, with Shri Parshottam Khodabhai Rupala, Hon'ble Union Minister of State for Agriculture and Farmers Welfare.

Start-up success stories

M/s. Greyy, Navi Mumbai, is incubatee for technology on development of clothing using cotton blend. This technology was developed by ICAR-CIRCOT, Mumbai, for nano-finishing technologies of textiles, which shows good functional properties like UV-protection, anti-microbial, and moisture wicking properties. The institute has expertise on blending technology of different textile grade fibres. M/s Greyy launched a t-shirt with this technology, which are quick drying (dry in half the time compared to normal cotton), wicks away moisture quickly, keeping the wearer dry and the fabric was infused with silver to make it anti-bacterial, and thus making it anti-odour.

Mrs. Savita Kovind, The First Lady of India visiting M/s. Greyy stall at FINE-2018: The start-up has completed first phase of technology mentoring and resident incubation period in progress. They have also started test marketing through various agencies. Business volume for the period 2017-18: ₹ 33 lakh.

M/s Natura Crop Care, Bengaluru: Mr Manoj Kumar, a doctoral graduate joined as an Onsite incubatee with ICAR- IIHR, Bengaluru by licensing Arka Microbial Consortium (solid and liquid), Decomposer, Neem Soap and Pongamia Soap Technologies. ABI Center of ICAR-IIHR provided office space, production space on rental basis and provided the necessary technical support for Natura Crop Care to establish itself. The startup also provided a marketing network through ICAR-IIHR's sales network for 1 year. Within a span of two months, they generated revenue to the tune of ₹ 1.0 lakh

Festival of Innovation and Entrepreneurship (FINE)

Shri Ram Nath Kovind, Hon'ble President of India, inaugurated the FINE, a week-long annual event, at Rashtrapati Bhavan on 19 March 2018. ICAR provided an excellent platform to its 20 Start-ups/Entrepreneurs/ Innovators for building the linkages with potential stakeholders. The Union Minister for Science and Technology, Earth Sciences and Environment, Forest & Climate Change, Dr Harsh Vardhan, the Secretary, Department of Science and Technology, Prof. Ashutosh Sharma, the Secretary (DARE) and Director General (ICAR), Dr Trilochan Mohapatra and other dignitaries were also present on the occasion.

Hon'ble President visited the start-up stall of ICAR-Indian Institute of Spices Research. The Start-up entrepreneur, Dr Chaitra Narayanan, M/s Codagu Agritech from Kushal Nagar, Karnataka presented a brief summary about her initiative. The technology comprising encapsulating delivery of agriculturally important microorganisms (biocaspules), is a patented technology developed at ICAR-Indian Institute of Spices Research is expected to herald a revolution in biofertilizer industry.

The programme was also graced with the presence of Shri Dharmendra Pradhan, Minister of Petroleum and Natural Gas; Minister of Skill Development and Entrepreneurship, and Shri Gajendra Singh Shekhawat, Hon'ble Union Minister of State for Agriculture and Farmers Welfare. About 700 participants attended the Conclave which includes 104 ICAR (ABI-Network) nurtured agri-startups/entrepreneurs/licensees from different corners of the country. It provided a unique platform for bringing together agri-professional, business experts, researchers and Farm Producers Organizations (FPO) in a face to face mode, same time country's finest mentors, angel investors, and venture capitalists were also interacted in different technical domains.

The platform was also equipped with an exhibition of agri-startups/entrepreneurs/licensees on farm machinery, fish gadgets, plant protection methods, post-harvest technologies, and seed and planting material, for sharing of success stories and explored business and marketing linkages, technology and financial tie-ups and partnership opportunities. It created the desired awareness and helped build an entrepreneurial environment particularly in agriculture sector with participation of various stakeholders such as the government, corporate, educational institutions and others who were interested to join hands and together built a better ecosystem for entrepreneurship in agriculture sector

The book, *AgRIM-Agri-Startups: Reflection of ICAR Technologies in Market*, is a compilation of profile of 100 Agri-Startups of different domains of agriculture and allied areas. These startups were supported by ICAR.

Smart India Hackathon 2018: AICTE under the aegis of MHRD, NIC, and MyGov launched Smart India Hackathon 2018 on 16 October 2017. The Smart India Hackathon 2018 focusses to develop innovative solutions for the various set of problems and challenges not only from various central ministries, but also from state governments and to some extent from industries and society as well. The Grand Finale of Smart India Hackathon (SIH) 2018 for problem statements shortlisted by ICAR was organized during 30-31 March 2018 at Chandigarh. The event was jointly hosted by Department of Agricultural Research and Education and Department of Agriculture Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare.

The Prime Minister, Shri Narendra Modi addressed and interacted with the participants of SIH 2018 through video conferencing on 30 March 2018

Smart India Hackathon 2018

After the three rounds of judging, 10 teams were selected for the power judging round wherein all the teams presented their software and finally three teams were awarded with the cash prize of ₹ 1 lakh, 75,000, and 50,000 respectively.

Change over form IS/ISO 9001-2008 to IS/ISO 9001:2015: The certificate of Quality Management Systems (IS/ISO 9001-2008) was granted to DARE/ ICAR by Bureau of Indian Standards (BIS) for three years (from 04.07.2013 to 03.07.2016) to improve the office management system to satisfy the customers, i.e. ICAR institutes. This certificate was renewed for next three years. Now, DARE/ICAR has upgraded the existing Quality Management Systems IS/ISO 9001-2008 to QMS IS/ISO 9001-2015, which focused on customer satisfaction.

To equip with knowledge about new standard and auditing system, a training programme on *Awareness and Internal Audit Training on IS/ISO 9001:2015,* was organized. In these training programmes 139 ICAR staff members were trained. These trained auditors will now be able to conduct an Internal Audits.

PROGRESSIVE USE OF HINDI

Individual orders were issued in November 2018 to officers/employees of the council possessing proficiency in Hindi to do their cent percent administrative work in Hindi. Till date 133 ICAR Institutes/ Centers have been notified in the Gazette under Official Language Rule 10(4). In addition to this, 16 sections of ICAR Hqrs were specified under rule 8(4) to do their cent percent administrative work in Hindi.

- Meetings of the Joint Official Language Implementation Committee of DARE and ICAR were held on 19.12.2017, 4.4.2018, 19.6.2018 and 26.9.2018 under the chairmanship of Special Secretary, DARE and Secretary, ICAR.
- In most of the ICAR Institutes/Centres Official Language Implementation Committees have been constituted and their meetings are being conducted regularly. Proceedings of these Committee meetings are received at the Hqrs. and appropriate suggestions and guidelines are given to the concerned institutes for their effective implementation.
- The quarterly progress reports are being sent On-line to the Regional Implementation Office. The quarterly progress reports received from various Institutes were reviewed and suggestions were given to them for effective implementation. ICAR Hqrs regularly participated in TOLIC's meetings.
- The employees were nominated for Hindi language, Hindi typing and shorthand training in every session. At Headquarters, training in Unicode typing is also being imparted by the Hindi Anubhag.
- During the year, four Hindi Workshops were conducted: Hindi Noting and Drafting writing, The role of Information Technology in Scientific Writing, Hindi workshop for Hindi officers and fourth for Section Officers and Accounts Officers.
- *Hindi week/Pakhwara/*Chetna Maah was organized during 14 September 2018 to 29 September 2018 at Headquarters and its institutes.
- During the period under report, Cash Awards were given to 10 pessonnel of Headquarters for doing their maximum official work in Hindi under the cash award scheme of Official Language Department. Besides, these schemes, we have started two more schemes at council level.

Rajarshri Tandon Rajbhasha Purskar Yojana: Under this scheme Institutes situated A, B & C region are awarded for their excellent implementation of official language in various categories. During the year 2016-17, following Institutes were awarded for doing their maximum work in Hindi:

	Big Institutes	Award
1.	Indian Sugarcane Research Institute, Lucknow	First
2.	Indian Agriculture Research Institute, Pusa, New Delhi	Second
	Institutes/Centres of 'A' and 'B' Region	
1.	Central Cotton Research Institute, Nagpur	First
2.	National Bureau of Plant Genelic Resourses, New Delhi	Second (Joint Prize)
3.	Central Institute for Arid Horticulture Bikaner,	
	Institutes/Centres of 'C' Region	
1.	Central Marine Fisheries Research Institute, Kochi.	First
2.	Central Coastal Agriculture Research Institute, Goa	Second

Ganesh Shankar Vidyarthi Hindi Patrika Purskar yojana: Under this scheme Institutes are awarded A, B & C region-wise for Hindi magazine published by them. During the year 2016–17, the following Magzines of Institutes were awarded:

- In accordance with the Instructions/Orders of Official Language Deptt. M/o Home Affairs, 24 Institutes were inspected during 2018 and suggestions were given for effective implementation of Official Language and to rectify the shortcomings observed during the inspection. This includes inspections of Parliamentary Committee on Official Language.
- House magazine of ICAR Hqrs. *'Rajbhasha Alok'* -2017 was released on 16.07.2018 on the occasion of the foundation day of the Council.
- Various training programmes for the farmers are being organized in Hindi and regional language by various ICAR Institutes. There has been a significant progress in the use of Hindi and other regional language in respect of the agriculture activities being undertaken by the KVK's and the Council.
- Cabinet Notes, Audit Accounts, Annual Plan, SDG, GB, Parliamentary Standing Committee

Name of magazine	Name of the Institute	Award
	A &B region Institutes	
Pusa Surabhi	Indian Agriculture Research Institute, Pusa, New Delhi.	First
Swarnima	Indian Institute of Wheat and Barley Research, Karnal	Second
Laksha	Indian Institute of Natural Resins and Gums, Ranchi	Third
	Institutes/Centres of 'C' Region	
Nilanjali	Central Inland Fisheries Research Institute, Barrackpore.	First
Masalo ki Mahak	Indian Institute of Spices Research, Kozhikode.	Second
Bagawani	Indian Institute of Horticulture Research, Bengaluru.	Third

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.

FINANCE

The Revised Estimates of DARE/ICAR for 2017–18 was ₹ 6,992 crore. An Internal resources of ₹ 251.82 crore (including interest on loans and advances, income from Revolving Fund Schemes and interest on Short Term Deposits) was generated during the year 2017–18. The total allocation Budget Estimate for 2018–19 is ₹ 7,800 crore.

TECHNICAL COORDINATION

During the ICAR Director's Conference, organized during 7–9 March 2018, the relevant academic, administrative and financial matters pertaining to research institutes were deliberated upon in detail and important decisions were taken.

Meetings of ICAR Regional Committees No. I, II, IV and V were held on 11–12 June, 2018, 23–24 June, 2018, 6–7 July, 2018 and 2–3, November, 2018 at Srinagar, Bhubaneswar, Ranchi and Karnal, respectively. The Regional Committee Meetings held once every two years, provide an ideal platform for reviewing the status of agricultural research, education and extension in the mandated states and union territories. The problems being faced by the states in agriculture and related fields and the technology options/ potential solutions available to be developed by the NARS system were discussed threadbare and actionable points were identified and assigned to the respective institutes/ universities/KVKs to be resolved in a targeted time frame. The action taken on the issues raised in the previous Regional Committee Meetings, was also reviewed.

During the reported period the Council provided financial support to 69 societies for the publication of Scientific Journals. In addition, Societies/associations/ universities were supported for holding National Seminars/ Symposia/Conferences (58) and International Seminars/Symposia/Conferences (21). Annual Report (2017–2018) of DARE/ICAR was laid on the table of both houses of parliament.

Awards

MoUs (24) were signed with the Central/State Universities and other Departments to co-operate in conducting research through All India Coordinated Research Projects (AICRPs)/Revolving Fund Scheme/ and any other such schemes funded/sanctioned by the Council under various schemes to the Host Institution from time to time at specified location(s) under the specified Supervisor/Principal Investigator/Leader of the Host Institution.

ICAR Awards 2017

Incentivizing individual employees and teams for their outstanding performance, across organizations, make them more efficient, responsive and productive apart from improving their level of job satisfaction. The Indian Council of Agricultural Research has been recognizing and rewarding the institutions, scientists, teachers, farmers and agricultural journalists every year. Various ICAR Awards for year 2017 were given in 17 different categories to 168 awardees. These comprise 116 scientists, 24 farmers, 3 institutes, I university, 2 AICRPs and 14 KVKs. It is heartening to note that out of the 116 scientists and 24 farmers, 23 were women scientists and 3 women farmers.

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17. Partnership and Linkages

DARE

International collaboration

Consultative Group on International Agricultural Research (CGIAR) is an international organization having close collaboration with Department of Agricultural Research and Education (DARE) and Indian Council of Agricultural Research (ICAR). It works through its 15 Research Centres. India is a donor member of CGIAR System from decades. Accordingly, it contributes to CGIAR System through Plan and Non Plan budget provision. Out of these 15 Centres, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has its headquarters at Hyderabad in the State of Telangana, India. The remaining CGIAR research organizations have headquarters elsewhere, but have strong presence in India in the form of a country or South Asia representative offices in India. India is also a permanent voting member in CGIAR System Council and has assumed important role in CGIAR System as a voting member. This responsibility requires reciprocation from India also.

Activities carried out with CGIAR System and its Centres, are as follows:

Work plan

- Work plan between ICAR and International Potato Centre (CIP) signed on 20 Mar 2018;
- New Work Plan between ICAR and World Fish (WFC) signed on 3 May 2018,
- Work plan between ICAR and International Wheat and Maize Improvement Centre (CIMMYT) singed on 1 June 2018,

ICAR - CIMMYT sign work plan

- Work plan between ICAR and International Water Management Institute (IWMI) signed on 25 June 2018; and
- Revised work plan between ICAR and Bioversity International signed on 9 Nov 2018.

Work plan signed with IWM

Collaborative research projects

- Scaling breeding and agronomic management for increasing wheat productivity and adaptation to climate change causing rising temperature and water scarcity in South Asia, for a period of three years.
- Enhancing resource-use efficiency and farmer's income through Conservation Agriculture (CA), Technologies in Pulses under different rainfed cropping systems, in collaboration with ICAR-IARI, New Delhi and ICARDA for a period of five years.
- Bio-fortification of lentil for Bihar, submitted by ICAR-IARI, New Delhi to be funded by HarvestPlus (CGIAR Bio-fortification Challenge Programme) for a period of four years.

Cooperation with international organisations

Six consultancy proposals were finalized and 16 International Conferences were held during the reporting period. ICAR-CABI Work Plan 2018–20 was signed on 19 September 2018 under Memorandum of Understanding for scientific and technical cooperation.

ICAR–CABI discuss work plan

MoUs/Workplans signed

The ICAR signed MoU and Workplans with international agencies for research and development.

Following MoUs were signed during the reporting period:

- ICAR and University of Copenhagen, Faculty of Science, Denmark
- ICAR and Rwanda Agriculture and Animal Resources Development Board
- ICAR and Agricultural Research Council (ARC), South Africa
- ICAR and Western Sydney University, Australia

ICAR signs MoU with the WSU, Australia for Research and Technical Collaboration

The following Workplans were signed during the reporting period:

- Workplan 2018–19 under the MoU between ICAR and Papua New Guinea–University of Technology

ICAR signs work-plan 2018–29 with the Papua New Guinea University of Technology

- Workplan 2018–20 under the MoU between DARE, M/o Agriculture, India and Ministry of Agriculture and Food Industry, Socialist Republic of Vietnam
- Workplan 2018–19 under MoU between M/o Agriculture of India (in DARE) and Ministry of Agricultural Development of Republic of Panama

Collaborative Research Projects of ICAR

Total 14 collaborative projects were approved during the year.

- Evaluation of Stress Tolerant Orphan Legumes for use in Dryland Farming Systems Across sub-saharan Africa and India-Promoting India-Africa Framework for Strategic Cooperation between ICAR-NBPGR and Kirkhouse Trust Unit 6, Fenlock Court, Blenheim Office Par, Long Hanborough Oxfordshire, England
- Optimizing sustainable use of forests whilst minimizing impacts of emerging zoonotic diseases: co-developing an interdisciplinary tool for forest ecosystems in India between ICAR-National Institute of Veterinary Epidemiology and Disease Informatics (NIVEDI), Bengaluru and Medical Research Council (MRC), NERC Centre for Ecology and Hydrology, Swindon, UK
- Benchmarks for ecosystem assessment: Indicators and guidelines for practical ecosystem based fishery management (EBFM) for a period of three years between ICAR-CMFRI and CSIRO, Australia
- Development of an early warning system for economically important livestock diseases between ICAR-NIVEDI, Bengaluru and CE&H, UK
- Improving Water Management, Agricultural Fund and Food Security in Drought Prone Areas, funded under US-India 21st Century Knowledge Initiative Grant Program of United States-India Educational Foundation (USIEF)
- Evaluation of POLY-4 (Polyhalite) in maize and wheat for enhanced yield, K and S use efficiency
- Indo-Norwegian Initiative for sustainable and functional aqua feeds (INAFEED), in the identified priority area of Aquaculture in collaboration with the National Institute of Nutrition and Seafood Research (NIFES), Norway for a period of three years (in-kind contribution by CIBA + NOK; Research Council of Norway)
- Fisheries Sector: Coastal Vulnerability Assessment for Local Self Government
- Fingerprinting Rice: Implementing a System to Monitor and Manage Global Food Fraud
- Molecular Markers for improving Reproduction of Cattle and Buffaloes
- Belgian-Indian Networking in the field of the GMO research and analysis, under Indo-Belgian Research and Technology Cooperation (Topping-up grant submission dossier) to the Department of Science and Technology (DST)
- Oil palm germplasm exchange for R&D between India and Malaysia
- C.R. Edit-CRISPR/Cas9 editing to test and control genes implicated in influencing Aeromonas disease resistance in carp and salmon, funded by DST NRC
- Off-grid, clean energy cooling for affordable storage of perishables for BOP farmers, received from ICAR-IARI, New Delhi for financial assistance from 'Partnership for Enhanced Engagement in Research (PEER), US-National

Academy of Sciences' as stage 2 of already implemented project entitled, Low carbon footprint cool storage structures to empower farmers, and improving storage and enabling processing of perishable produce, funded by GCFSI (Global Centre for Food Systems Innovation) and in-kind contribution of ICAR-IARI.

Germplasm exchange

The cases of export of germplasm are processed in IC- Division as per the provisions/guidelines of the Biological Diversity Act, 2002 and the Biological Diversity Rules, 2004 also subject to guidelines/ notifications issued by Ministry of Environment and Forests, from time to time. In the area of exchange of genetic resources, cases from concerned scientists of ICAR through authorized national bureaus on the basis of signed/agreed collaborative research projects involving ICAR, were processed in accordance with the provisions of Biodiversity Act and further guidelines notified in this regard. Approval of competent authority in respect of 5 cases was conveyed.

Annual Membership contribution

Contribution for Annual Membership were released for Centre for Agriculture Bioscience International (CABI), UK; International Seed Testing Association (ISTA), Switzerland; International Society for Horticultural Science (ISHS), Belgium; and Centre for Sustainable Agricultural Mechanization, (CSAM) (Regional Institution of UN ESCAP), Beijing.

Foreign visits for ICAR Scientists which were organized/funded by CSAM (10) and CABI (4) were finalized**.**

Agricultural Research Collaboration

Indo-SAARC: India has been collaborating in promoting Agricultural Sectoral Research and Developmental activities in the SAARC Region. Participation of DARE/ICAR was confirmed in the various SAARC programmers. Several trainings were conducted successfully. Institutional charges were waived off for the SAARC Programmes held at ICAR Institutes.

- An Exposure visit was undertaken to Bangladesh for Conservation Agriculture for Sustainable Intensification of Agriculture, Commercial Vegetable Production and Rural Development in Bangladesh, from 26 to 31 March 2018. Dr A.K. Biswas, Principal Scientist, IISS Bhopal participated in the meeting.
- Dr K. Selveraj, Scientist NBAIR, Bengaluru and Muktesh Kumar Khokhar, Scientist, NCIPM attended the SAARC Expert Consultation Meeting on 'Best Practices of Integrated Plant Nutrition System (IPNS) in SAARC countries' on 28–31 May, 2018 at BARI Bangladesh.
- Climate Smart Agriculture Conference for SAARC Countries held at NAARM, Hyderabad from 17 to 19 April 2018.
- SAARC/SAC Regional training programme on Field Epidemiology Training Programme for the Veterinarians (FETPV) held from 15 to 23 May 2017 at ICAR-NIVEDI, Bengaluru.
- A Regional Training Programme for SAARC Countries on Mass Breeding and Culture Techniques of Catfishes, was held at ICAR-CIFE, Bhubaneswar, from 16 to 21 July 2018.
- Regional Consultative Meeting for Exchange of Rice Based Production and Value Chain Development Technologies in SAARC Member States from 13 to 19 August 2018 in India (NRRI Cuttack).
- Regional Expert Consultation on 'Women's Empowerment for Agriculture Development in South Asia: Enabling Policies' jointly was organized by SAARC Agriculture Centre (SAC), Dhaka, Bangladesh at ICAR-Central Institute of Women in Agriculture (ICAR-CIWA), Bhubaneswar, India from 5 to 7 September 2018.
- Training Programme on Integrated Nutrient Management for Improving Soil Health and Crop Productivity, was held from 5 to 10 Sep 2018, in IISS, Bhopal, India.
- Dr G.A.K. Kumar, Principal Scientist, NRRI and Dr R.N. Padaria, Professor, IARI attended the First SAARC Agriculture Cooperative Business Forum to Attain SDG-1 and SDG-2 in South Asia, from 28 to 30 August 2018 at Kathmandu.

Indo-ASEAN Research Collaboration

DARE hosted the 4th ASEAN India Ministerial meeting on Agriculture and Forestry during the period from 11 to 12 January 2018, and was attended by representatives from 10 ASEAN Countries and ASEAN Secretariat. The meeting was co-chaired by India's Minister of Agriculture and Farmers' Welfare Shri Radha Mohan Singh and Thailand's Minister of Agriculture and Cooperation Grisada Boonrach.

The meeting aimed to facilitate promotion of joint research for development of technologies for increasing production and productivity of crops, livestock and fisheries, and natural resources management, among others in the region; development of joint ventures, exchange of technologies, expertise and material; enhance cooperation on exchange of expertise to promote resilience in food security to address the price volatility of food supplies in the region. The discussions held during meeting, focused on enhancing cooperation on exchange of expertise to promote resilience in food security and to address the price volatility of food supplies in the region.

The Medium Term Programme of Action, ASEAN-India Cooperation in Agriculture and Forestry (2016–2020) was also endorsed by 4th AIMMAF. In the Plan of Action (2016–2020), the various collaborative projects/training programmes and other action programmes, i.e. organize meetings of AIWG on Agriculture and Forestry, publication of ASEAN-India Newsletter on Agriculture and Forestry, organize

4th ASEAN-India Ministerial Meeting on Agriculture and Forestry

ASEAN-India Agri-Expo and organize an ASEAN India Ministerial Meeting on Agricultural and Forestry. The 4th AIMMAF also supported the prioritization of joint collaborative projects in the areas of (*i*) Agroforestry interventions for livelihood opportunities, (*ii*) Demonstration and exchange of farm implements and machinery, and (*iii*) Genetic improvement of parental lines and development of heterotic rice hybrids. The 4th AIMMAF also emphasized on more capacity building programmes in different areas of Agriculture and forestry.

Indo BIMSTEC Research Collaboration

During the reported period, BIMSTEC held meetings and workshops on issues important for BIMSTEC Member States. Participation of this Department was ensured by nominating suitable Officers/Scientists from DARE/ICAR.

Indo Afghanistan Research Collaboration

Indian Agricultural Research Institute (IARI) is playing an important role in developing trained human resource for agricultural research in Afghanistan and establishing Afghan National Agricultural Sciences and Technology University (ANASTU) at Kandahar in Afghanistan, with the support of the Ministry of External Affairs (MEA), Government of India under the bilateral cooperation programme between Afghanistan and India. Besides Agronomy, syllabi for the MSc courses in Agricultural Economics, Plant Protection, Horticulture and Animal Husbandry for ANASTU were developed. A proposal to establish Afghanistan Agro-Biodiversity Genetic Garden (AAGG) at ANASTU, Kandahar, was submitted to MEA for approval. Another proposal to establish Tele-Teaching facility at ANASTU, Kandahar and IARI, New Delhi, was submitted to the MEA for approval. The proposal of ANASTU to include the Logo of IARI in the degree awarded by ANASTU was approved in principle by the IARI.

Indo Myanmar Research Collaboration

Revised Post Graduate Handbook of Yezin Agricultural University (YAU) was released by the Minister of Education, GOUM on 2 April 2018 in the presence of the Ambassador of India to Myanmar. Three new postgraduate programmes (MSc and PhD) (Agricultural Extension Education; Molecular Biology and Biotechnology; and Food Engineering and Technology) were initiated from the first semester of the academic session 2017–18. Thirteen courses were identified to be delivered by the IARI faculty from India during the Second semester of the current academic session between May and September 2018.

Admission to MSc and PhD programmes under ACARE for three academic sessions were approved by MEA. Four MSc students (2 in Post-Harvest Technology; and 1 each in Genetics and Agricultural Extension) were admitted to IARI in the current academic session.

Four villages within a radius of 30 km of ACARE were adopted under Participatory Knowledge Management programme for demonstration of suitable production techniques. The requisite laboratory consumables and relevant ICAR were supplied.

Agrinnovate India Limited

Agrinnovate India Limited is steadily moving towards meeting its objectives and building 'A World of Innovative Partnerships'. The company has achieved revenue from operations of ₹ 354,634 as against ₹ 1344,222 in the Financial Year 2017–18. The depreciation was registered during the Current Year at ₹ 1,345,126 as against ₹ 1,886,178 for the previous year 2016–17. In the Financial Year 2017–18, the company has earned Net Profit of ₹ 15,839,715 as against Net Profit of ₹ 21,052,092 in Financial Year 2016–17.

Business development activities: AgIn participated in various workshops and National level meets and is

also in process of collaborating with Asia-Pacific Centre for Technology Transfer (APCTT), MANAGE, TRVP-TANUVAS, IICA, ABIC, Nepal and African-Asian Rural Development Organization (AARDO) and Association of South East Asian Nations (ASEAN), Russian Far East Federation.

Promotional activities: AgIn actively collaborated with African-Asian Rural Development Organization (AARDO) and also strengthened the association with ASEAN Secretariat for organizing International capacity building programmes and other projects. AgIn also organized a Sensitization Workshop for all the State Agricultural and Veterinary Universities and apprised them of the operations and guidelines that were in place.

Technology transfer: AgIn was able to successfully complete the technology transfers for Micronutrient Foliar Formulations for site-specific nutrient management of Tropical Tuber Crops; Vivek Millet Thresher-cum-Pearler; VL Insect Trap; VL Syahi Hal; CMVL Baby Corn 2; Mineral mixture for sheep and goat; Anionic mineral mixture for reducing post-partum problems in cattle and buffaloes; Decision support system for grapes.

Policy initiatives: The Board approved the commercialization activities for ICAR Institutes and National Agricultural Research System (NARS).

Implementation of commercialization guidelines: AgIn organized Techno-commercial and Expert committee meetings for select technologies of various ICAR Institutes like CCARI-Goa, CIAE-Bhopal, CIBA-Chennai, CIPHET-Ludhiana, CIRB-Hisar, CPRI-Shimla, CSSRI-Karnal, CTCRI-Kerala, DGR-Junagadh, IIHR-Bengaluru, IIMR-Hyderabad, IINRG-Ranchi, IIRR-Hyderabad, IISR-Kerala, NBAIM-Mau, NDRI-Karnal, NIANP-Bengaluru, NRC on Meat-Hyderabad, NRCG-Pune, VPKAS-Almora.

CENTRAL AGRICULTURAL UNIVERSITY, IMPHAL

The Central Agricultural University, Imphal, having 13 constituent colleges is a fully residential university covering all the north-east hill states under its jurisdiction except Asom. Currently the University is celebrating 25 years of its existence. The University offers 9 Undergraduate, 38 Masters and 23 PhD Degree programmes in different subjects/ disciplines at its 13 constituent colleges. A total of 2,153 students are currently studying in the university (including the newly admitted students in Undergraduate 488; Post graduate 191 and PhD 36 students). The University has been placed at 13th rank in the ranking status of Agricultural Universities for the year 2017 by ICAR, New Delhi. Recently the university has also been awarded the prestigious University of The Year (in existence for 11–30 years) in the 5th FICCI Higher Education Excellence Awards 2018 by the Federation of Indian Chambers of Commerce and Industry. At present the university has 69 ongoing internally funded research projects and 117 numbers of externally funded projects including 35 All India Coordinated Research Projects (AICRPs) and 4 All India Network Research Projects (AINRPs). A total of 143 location specific recommendations and scientific findings in agriculture and allied sciences for NEH region were developed by the university till date. The university has established 6 Krishi Vigyan Kendras, 6 Multi Technology Testing Centres and 6 Vocational Training Centres in different parts of north east India in an effort for popularization of modern innovative and sustainable agriculture and agro-based allied activities in the region. During the year, the university organised 7 vocational training programmes of more than one month duration and benefitted 195 unemployed youths. A one day state level workshop on "Biodiversity and Sustainable Agriculture for Doubling of Farmers' Income" was organised on 18 April 2018 in the presence of Shri M. Venkaiah Naidu, Hon'ble Vice-President of India as Chief Guest. During the year the university has also signed MoU's with ICAR-CIFT, Kochi; Ayurvet Limited, New Delhi; Power Finance Corporation Ltd. (PFC), New Delhi and PCRA, Guwahati, for strengthening the academic, research and extension activities of the university.

RANI LAKSHMI BAI CENTRAL AGRICULTURAL UNIVERSITY, JHANSI

The Rani Lakshmi Bai Central Agricultural University, Jhansi, initiated PG education in Agronomy, Genetics and Plant Breeding and Plant Pathology. The seed production programme in pulses, mustard and millets was strengthened by establishing Seed Hubs sanctioned in the University. A new centre of AICRP on Rapeseed-Mustard at Jhansi, was established to promote cultivation of this important oil seed crop in the Bundelkhand region.

DR RAJENDRA PRASAD CENTRAL AGRICULTURAL UNIVERSITY, PUSA

Dr Rajendra Prasad Central Agricultural University, Pusa, Samastipur (Bihar) has presently six faculties, six colleges, seven research institutes/ stations and 14 Krishi Vigyan Kendras (12 with RPCAU and two with NGOs), 32-AICRPs, 3 international projects, 11 Government of India funded projects, 4 Government of Bihar funded projects, and 27 university-funded projects. The improved varieties—Rajendra Kauni (Foxtail) and Rajendra Neelam (aerobic rice), were released by CVRC, Rajendra Saraswati by SVRC and Rajendra Gehun-1 by university for different agro climatic conditions.

Foreign Deputation

ICAR scientists (64 scientists) were granted permission by this department for various fellowships/ training at foreign organizations/institutes during the reported period.

Sanctioned Foreign deputation proposals of DARE/ ICAR officials

- Deputation of Dr S.V. Sai Prasad, Head, IARI Regional Station, Indore; Dr M. Sivasamy, Head, ICAR-IARI, Regional Station, Wellington; Dr Vaibhav Kumar Singh, Scientist, Div of Plant Pathology, IARI, New Delhi; Dr Vikas V.K., Scientist, ICAR-IARI, Regional Station, Wellington; Dr Gyanendra Pratap Singh, Director, ICAR-IIWBR, Karnal; Dr Subhash Chander Bhardwaj, Pr. Scientist and Scientist, I/c Regional Station, ICAR-IIWBR, Shimla; Dr Sanjay Kumar Singh, Pr. Scientist, ICAR-IIWBR, Karnal; Dr Ravish Chatrath, Pr. Scientist, ICAR-IIWBR, Karnal; Dr D.P. Singh, Pr. Scientist and PI (Crop Protection), ICAR-IIWBR, Karnal; Dr Satish Kumar, Scientist, ICAR-IIWBR, Karnal, visited Marrakesh, Morocco to participate in BGRI 2018 technical workshop during 14–17 April 2018 under workplan 2017–21 signed between ICAR and the College of Agriculture and Life Sciences, Cornell University, Ithaca, New York.
- Dr Trilochan Mohapatra, Secretary (DARE) and DG, ICAR, visited Bangkok, Thailand to attend APAARI Executive Committee meeting on 28 May, 2018 followed by 'Regional Expert Consultation on Agricultural Biotechnology-Scoping partnership to improve livelihoods of farmers in Asia Pacific' during 29–31 May, 2018.
- Dr Anuradha Agrawal, Principal Scientist and Incharge, Tissue Culture and Cryopreservation Univt (TCCU), NBPGR, New Delhi, visited Bangkok, Thailand during 29–31 May, 2018 to attend 'Regional Expert Consultation on Agricultural Biotechnology-Scoping partnership to improve livelihoods of farmers in Asia Pacific'.
- Dr Joykrushna Jena, DDG (Fisheries), ICAR, and Dr J.K. Sundaray, Pr. Scientist and HoD, ICAR-CIFA, Bhubaneswar, visited Maldives during 26–28 June, 2018 to attend the 29th Network of Aquaculture Centres in Asia Pacific (NACA) Governing Council meeting (GCM-29).
- Dr Prabhakar Nanda, Pr. Scientist, ICAR-IIWM, Bhubaneswar, visited Cornell University, Ithaca, New York, USA, to attend training programme on 'Food and Agricuture Executive Management Programme' during 23 July–31 July, 2018 under workplan 2017–21 signed between ICAR and College of Agriculture and Life Sciences, Cornell University, USA.
- Dr Gaurav Rathore, Pr. Scientist and HoD, ICAR-National Bureau of Fish Genetic Resources (NBFGR), Lucknow, and Dr B Madhusudana Rao, Principal Scientist, ICAR-Central Institute of Fisheries Technology (CIFT), Kochi attended FAO-NACA regional consultation on anti-microbial resistance risk to aquaculture in Asia during 4–7 September 2018 in Bangkok, Thailand.
- Dr Gopalareddy K, Scientist, ICAR-IIWBR Karnal, participated in training on 'Marker assisted selection and breeding of Wheat rust resistance' from 1 to 30 September 2018 at Cornell University, Ithaca, USA during 1 to 30 September 2018 under ICAR-Cornell workplan 2017–21.

Foreign visits

Total 380 scientists' foreign visit approval were granted from IC-IV Section during the year 2018 (up to November 2018).

Foreign visit of Secretary (DARE) and Director General (ICAR)

- Dr Trilochan Mohapatra, Secretary, Department of Agricultural Research and Education (DARE) and Director-General, Indian Council of Agricutlural Research (ICAR), Krishi Bhawan, New Delhi, attended Award Ceremony at Marrakesh, Morocco from 14 to 16 April 2018.
- Participated in the 51st Annual Board of Trustees (BoT) meeting of Bioversity International from 9 to 11 May 2018 held in Rome, Italy.
- Participated in the pre-discussion meeting of International Livestock Research Institute (ILRI) and its Regional Meeting on 12–14 November 2018, held in Kathmandu, Nepal.
- Participated in the 52nd Bioversity International Board of Trustees (BoT) meeting from 25 to 28 November 2018 held in Washington DC, USA.

Foreign visit of Special Secretary (DARE) and Secretary (ICAR)

- Visited International Livestock Research Institute (ILRI) and International Center for Research in Agro-forestry (ICRAF) Headquarters in Nairobi to meet with their Senior Management/Scientists and Addis Ababa from 13 to 16 February 2018
- Participated in 6th CGIAR System Council meeting held in Berlin, hosted by Germany from 16 to 18 May 2018
- Participated 7th System Council meeting and pre-events from 12 to 16 November 2018 held in Seattle, USA

Foreign visit of ICAR s scientist(s)/officer(s) for participation in various programs organized by CGIAR Centres and under approved projects/MoUs/Work Plans

- Dr Shiv Prasad Kimothi, Assistant Director General (Technical Coordination) ICAR, New Delhi and Dr S. K. Dhyani, Principal Scientist (Agroforestry), ICAR, NRM Division, New Delhi, participated in the SAC–Donor Coordination Meeting on SAARC Regional Agricultural Projects at Kathmandu, Nepal, from 5 to 6 April 2018.
- Dr Tolety Janakiram, Assistant Director General, ICAR Hqrs, New Delhi attended SAARC Regional Consultation Meeting of Development of Country Specific Good Agriculture Practices, Standards and Harmonization of SAARC GAP

for Vegetables and Fruits in Kathmandu from 8 to 10 April 2018.

- Dr A. K. Patra, Director, ICAR-Indian Institute of Soil Science, Bhopal participated in the Joint IGAD Pre-Conference in Berlin, Germany during 19th March 2018 to 20th March 2018 and 11th Research Data Alliance (RDA) Plenary meeting from 21 to 23 March 2018.
- Dr S. K. Singh, Project Director (Acting), DKMA and Shri Anil K. Sharma CP&PRO, ICAR, Krishi Bhawan, New Delhi participated in FOODEX JAPAN at Makuhari Messe, Japan, from 4 to 9 March 2018.
- Dr S. K. Singh, Project Director, DKMA and Shri Anil K. Sharma, CP&PRO for participated in 13th edition of Salon International de I' Agriculture au Maroc (SIAM in Meknes, Morocco) from 24 to 29 April 2018.
- Dr Ashok Kumar Singh, Dy. Director General (Agri. Extn.) attended the "Regional Collaborative Platform Workshop for Conservation Agriculture Sustainable Intensification (CASI)" to be held at Kathmandu, Nepal from 22 to 23 July 2018.
- Dr C. A. Srinivasmurthy, Director of Research, CAU, Imphal attended oral presentation at the 6 International Dry Tolet conference at Tampere, Finland from 22 to 24 August 2018.
- Dr Ashok Kumar Singh, Deputy Director General (Agril. Extension), ICAR Hqrs, Krishi Bhawan, New Delhi attended the 21st World Congress of Soil Science at Rio De Janeiro, Brazil, from 12 to 17 August 2018
- Dr Sanjeev Saxena, Assistant Director General (IPTM&PME), ICAR Hqrs, participated in the BIMSTEC Regional Workshop at NAY Pyi Taw, Myanmar during 30 to 31 July 2018
- Dr Sujay Rakshit, Director, ICAR-IIMR, Ludhiana and Dr V.K. Sehgal, Pr. Scientist, ICAR-IARI, New Delhi, participated in the follow-up meeting on 'Mapping maize mega-environment of South Asia' on 30 January 2018 in Bangkok
- Dr J.K. Jena, Dy. Director General(Animal Sciences), ICAR Krishi Bhawan, New Delhi visited International Livestock Research Institute (ILRI) and International Center for Research in Agroforestry (ICRAF) Headquarters in Nairobi to meet Senior Management/ Scientists and Addis Ababa to meet with Secretary, African Union from 13 to 16 February 2018.
- Dr N.P. Singh, Director, ICAR-IIPR, Kanpur and Dr O.P. Yadav, Director, ICAR-CAZRI, Jodhpur participated in the Launch meeting of CRP-GLDC from 14 to 16 February 2018 in Ethiopia
- Dr Anand Kumar Singh, Deputy Director General (CS), ICAR, Hqrs., New Delhi participated in the Direct Seeded Rice Consortium (DSRC) Launch meeting on 6 February 2018 at IRRI Headquarters, Philippines
- Dr R.M. Sundaram, Pr. Scientist; ICAR-IIRR, Hyderabad, Dr Shiak N. Meera, Pr. Scientist; ICAR-IIRR, Hyderabad, Dr L.V. Subba Rao, Pr. Scientist; ICAR-IIRR, Hyderabad, Dr R. M. Kumar, Pr. Scientist; ICAR-IIRR, Hyderabad, Dr A.K. Singh, ICAR-IARI, New Delhi, Dr O.N. Singh, Pr. Scientist, ICAR-NRRI, Cuttack, attended International Hybrid Rice Symposium (IHRS) 2018 held in Indonesia being organized by IRRI and Indonesian Agency for Agriculture Research and Development from 27 February to 1 March 2018
- Dr H. Pathak, Director, ICAR-NRRI, Cuttack attended 'Consortium for Unfavorable Rice Environments (CURE) Phase 2 Project Final Meeting' from 21 to 22 February, 2018 at Bangkok, Thailand
- Dr Sewa Ram, Pr. Scientist, ICAR-IIWBR, Karnal participated in 4th Latin American Cereals Conference, 13th International Gluten Workshop and 2018 Global Wheat Program Visitor's Week from 11 to 23 March 2018 in Mexico
- Dr Gyanendra Pratap Singh, Director, ICAR-IIWBR, Karnal attended Visitor's Week for Familiarization with the research activities of CIMMYT from 19 to 23 March 2018 from at CIMMYT, Mexico
- Dr Poonam Jasrotia, Sr. Scientist and Dr Chuni Lal, Pr. Scientist, ICAR-IIWBR, Karnal attended training course on Barley Improvement at Rabat Morocco from 9 to 20 April 2018
- Dr N.P. Singh, Director, Dr S.K. Chaturvedi, Pr. Scientist, Dr (Mrs) Uma Sah, Pr. Scientist, ICAR-IIPR, Kanpur and Dr C. Tara Satyavathi, Project Coordinator, ICAR-AICRP on Pearl Millet, Jodhpur attended Annual Review and Planning Workshop of TL-III and HOPE-II from 4 to 6 April 2018 in Uganda
- Dr (Mrs) S. Backiayrani, ICAR-National Research Centre for Banana, Tiruchirapalli attended the East Africa Banana Breeding Project, Annual Meeting banana breeding strategy from 24 to 29 April 2017 in Uganda
- Dr S. Bhaskar, ADG (AAF&CC), ICAR, New Delhi, Dr Anil Kumar, Director (Acting), Dr Raza Haider Rizvi, Pr. Scientist, ICAR-CAFRI, Jhansi participated in the International Conference on 'Promotion on Agro-forestry for Rural Income Generation, Climate Change and Adoption' from 27–29 April 2018 in Kathmandu, Nepal
- Dr S. Mauria, ADG (International Relation), ICAR Krishi Bhawan, New Delhi attended 17th meeting of CGIAR ISPC from 19 to 20 April 2018 in Rome, Italy hosted by Food and Agriculture Organization of the United Nations (FAO)
- Dr Swarna Ronanki, Scientist, ICAR-IIMR, Hyderabad for attended 2018-Global Sorghum Conference: Sorghum in 21st century—Food, feed and fuel for rapidly changing world from 9 to 12 April 2018 in Cape Town, South Africa
- Dr V. A. Tonapi, Director, ICAR-IIMR, Hyderabad

for participated in the concluding meeting under ICIAR Project from 9 to 12 April 2018 in South Africa

- Dr V. K. Mishra, Pr. Scientist and Head (A) ICAR-CSSRI, RRS, Lucknow attended ORYZA Training Program for Basic Applications from 23–27 April 2018 at IRRI Los Banos, Philippines
- Dr G.P. Dixit, Project Coordinator, ICAR-IIPR, Kanpur, Dr H.K. Dikshit, Pr. Scientist, ICAR-IARI, New Delhi, Dr Sanjeev Gupta, Pr. Scientist, ICAR-IIPR, Kanpur, Dr S.K. Chaturvedi, Pr. Scientist, ICAR-IIPR, Kanpur, Dr Debjyoti Sen Gupta, Scientist, ICAR-IIPR, Kanpur, Dr (Mrs) Uma Sah, Pr. Scientist, ICAR-IIPR, Kanpur, Dr C.S. Praharaj, Pr. Scientist, ICAR-IIPR, Kanpur, Dr (Mrs) Meenal Rathore, Sr. Scientist of ICAR-IIPR, Kanpur, Dr S.P.S. Tanwar, Pr. Scientist, ICAR-CAZRI, Jodhpur, and Dr A. K. Patra, Director, ICAR-IISS, Bhopal, participated in Seventh International Food Legumes Research Conference from 6 to 8 May 2018 followed by field visit on 9 May 2018 held in Morocco
- Dr Arvind Kumar, Scientist, CSSRI, Karnal attended training course on 'Wheat Improvement' from 10 April 2018 to 2 May, 2018 in Morocco
- Dr P.S. Brahmanand, Principal Scientist, ICAR-IIWM, Bhubaneshwar attended training programme on DSSAT-2018 Assessment of Crop Production, Nutrient Management, Climate Risks and environmental sustainability with simulation models from 14 to 19 May 2018 at University of Georgia, USA
- Dr Jitendra Kumar, Pr. Scientist, ICAR-IIPR, Kanpur participated in Seventh International Food Legumes Research Conference (VII-IFLRC) from 6 to 8 May, 2018 followed by field visit on 9 May 2018 in Morocco
- Dr Samiran Bandyopadhyay, Sr. Scientist, ICAR-IVRI, Izatnagar; Dr Bibek Ranjan Shome, Pr. Scientist, ICAR-NIVEDI, Bengaluru; Dr Rajeshwari Shome, Pr. Scientist, ICAR-NIVEDI, Bengaluru; Dr Manoj Kumar Singh, Pr. Scientist, ICAR-CIRG, Mathura; Dr Anupam Krishna Dixit, Sr. Scientist, ICAR-CIRG, Mathura; and Dr Naresh Kumar, Pr. Scientist, ICAR-NDRI, Karnal, attended the ICAR-ILRI Research Collaborative Workshop from 30 June to 9 July 2018 in Nairobi, Kenya
- Dr N.P. Singh, Director, Dr Abhishek Bohra, Scientist, ICAR-IIPR, Kanpur, Dr Vilas A Tonapi, Director and Dr R. Madhusudana, Pr. Scientist of ICAR-IIMR, Hyderabad participated in Data Management Review, Planning and Training Workshop of BMS from 23 to 27 July 2018 in Malawi
- Dr Rashmi Yadav, Sr. Scientist, ICAR-NBPGR, New Delhi participated in the 21st Crucifer Genetics Conference (Brassica 2018) from 1 to 4 July 2018 in France
- Dr (Mrs) Smita Sirohi, Head, ICAR-NDRI, Karnal attended the 30th International Conference on Agricultural Economics from 28 July 2018 to 2 August 2018 in Canada
- Dr Rashmi Aggarwal, Head, Division of Plant Pathology, ICAR-IARI, New Delhi to attended the International Congress of Plant Pathology (ICPP-2018) from 29 July 2018 to 3 August 2018 held in USA
- Dr C. Bharadwaj, Principal Scientist, Division Genetics, ICAR-IARI, New Delhi participated in GOBII Annual Review Meeting and PHG Workshop from 14 to 19 August 2018 at IRRI, Philippines
- Dr S. Uma, Director, ICAR-NRCB, Tiruchirapalli attended XXX-International Horticultural Congress (IHC)-2018 on 'Growing and Marketing Bananas under Subtropical Conditions' from 12 to 16 August 2018 in Turkey
- Dr Girish Kumar Jha, Principal Scientist and Dr Aditya K.S., Scientist, ICAR-Indian Agricultural Research Institute, New Delhi participated in the 30th International Conference of Agricultural Economists (ICAE 2018) held in Vancouver, British Columbia, Canada from 28 July 2018 to 2 August 2018
- Dr Dinesh Kumar, Pr. Scientist (FFC), ICAR, Krishi Bhawan, New Delhi and Dr Sudeep Kumar, Pr. Scientist, ICAR-NBPGR, Pusa, New Delhi visited Kenya for sharing of knowledge in Ug99 wheat stem rust programme from 28 September 2018 to 4 October 2018
- Dr Hanif Khan, Scientist, ICAR-IIWBR, Karnal, Dr C. Manjunatha, Scientist, ICAR-IARI Regional Station, Wellington and Dr K.K. Mishra, Scientist, VPKAS, Alomora participated in the training course on stem rust from 29 September 2018 to 9 October 2018 in Kenya
- Dr Naveen Prakash Singh, Pr. Scientist, ICAR-NIAP, New Delhi participated in the Partners' Meeting on Food Systems and Foresight in the Eastern Gangetic Plains on 27 September 2018 in Kathmandu, Nepal
- Dr G.P. Singh, Director, ICAR-IIWBR, Karnal and Dr J. C. Sekhar, Pr. Scientist, Winter Nursery Centre, ICAR-IIMR, Rajendranagar participated in the CIMMYT Board Meeting from 3 to 6 Oct 2018 in Nepal
- Dr L. V. Subba Rao, Pr. Scientist, Dr Shaik Meera, Pr. Scientist, Dr R. M. Kumar, Pr. Scientist, Dr Chitra Shanker, Pr. Scientist, Dr Amtul Waris, Pr. Scientist, Dr Jyoti Badri, Scientist (IIRR, Hyderabad); Dr Padmini Swain, Pr. Scientist, Dr M.J. Baig, Pri. Scientist, Dr J.N. Reddy, Pr. Scientist, Dr Mohammad, Shahid, Scientist, Dr Anjani Kumar, Scientist (NRRI, Cuttack) participated in the 5th International Rice Congress-2018 from 15 to 17 October 2018 in Singapore
- Dr Ranjith Kumar Ellur, Scientist and Dr Arun Kumar M.B., ICAR-IARI, Pusa, New Delhi

attended 5th International Rice Conference from 15 to 17 October 2018 in Singapore

- Dr Suseela Mathew, Principal Scientist and Head-B&N Division, Dr Amulya Kumar Mohanty, Principal Scientist and Head, EIS Division and Dr George Ninan, Principal Scientist and FP Division, ICAR-CIFT, Cochin visited WorldFish, Cambodia to interact with Scientists regarding 'Value chains and nutrition with a focus on fish consumption and human nutrition' from 22 to 28 October 2018
- Dr Himanshu Pathak, Director, ICAR-NRRI, Cuttack participated in 22nd Annual meeting of the Council for Partnership on Rice Research in Asia (CORRA) from 14 to 17 October 2018 in Singapore
- Dr Parbodh Chander Sharma, Director, ICAR-CSSRI, Karnal participated in the 5th International Rice Congress (IRC) from 14 to 18 October 2018 in Singapore
- Dr P. K. Chakrabarty, Assistant Director General (PP&B), ICAR Hqrs., New Delhi attended the FAW Technical Conference from 29 to 31 October 2018 in Addis Ababa, Ethiopia
- Dr P.C. Das, Principal Scientist, Dr D. Panda, Scientist and Dr Khuntia Murmu Scientist, ICAR-CIFA, Bhubaneswar visited WorldFish, Malaysia to interact with WorldFish Team on Sustainable aquaculture with a focus on farm performance and prawn strains, life cycle studies and other aspects from 22 to 28 October 2018
- Dr S.R. Voleti, Director (A), ICAR-IIRR, Hyderabad participated in the 5th International Rice Congress-2018 from 15 to 17 October 2018 in Singapore
- Dr A.K. Das, Principal Scientist, Dr Pranaya Kumar Parida, Scientist and Dr (Mrs) Aparna Ray, Scientist, ICAR-CIFRI, Barrakpore attended interactive Meet under ICAR World Fish W3 Plan Agreement on Small Scale Fisheries program from 22 to 28 October 2018 in Bangladesh
- Dr P.C. Das, Principal Scientist, Dr D. Panda, Scientist and Dr Khuntia Murmu Scientist, ICAR-CIFA, Bhubaneswar visited WorldFish, Malaysia to interact with WorldFish Team on Sustainable aquaculture with a focus on on-farm performance and prawn strains, life cycle studies and other aspects from 29 October to 3 November 2018
- Dr C.N. Ravishankar, Director, ICAR-CIFT, Cochin, Dr Basanta Kumar Das, Director, ICAR-CIFRI, Barrackpore and Dr (Mrs) Bindu R. Pillai, Director, ICAR-CIFA, Bhubaneshwar participated in the ICAR-World Fish Research Strategy Workshop from 26 to 27 November 2018 in Penang, Malaysia
- Dr Anand Kumar Singh, DDG (Crop Science), ICAR Hqrs., New Delhi visited CIMMYT, Cd. Obergon, Mexico from 19 to 23 March 2018 to discuss the ICAR-CIMMYT Work Plan
- Dr Rajbir Yadav, Pr. Scientist, ICAR-IARI, Pusa, New Delhi attended Visitor's Week for Familiarization with research activities of CIMMYT from 19 to 23 March 2018 at CIMMYT, Mexico
- Dr Narendra Pratap Director, ICAR-NIASM, New Delhi participated in the 5th International Rice Congress on 14–17 November 2018 in Singapore
- Dr S. Bhaskar Assistant Director General (AAF&CC), ICAR, KAB-II, Pusa, New Delhi participated in the CCAFS Partners Meet and Workshop titled 'Developing an integrated strategy for CCAFS for building climate-resilient agriculture in South Asia from 21 to 23 November 2018 in Colombo, Sri Lanka
- Dr A.K. Singh Dy. Director General (Agril. Extn.) ICAR, New Delhi participated in the CCAFS Partners Meet and Workshop titled "Developing an integrated strategy for CCAFS for building climate-resilient agriculture in South Asia from 21 to 23 November 2018 in Colombo, Sri Lanka
- Dr Anand Kumar Singh, Deputy Director General (Hort. Sci. and Crop Sci.), ICAR Hqrs., New Delhi visited Lima, Peru to discuss ICAR-CIP collaboration with International Potato Center from 17 to 25 November 2018
- Dr J.K. Jena, Deputy Director General (Fisheries and Animal Science), ICAR, New Delhi participated in the ICAR-WorldFish Research Strategy Workshop from 26 to 27 November 2018 in Penang, Malaysia

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18. Supporting Basic and Strategic Research

The main objective of the National Agricultural Science Fund, with an outlay of ₹ 164.5 crore, is to build capacity for basic, strategic and cutting edge application research in agriculture and address issues which can be solved by intensive basic and strategic research jointly by team of organizations/ institutions. The scheme has already funded 174 projects, mostly in consortium mode out of which 65 are on-going projects and 62 are multi-institutional in nature. In the last one year NASF has taken many initiatives like applications of CRISPR/Cas technology in plants and animals, animal cloning, double haploids in crops, and transgenics in plants and animals.

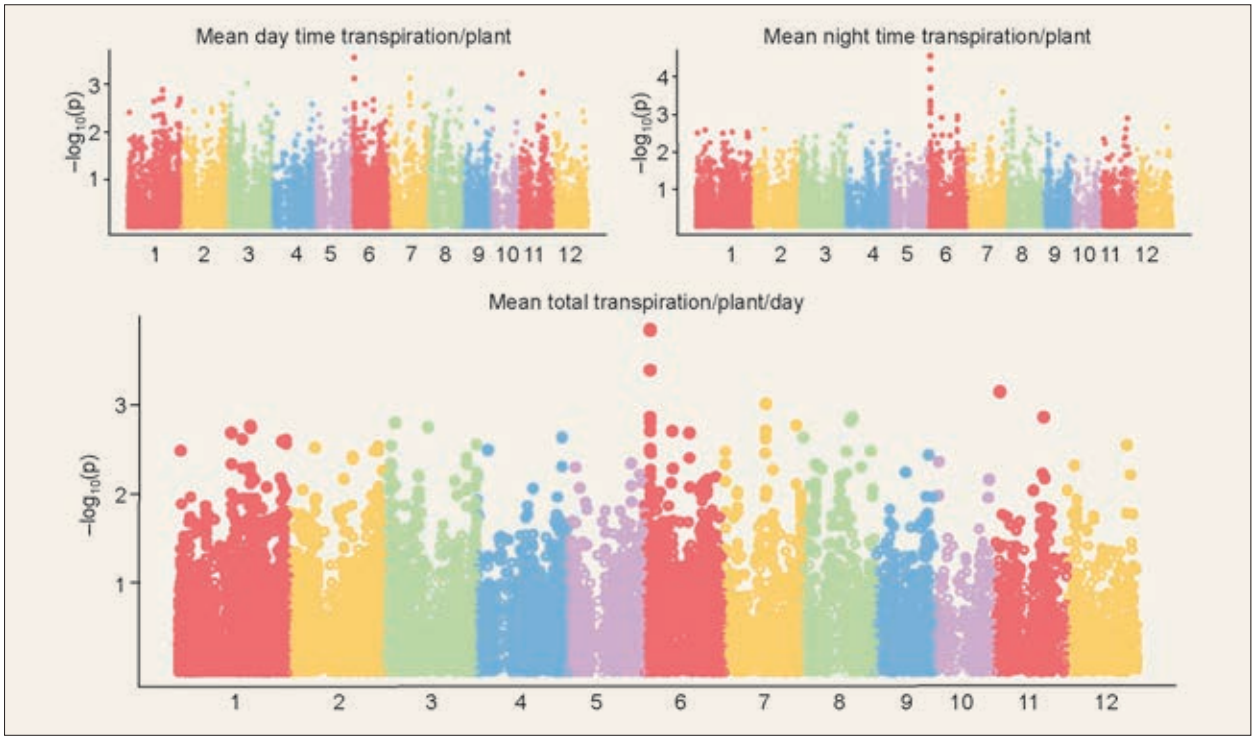
The NASF made an advertisement for inviting new project proposals (Call VIII). A total of 680 pre-proposals were received. A total of 29 new projects were approved during the period. NASF was also engaged in creating awareness for the need and nature of the basic research for agriculture among institutions within and outside the traditional NARS for prioritization of research.

Six Annual Review meetings were held to review the 46 ongoing projects. A survey based on a questionnaire was done among the Principal Investigators (CPIs and CCPIs) of the ongoing projects to understand the scientists' perception on the processes being followed by the NASF for award of new projects, monitoring, reviewing, release of funds and other form of supports. The results indicated that the steps and methods followed for the award of the projects and implementation are useful and efficient for the proponents. Response of 95% of the PI belonged to the category 'Satisfaction more than 80%'. The feedback received from the stakeholders will further help NASF in improving the system.

Salient achievements

During 2018–19, besides having more than 100 research publications in reputed journal, NASF had four patents and 16 technologies. The research highlights of some selected projects are as follows:

Phenomics of moisture deficit stress tolerance and nitrogen use efficiency in rice and wheat: Water use efficiency and transpiration (diurnal and nocturnal) rate of 150 rice germplasm lines were analyzed. Genotypes with contrasting diurnal and nocturnal transpiration under well watered and moisture deficit stress conditions were identified. A low correlation between leaf area and mean transpiration in rice-germ plasm suggested that large portion of genotypic variation in transpiration is controlled by physiological mechanisms, which is involved in stomatal regulation besides the leaf area. 18 QTLs for mean day time transpiration and 12 QTLs for mean night time transpiration per unit leaf area were mapped. A region on chromosome 6 appears to control whole plant



Manhattan plots of GWAS for transpiration

transpiration. Similarly, 183 wheat germplasm lines and 184 RILs of HD2967 × C306 cross were phenotyped and genotypes with higher WUE and grain yield were identified.

Transgenic pigeon pea and chickpea: Event selection trials of transgenic pigeon pea and chickpea were conducted to identify the best event each in pigeon pea and chickpea, based on trait efficacy (resistance to gram pod borer), expression of Bt protein at various stages and related agronomic characters including yield. PCR analyses with gene specific primers revealed segregation of transgene in the progenies and presence of vector backbone in few of the events. Expression of the Bt gene was detected in all the positive progenies of the transgenic lines. However, the expression of the gene drastically dips post flowering stages. Insect bioassay was conducted both in field condition and *in-vitro* conditions and mortality of larvae was correlated with protein expression.

Event Selection Trial in chickpea and pigeon pea and chickpea

Transgenic overexpression of phosphite dehydrogenase for integrated weed and disease management: The complete inhibition of fungal plant pathogens was observed between 80–100 mM, and the bacterial pathogen, *Xanthomonas oryzae* pv. *Oryzae,* was inhibited at the concentration of 35 mM. The compound showed herbicidal activity at higher concentration of 1,600 mM and above. The data indicated potential of potassium phosphite as fungicidal and bactericidal compound for use as an agro-input in rice farming. Morphotypes (40) were identified from culturable microbiome of non-transgenic rice and 46 different morphotypes were identified from culturable microbiome of transgenic rice from 30 day-old rice plants. From 60 day-old rice plant 44 different morphotypes were identified from transgenic rice and 40 from non-transgenic rice. No significant difference could be observed for the diversity of culturable microbiome of transgenic and non-transgenic rice.

Molecular cross talk between defense pathways in rice: Fourteen key defense genes were identified through microarray analysis of global genome expression profiles modulated under combined challenge of BB (bacterial blight) + GM (gall midge) or BB+BL (fungal blast) in the selected gene pyramided lines. Further, the expression of some key genes like cytochrome P450 family gene, terpene synthase, Bowman-birk type trypsin inhibitor, lipoxyginase, and glucan endo-beta glucosidase was relatively inhibited in plants subjected to combined challenge by either BB+BL or BB+GM as compared to those in plants with single-pest attack. The examination of possible antagonism and their impact on manifestation of resistance revealed that there was no adverse effect of pyramiding of genes on the expression of resistance against the target pests.

Hilsa breeding and management

A workshop on *Hilsa Breeding and Management: Way Forward* was held. The Empowered Committee emphasized that there is need for captive breeding of Hilsa to get gonodial maturity stage leading to complete life cycle, and the studies should be undertaken under both fresh- and brackish-water conditions. A fresh project consisting of continuing activities to achieve the final goal needs to be initiated.

Epigenetic regulation of leaf rust resistance of wheat: The role of three different epigenetic modifications, viz. sRNA, histone modifications and DNA methylation were studied. The work on miRNA revealed several conserved sequences. Using qRT-PCR, three miRNAs were also validated. Targets of differentially expressed miRNAs were also identified using degradome data and other *in silico* approaches. Genes encoding effectors and some ncRNAs in *Puccinia triticina* (Pt) genome were also identified from the available transcriptome and EST data using *in silico* approaches.

Pluripotency in buffalo stem cells: The pure recombinant proteins (rBuLIF) were successfully produced from bacteria (*Escherichia coli*), yeast (*Pichia pastoris*) and mammalian cells (COS-1) which can be used for various *in-vitro* and *in-vivo* applications. The molecular signalling triggered by rBuLIF in COS-1 cells was elucidated, which generated new knowledge in explaining the pleotropic mechanism of this molecule. Glycosylated rBuLIF initiates cell growth arrest in COS-1 cells that is mediated through stat3 activation. In addition, rBuLIF also activates MEK/ERK, Ras, mTOR, Hippo-Taz, and RAP1 signaling.

Development of next generation vaccine for PPRV: The study identified putative 37 up-regulated and 13 down-regulated genes, which are associated with innate immune response pathway. Genes namely IL18RAP, ADGRG3, P2RX1, GCA, ISG20, IFI6, CD93, SOCS3, CCR4, ITK and CD96 have critical role in regulating innate immune response. A mouse model was established for PPRV infection to study the disease pathogenesis mechanistically. Taking a clue from myeloid cells mounting IFN response upon exposure to PPRV, different doses of PPRV (1,100 and 10,000 pfu) were injected into IFNR KO mice and the disease progression was monitored. All the animals developed encephalitis, lost body weight, were hypothermic and succumbed to infection by day 7. The virus titres in the brain tissues of these animals suggested the active replication of virus in mice.

Precision Agriculture in India

A workshop on *Precision Agriculture in India–Way Forward* was held to review the present status of Precision Agriculture in India and to device the comprehensive management system for Precision Agriculture aiming to optimizing the productivity with precise use of resources and ecological security

Detection of peptide biomarkers for bovine mastitis: Antimicrobial peptides (AMPs) were isolated from skin secretions of frog (*Hylarana temporalis*) and abdominal fractions of ants/hornet fly. Some HPLC purified fractions showed potent antibacterial activity against Gram positive and negative bacteria. One of the lead peptides identified from hornet fly (vestinin) was effective against MDR isolates. This peptide was stable in presence of salts ($MgCl_2$, KCl, NaCl, NH_4Cl, $CaCl_2$), enzymes (trypsin, proteinase-K) and temperature up to 100°C for 1 h. The peptide was also minimally haemolytic (2%) on RBCs of different species.

CctA and hyaluronidase gene mutants of *Clostridium chauvoei* for vaccine potential: Phenotypic evaluation *Clostridium chauvoei* cctA mutant indicated that it scarcely haemolysed sheep RBCs, while wild type *Clostridium chauvoei* showed intense haemolysis confirming the inactivation at phenotypic level. The growth rate of the mutant, though slower than wild type in the initial phases, was comparable to that of wild type during later phases. Reversion possibility of the mutant was evaluated for 35 generations and it was found to be stable. Cytotoxicity assays using the culture supernatants of the wildtype and mutant *C. chauvoei* on MDBK cells indicated that the *C. chauvoei* cctA mutant was significantly less cytotoxic compared to wildtype *C. chauvoei*.

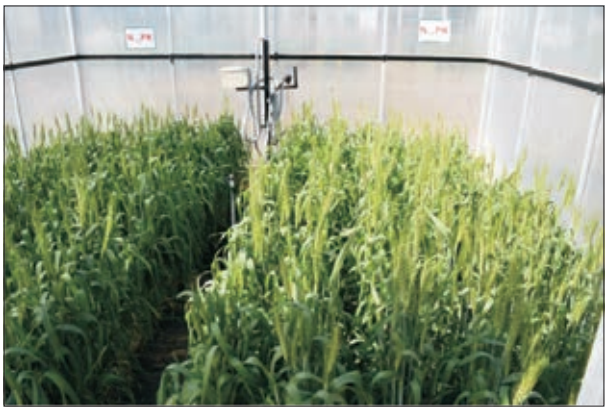
Graded levels of nano-selenium on broilers: Nano selenium particles were successfully synthesized. The shape of particles was spherical and average size was 40 nm by transmission microscopic analysis. Two bacteria isolated from the coal mine waste water and agriculture field were found suitable for synthesis of nano selenium in cost effective way. The assessement effect of nano-Se on broiler birds revealed higher body weight gain and FCR compared to control group at the end of fifth week.

Anti-tick phytochemicals for control of acaricide-resistant ticks: A nano formulation showing 80–100% *in-vitro* efficacy while 60–70% efficacy in a pilot study using experimentally and naturally infested animals against adult ticks was developed. The discriminating concentration of ivermectin was determined as 93.54 ppm and validated in isolates collected from Bihar, Punjab, and Uttar Pradesh. The isolate collected from Punjab was highly resistant. Two formulations (F5 and F10) showed 80–90% efficacy in pilot *in-vivo* study. Approximately 300 transcripts were differentially expressed in midgut of treated ticks.

Electronic nose for optimum harvesting and fruit quality: Signature volatile metabolites emitting from apple were identified to sense the ripening stages and nutritional quality of apples. Based on these signature volatiles, a low cost sensor was developed to sense ripening stages and nutritional quality of apples. Further a 'SMART FRUIT NOSE App' was developed, which could be used with existing Android phones for visualization of sensor response.

Effect of elevated CO_2 and temperature on water productivity and nutrient use: The N-concentration in wheat grain varied from 1.66 to 2.26%, with significantly lower values under elevated CO_2 (eC) as compared to ambient. Temperature increase either alone or in combination with eC, showed a significant trend of increase in grain N concentration. Similarly, significantly higher N uptake and protein content were observed under elevated CO_2 and elevated temperature (eCeT) treatment at N_{150} owing to higher grain yield and higher grain N concentration. The P concentration did not show any specific trend. The grain K concentration reduced significantly with elevation in

An electric nose for optimum harvesting time and quality



Wheat crop in Open Top Chamber Facility (OTC)

temperature and/or elevation in CO_2. While dry gluten content showed significant reduction under eC and eCeT conditions.

Enhancement of decomposition rate of bio-waste: To degrade lignin and cellulose, seven thermophilic fungi, four bacteria and two actinomycetes were isolated from municipal solid waste, which involves primarily complex enzymes, viz. cellulase, phenol oxidase (laccase) and heme peroxidases [lignin peroxidase (LiP) and manganese peroxidase (MnP)]. To develop suitable microbial consortia, compatibility test was performed among all these positive strains. No antagonistic activity was found. Using these potential consortia, decomposition of horticultural, kitchen and vegetable wastes was studied in a closed vessel with constant temperature at 50±5°C for 21 days. These consortia of microbes enhanced the decomposition process as well as compost reached its maturity and stability within 21–30 days.

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Capacity building for addressing farmers' distress

The baseline survey of about 1,100 distressed farming families across Punjab, Maharashtra and Telengana was done. Information about depression, self-esteem, cognitive distortions, resilience, wellbeing, suicidal ideation etc. was collected to know the cumulative stress index (CSI) and psychological resources index (PRI) of these farmers. The basic and advanced trainings were given to peer support volunteers (PSVs) based on six modules. The project aimed at providing a sort of psychological first aid (PFA) to farmers through the system of peer support and it is equipping farmers with coping skills to handle stress in a time of agrarian crisis. The project is focusing on strategies to de-stigmatize mental health issues in the rural areas. Slogan *Karoge Baat, Banegi Baat* (Talk and you will get a solution) is getting popular with the farmers in three states. PSVs are also spreading the message to shun conspicuous consumption and cut expenses on social events. Message of the simplicity adopted by Punjab Agricultural University in Kisan Mela has snowballed into a state-wide movement with more than 150 village panchayats, mainly in the pockets of suicide, have adopted resolutions not to splurge on social ceremonies

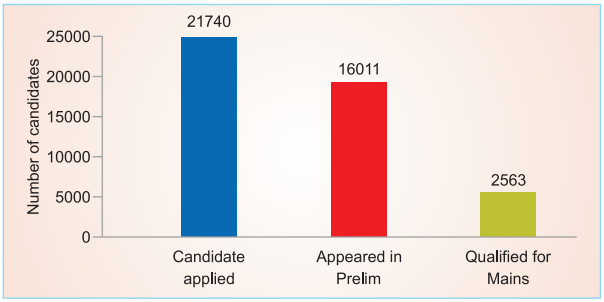
19. Strengthening the Research System

Direct Recruitment/Lateral Entry

During the period the Agricultural Scientists' Recuitment Board (ASRB) advertised 70 post in three advertisements. Out of these 71% of the posts were Research Management Positions (Deputy Directors General, Directors of National Institutes, Directors, Joint Directors of National Institutes, Assistant Directors General, Project Directors and Joint Directors) while remaining were middle level Positions (Heads, and Project Coordinators).

Agricultural Research Service Examination-2016

A combined examination for ARS 2016 (Prelims) and NET 2017(I) was conducted in online mode for 180 vacancies in 31 disciplines at 23 Centres across India. A total of 21,740 candidates had registered for the examination and 16,011 candidates appeared in the examination. A total of 2,563 candidates (16%) qualified for the ARS (Main) Examination.



Details of ARS-2016 examination

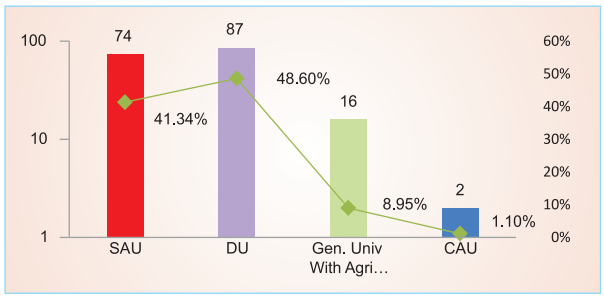
For ARS-2016 Exam, 831 candidates qualified for viva voce. In a few disciplines, the ratio of 1:5 could not be adhered to as sufficient candidates were not available in this ratio owing to not scoring the minimum prescribed qualifying marks. Details of such disciplines are given in Table below.

Disciplines	Vacancies	Qualified for viva voce	Required as per ratio of 1:5
Agricultural Biotechnology	9	41	45
Nematology	2	9	10
Plant Biochemistry	4	8	20
Animal Biotechnology	1	4	05
Animal Genetics and Breeding	7	32	35
Fisheries Resource Management	9	32	45
Agricultural Chemicals	3	7	15
Agroforestry	3	3	15
Soil Sciences	13	50	65
Land and Water Management Engineering	8	33	40

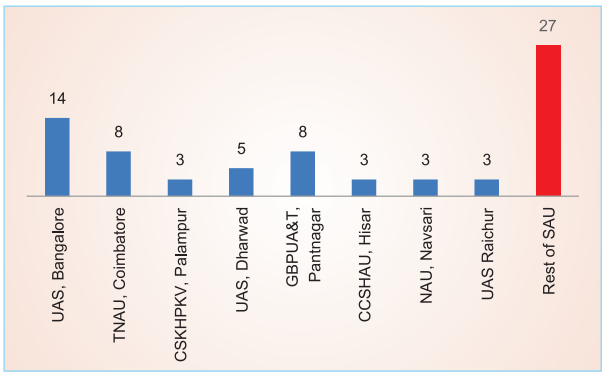
The *viva voce* was conducted from 9 November 2017 to 5 February 2018 for 831 applicants. Based on the marks scored in the written as well as viva voce, 179 candidates were recommended for appointment to ARS in order of merit.

View of ARS Viva -Voce

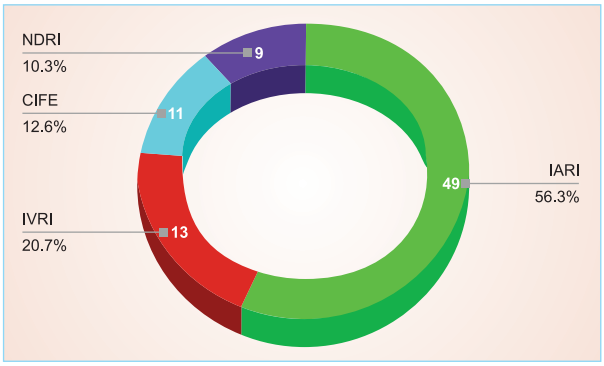
Out of 179 recommended candidates, 74 were from 27 State Agricultural Universities, 87 from four Deemed-to-be Universities (49, IARI, New Delhi; 11CIFE, Mumbai; 18 IVRI, Izatnagar; 9, NDRI, Karnal), 7 from BHU, Varanasi; 16 from General Universities; and two candidates from Central Agricultural University, Imphal. Out of 179 recommended candidates, 36% were women candidates.



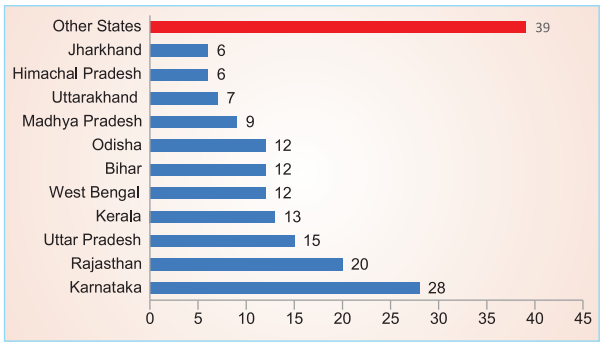
Organization wise contribution in ARS



Performance of Top Eight SAUs in ARS-2016



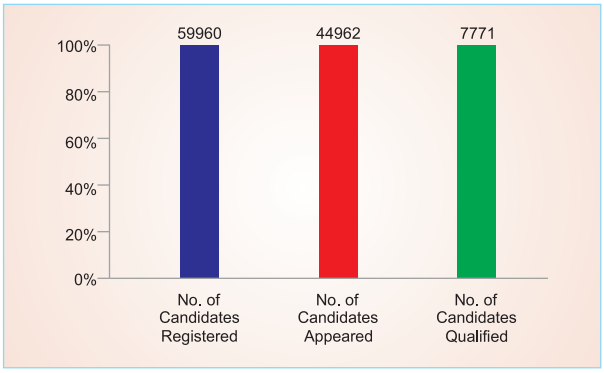
Performance of Deemed-to-be Universities



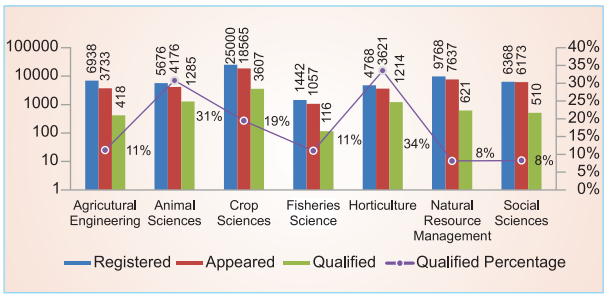
State-wise details of successful candidates

National Eligibility Test (NET) Examination-2018 (I)

A combined examination for ARS 2017 (Preliminary) and NET 2018(I) was conducted from April 6 to 10, 2018 in online mode. A total of 59,960 candidates registered for NET (I)-2018 examination and 44,962 appeared. Only 7,771 candidates (17.28%) qualified the examination.

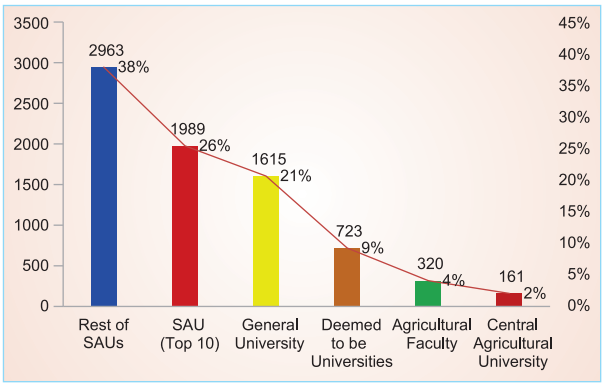


Details of NET-2018 examination



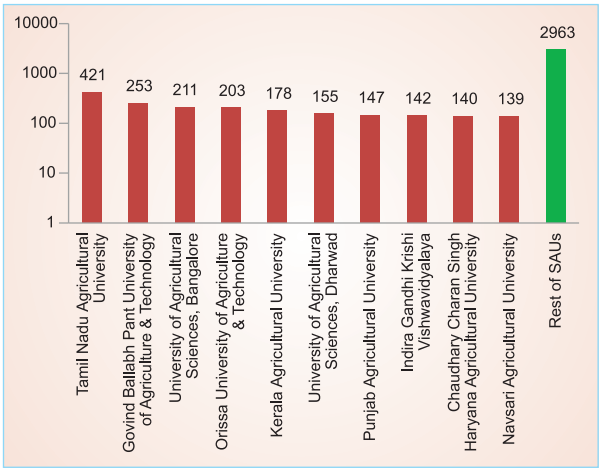
Major discipline wise details of candidates

The highest percentage of candidates qualified in Veterinary Anatomy (68.57%) followed by Animal Reproduction and Gynaecology (62.04%), Poultry Science (58.23%), Fish Genetics and Breeding (55.32%), Animal Nutrition (50.92%), Veterinary Medicine (45.95%), Veterinary Pharmacology (43.40%), Animal Genetics and Breeding (43.24%), Fruit Science (39.79%), Agricultural Entomology (38.68%). The lowest percentage of candidates qualified in Food Technology (0.11%). In disciplines, viz. Aquaculture, Home Science, Environmental Science, Agricultural Business Management and Agricultural Extension the success rate was around 6%.



Organization wise performance of candidates

Analyses of the data revealed that out of 7,771 qualified candidates, 1,989 (26%) were from 10 State Agricultural Universities (TNAU, Coimbatore; GBPUAT, Pantnagar; UAS, Bengaluru; OUAT, Bhubaneshwar; KAU, Thrisur; UAS, Dharwad; PAU, Ludhiana; IGKV, Raipur; CCSHAU, Hisar; Navsari Agricultural University, Navsari), 2,963 (38%) were from rest of the SAUs, 1,935 (25%) were from General Universities with Agricultural Faculties; 723 (9%) were from Deemed-to-be universities (IARI, New Delhi; IVRI, Izatnagar; NDRI, Karnal; and CIFE, Mumbai) and 161 (2%) from Central Agricultural University.

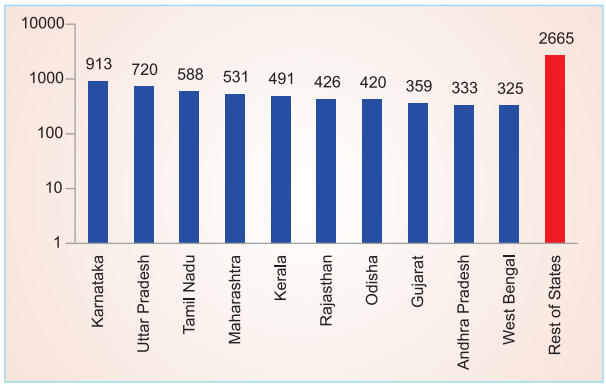


Performance of top ten SAUs

Out of 7,771 qualified candidates about 66% of successful candidates were from ten states (Karnataka, Uttar Pradesh, Tamil Nadu, Maharashtra, Kerala,

Rajasthan, Odisha, Gujarat, Andhra Pradesh and West Bengal).

Among 7,771 qualified candidates, 49% were female candidates and 61% were from rural areas.



State wise performance in NET Examination 2018

Stenographer Grade-III Examination, 2017

An all India open competitive examination was conducted to fill up 95 positions of Stenographer grade-III for ICAR Headquarters, New Delhi and for various Research Institutes and the Krishi Vigyan Kendras (KVKs) located all over the country. The examination was conducted in online mode on 29 October 2017 at 215 centres in 47 cities located in 28 states and union territories. A total of 91,446 candidates had registered for the examination and 48,915 (53%) candidates actually appeared in the examination.

Analysis of data showed that out of 91,446 registered candidates 69% candidates opted centres located at ten cities (Delhi, Lucknow, Patna, Jaipur, Kolkata, Kanpur, Hyderabad, Dehradun, Bhopal and Mohali) and remaining 31% opted other centres located at 37 cities. Out of 48,915 candidates who had appeared 1,936 candidates are declared provisionally qualified for appearing in Skill Test.

Lower Division Clerk (DR) Examination-2016 for ICAR Institutes

For filling up positions of LDC at the ICAR institutes, examination was conducted on 24 February 2018 in online mode. A total of 15,049 candidates registered for the examination and 8,128 (54%) candidates appeared in the examination, and 1,037 candidates were declared provisionally qualified for appearing in Skill Typing Test. Based on the qualifying skill test, 340 applicants have been declared as qualified for being considered for appointment as LDC in 48 ICAR Institutes.

Common Written Examination for Technician (T1)

For filling up positions of Technician (T1) at the ICAR institutes, A Common Written Examination was conducted on 1 July 2018 at 27 centres across India in online mode. A total of 11,797 candidates had registered for the examination and 9,204 candidates actually appeared in the examination. Evaluation process is under progress.

Lower Division Clerk (DR) Examination-2017 for ICAR Headquarter

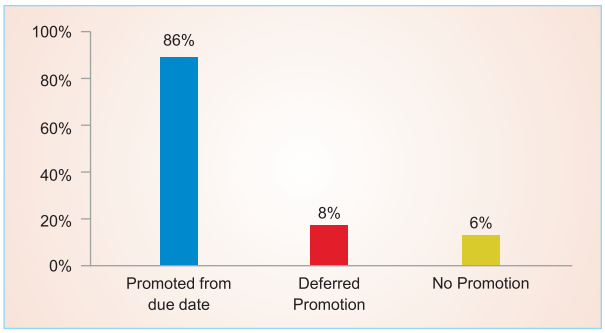
For filling up 78 positions of LDC at the ICAR Headquarter, applications were registered in online mode and the examination is also to be held in online mode. A total of 379,097 candidates registered for the examination. The dates for conduct of Examination are being finalised.

Limited Departmental Competitive Examinations 2017

Limited Departmental Competitive Examination was held on 21–22 December 2017 to fill up for the posts of Section Officer and Private Secretary. Details are as follows:

Category	Vacancies	Candidates Applied	Candidates Appeared
Section Officer	14	117	109
Private Secretary	3	11	
Total	**17**	**128**	**109**

Interview Board in Progress



Performance of candidates assessed for promotion

Career Advancement Scheme (CAS)

During the year, 219 proposals received from different institutes in 56 disciplines were considered under CAS for promotion from senior scientists to the grade of principal scientists.

❑

20. Training and Capacity Building

The Human Resource Management Unit at ICAR HQs is promoting systematic approach to training in ICAR. The highlights of Training and Capacity Building of ICAR employees of all categories are enumerated below.

Development and implementation of annual training plan

In total 109 Institutes/ICAR HQs developed the Annual Training Plan (ATP) for all categories of employees for the reporting period in the beginning of the year and implemented effectively. The implementation of ATP for the earlier year was assessed at the end of the year, and approriate feedbacks were given to all the ICAR-Institutes for better implementation in future.

Organization of training programmes

Scientific staff: The ICAR-Institutes/HQs organized 242 training programmes for scientific staff for enhancing their competency. In total, 1,165 Scientific staff of ICAR of different grades undergone various training programmes. Seven new training programmes based on the identified training needs were designed, developed and organised for scientific staff (Table 1). In these new training programmes, 127 scientists (109 ICAR employees + 18 Non-ICAR employees) in various grades participated. Out of which, about 25% scientists got training first time after their FOCARS training.

New training programmes for scientific staff

Title of training programme(s)	Organizing Institute
Advanced remote sensing and GIS applications in integrated land resource management	ICAR-NBSS&LUP, Nagpur
Tools and techniques of analysis of biomolecules	ICAR-IARI, New Delhi
Experimental designs and statistical data analysis	ICAR-IASRI, New Delhi
Advances in simulation modelling and climate change research towards knowledge based agriculture	ICAR-IARI, New Delhi
Recent advances of bioinformatics in agricultural research: a practical perspective	ICAR-IASRI, New Delhi
Genomics-assisted breeding for crop improvement	ICAR-IARI, New Delhi
Management of plant genetic resources	ICAR-NBPGR, New Delhi

Training programme at ICAR-IARI, New Delhi

Training programme at ICAR-NBPGR, New Delhi

International exposure

A senior executive development programme on 'Developing effective organizational leadership of Senior officers of ICAR' within-country and International exposure visits were organized by ASCI, Hyderabad, in coordination with ICAR-NAARM, Hyderabad and HRM Unit, ICAR HQs. In this programme, 20 multidisciplinary Senior Scientific and Administrative staff together participated in two batches. The In-country programme was held at ASCI,

Participants visiting Australian Centre for Field Robotics, University of Sydney, Sydney

Hyderabad. First time, International exposure visits (China, Malaysia and Thailand, Singapore, Australia and New Zealand, were organized as part of this programme. The programme was envisaged to enhance leadership capacities, competence, skills of senior research managers and officers to improve the organizational efficiency.

HRD nodal officers: For effective and efficient implementation of training functions in the Institutes/ HQs, a competency enhancement programme on "Effective Implementation of Training Functions by HRD Nodal Officers of ICAR" was organized by ICAR-NAARM, Hyderabad. They were exposed to various training functions including developing a System of training in the Institute; pursuing Systematic Approach to Training; performing Training Needs Analysis (TNA) of all categories of employees; developing Annual Training Plan (ATP) based on TNA; Evaluation of Trainings; Monitoring and Impact Assessment of trainings; and Maintaining Database of training and trained manpower, etc.

Training programme at ICAR-IIWBR, Karnal

Specialized training programmes organised for technical staff

Training programme	Organizing institute
Competence enhancement programme on soft skills and personality development	ICAR-NAARM, Hyderabad
FCV tobacco field crop management	ICAR-CTRI, Rajahmundry
ICAR-ERP	ICAR-IASRI, New Delhi
Basic microbiological techniques for studying microbes	ICAR-IARI, New Delhi
Experimental data analysis	ICAR-IASRI, New Delhi
Selection, adjustment, operation and maintenance of agricultural implements for field and horticultural crops	ICAR-CIAE, Bhopal
Microbiological examination of seafood	ICAR-CIFT, Cochin
Basic training on routine chemical analysis	ICAR-NDRI, Karnal
Networking-basics and management	ICAR-IASRI, New Delhi
Principles and production techniques of hybrid seeds in vegetables	ICAR-IIVR, Varanasi
Competence enhancement programme on motivation and positive thinking	ICAR-NAARM, Hyderabad
Precision agriculture technologies	ICAR-IARI, New Delhi
Application of remote sensing and GIS in natural resource management (ARSGN)	ICAR-IISWC, Dehradun
Computer application	ICAR-IASRI, New Delhi
Layout and maintenance of field experiments and recording observations	ICAR-IARI, New Delhi
Instrumentation techniques for analysis of soil, plant and water	ICAR-IARI, New Delhi
Farm management	ICAR-IIFSR, Modipuram
Hi-tech propagation and nursery management for production of quality planting material	ICAR-IIHR, Bengaluru
Identification of insect pests/ vectors/ their damaging symptoms and management	ICAR-IARI, New Delhi
Good agricultural practices (GAPs) for enhancing resource-use efficiency and farm productivity	ICAR-IARI, New Delhi
Agrometeorological data collection, analysis and management	ICAR-CRIDA, Hyderabad
ICAR-ERP	ICAR-IASRI, New Delhi
Communication and scientific writing for technical officers	ICAR-NAARM, Hyderabad
Use and maintenance of advanced instruments in soil and plant analysis	ICAR-IISS, Bhopal
Statistical techniques for agricultural data analysis	ICAR-IASRI, New Delhi
Fundamental concepts and methodology for agricultural water management	ICAR-IARI, New Delhi
Farm management	ICAR-IIFSR, Modipuram

Technical staff: ICAR-Institutes organized 83 training programmes for technical staff for enhancing their competency. In total, 815 Technical staff of ICAR of various grades undergone various training programmes. In specialized training programmes, 433 Technical staff of ICAR and 66 Technical staff of non-ICAR-Institutes participated, out of which 33.7% employees got first time opportunity after joining service.

Technical staff associated with library: Technical staff associated with library work in various ICAR Institutes/HQs were nominated by the ICAR HQs for Training Programme organised by ICAR-NAARM, Hyderabad on KOHA. Thirty five techinal staff from different ICAR-Institutes, HQs and 01 from SAU were trained, out of which 89% attended first time.

Administrative staff: ICAR-Institutes/HQs organized 44 training programmes for Administrative including Finance staff for improving their competency. Administrative staff 902 of ICAR of various grades undergone various training programmes organized by ICAR-Institutes/HQs, ISTM, NIFM, Central and State Government Departments, etc. Following customized training programmes were developed on the basis of identified training needs in which 124 Administrative staff including finance were trained.

Training programmes organized for administrative including finance staff

Title of training programme(s)	Organizing Institute
Refresher course for section officers, AAOs, AFAOs and Assistants	ICAR-NAARM, Hyderabad
Establishment and financial matters for under secretaries, SAOs, SFAOs, AOs and FAOs	ICAR-NAARM, Hyderabad
ICAR-ERP	ICAR-IASRI, New Delhi
Refresher course on administration and finance management for section officers, AAOs, AFAOs and Assistants	ICAR–NAARM, Hyderabad
Establishment and financial matters for under secretaries, SAOs, SFAOs, AOs and FAOs	ICAR-NAARM, Hyderabad

Refresher course on Administration and Finance Management for section Officers, AAOs, AFAOs and Assistants of ICAR Institutes

Stenographers: ICAR-NAARM, Hyderabad also organized a Training programme on '***Enhancing Efficiency and Behavioural Skills***' in coordination with HRM Unit, ICAR HQs in three batches at ICAR-NAARM, Hyderabad; ICAR-CIFE, Mumbai and ICAR-NBSS&LUP RC, Kolkata. In this programme,92 Stenographers in various grades participated.

Training of Stenographer Grade at ICAR-CIFE, Mumbai (Off-campus training by ICAR-NAARM, Hyderabad)

Regular drivers: ICAR-CIAE, Bhopal organized a specialiazed Training Programme on '***Automobile Maintenance, Road Safety and Behavioural Skills***' in coordination with HRM Unit, ICAR HQs for Regular Drivers in Technical grade of ICAR. In this programme, 87 Regular Drivers participated in 3 batches. Such a programme has been acknowledged by DoPT, GoI.

Training of Regular Drivers at Workshop

Skilled support staff: Based on the identified training needs, ICAR-Institutes are now organising trainings to skilled support staff. Training programmes were organized by 38 ICAR-Institutes and a total of 443 SSS were trained.

Employees trained

During the reporting period, 3,325 employees participated in training and capacity building programmes, out of which Scientists, Technical, Administrative including Finance, and Skilled Support Staff (SSS) were 1165, 815, 902 and 443, respectively. Compared to 2013–14, there was considerable improvement in number of employees undergone trainings particularly in case of Technical, Administrative and Skilled Support Staff, where per cent improvement was 120.3, 48.8 and 1007.5, respectively along with overall improvement of 38% in all the categories of employees during 2017–18.

Crop Science Division deputed the highest number

Trainings organized by various SMDs

SMDs/HQs	Scientists	Technical Staff	Administrative Staff	SSS	All Employees
Crop Science	65	15	12	6	98
Hort Science	18	20	5	19	62
NRM	25	17	3	2	47
Ag. Education	42	11	9	1	63
Ag. Engineering	25	4	0	1	30
Animal Science	36	8	4	7	55
Fisheries Science	16	4	5	2	27
Ag. Extension	14	4	5	0	23
ICAR HQs	1	0	1	0	2
Total	**242**	**83**	**44**	**38**	**407**

of scientists (332), technical staff (253) and administrative staff (257) while highest number of SSS staff was deputed by Horticultural Science Division (121) for various capacity building programmes.

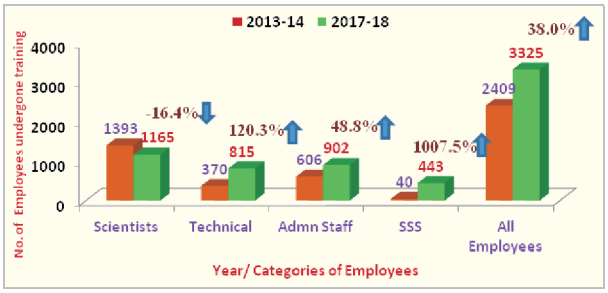
In terms of per cent employees trained under each category, Scientists (24.7%), Technical (17.7%), Administrative including Finance (27.3%) and Skilled Support Staff (10.4%) were trained in various aspects as per their training needs with overall 19.7% employees across the categories got opportunity for capacity building. This is evident that 10.4, 10.8 and 9.7% more Technical, Administrative including Finance and Skilled Support Staff, respectively got training opportunities during 2017–18 as compared to 2013–14 with overall improvement of 7% in capacity building of all the categories of employees.

During the reporting period, the training programmes organised for Scientists, Technical, Administrative including Finance, and Skilled Support Staff were 242, 83, 44 and 38, respectively.

Crop Science Division organised maximum number of trainings for scientists (65) and administrative staff (12) while Horticultural Science Division organised maximum number of trainings for Technical (20) and skilled support staff (19). Overall maximum trainings were organized by Crop Science Division (98).

Impact assessment of training programmes

For the first time, Impact Assessment of training programmes attended during 2016–17 by various categories of employees was done during 2017–18. A total of 106 ICAR-Institutes submitted Impact Assessment Report for 2,211 trainees who had attended training programme during 2016–17 with an average age of 43.5 years and average experience of 16.6 years. Out of 2,211 participants, 403 were the female participants. The proforma developed by DoPT for this purpose was used.



Improvement in Capacity Building of ICAR Employees since Creation of HRM Unit

Based on the feedback of trainees received from different ICAR-Institutes, the overall impact of training was considerable-great extent with average rating of 3.75/5.00. Similarly, based on the feedback of reporting officers of the trainees received from different ICAR-Institutes, the overall impact of trainings on trainees was also considerable-great extent with average rating of 3.55/500.

Constitution of Training Board of ICAR

As per approved new ICAR HRM Policy: Training and Capacity Building, a Training Board under the Chairmanship of DG, ICAR was constituted which has started giving overall direction for the implementation of the Policy w.e.f. 1 April 2018. The present Training Board of ICAR is as under:

1. Director General, ICAR	Chairman
2. Secretary, ICAR	Member
3. Deputy Director Generals (3 for 3 years)	Members
4. Director, ICAR-NAARM, Hyderabad	Member
5. Joint Secretary (Training), DoPT, GoI,	Member
6. Assistant Director General (HRM)	Member Secretary

Resource generation

The NARES including ICAR is committed to solve the existing problems of Indian agriculture and enhancing agricultural production and productivity in the country through science-led and technology-driven farming systems approach. Therefore, it was felt appropriate to extend the training facility of ICAR to the employees of SAUs, CAUs and ICAR funded KVKs in various training programmes for enhancing their competency by charging a nominal fee without putting additional burden on the HRD fund of ICAR. By this way, approximately ₹ 30 lakh was generated through participation of employees particularly from SAUs, CAUs, Central/State Government and ICAR funded KVKs the reporting period.

❑

(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/MTS	5
	Total	49

NAMES OF THE IMPORTANT FUNCTIONARIES

Sl.No.	Name	Designations
1.	Dr Trilochan Mohapatra	Secretary (DARE) and DG (ICAR)
2.	Shri Sushil Kumar	Additional Secretary (DARE) and Secretary (ICAR)
3.	Shri Bimbardhar Pradhan	Additional Secretary and Financial Advisor
4.	Shri Rajan Agrawal	Director
5.	Shri Mohinder Kumar	Principal Staff Officer
6.	Shri A.R. Sengupta	Deputy Secretary
7.	Shri U.S. Pandey	Under Secretary
8.	Shri Jitendra Misra	Under Secretary
9.	Shri Prem Prakash Maurya	Under Secretary
10.	Shri A.G. Subramanian	Under Secretary
11.	Shri Rajesh Kumar	Under Secretary
12.	Shri T.B. Baviskar	Under Secretary
13.	Shri P. Ramamoorthy	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 2017-18 and BE 2018-19 in r/o DARE Secretariat, Contribution, AP Cess, CAUs and NAAS and IAUA are given in Table 1.

Table 1. Budget Estimates and Revised Estimates of DARE

(Rupees in Lakh)

Items		Budget Estimates	Revised Estimates	Budget Estimates
		2017-18	2017-18	2018-19
		Unified Budget	Unified Budget	Unified Budget
Major Head '3451'				
090	Secretariat-Economic Services	760.00	751.00	816.00
Major Head '2415'				
80 General				
80.120	Assistance to other institutions			
01	Grant-in-Aid Central Agricultural University Imphal			
010031	Grants in Aid General	–	–	–
010035	Grants for creation of Capital Assets	–	–	–
010036	Grants in Aid Salaries	–	–	–
02	Grant-in-Aid Central Agricultural University Bundelkhand			
020031	Grants in Aid General	200.00	345.00	400.00
020035	Grants for creation of Capital Assets	3000.00	2905.00	3800.00
020036	Grants in Aid Salaries	700.00	100.00	500.00
03	Grant-in-Aid Central Agricultural University Bihar			
030031	Grants in Aid General	1000.00	800.00	1000.00
030035	Grants for creation of Capital Assets	100.00	100.00	360.00
030036	Grants in Aid Salaries	6500.00	7300.00	7540.00
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	192.00	150.00	156.00
050035	Grants for creation of Capital Assets	8.00	–	–
050036	Grants in Aid Salaries	–	–	–
80.798	International Co-operation (Minor Head)			
01	India's Membership Contribution to Commonwealth Agricultural Bureau			
010032	Contribution	25.00	99.55	25.00
02	India's Membership Contribution to Consultative Group on International Agricultural Research			
020032	Contribution	549.75	525.75	525.75
04	Asia Pacific Association of Agricultural Research Institutions			
040032	Contribution	14.60	14.60	14.60
05	N.A.C.A.			
050032	Contribution	44.00	44.00	44.00
06	Regional Coordination Centre for Research & Development of Coarse Grains, Pulses, Roots and Tuber Crops (CGPRT) in the Humid Tropics of Asia & the Pacific			
060032	Contribution	–	–	–
07	International Seed Testing Association, Zurich, Switzerland			
070032	Contribtion	4.25	8.50	4.25
08	International Society for Horticulture			

(Continued)

Table 1. (Continued) (Rupees in Lakh)

Items		Budget Estimates 2017–18 Unified Budget	Revised Estimates 2017–18 Unified Budget	Budget Estimates 2018–19 Unified Budget
	Science, Belgium			
080032	Contribution	0.40	1.60	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	1300.00	2116.00	2366.00
010035	Grants for creation of Capital Assets	1900.00	1450.00	1650.00
010036	Grants in Aid Salaries	8800.00	8434.00	9384.00
02	Grant-in-Aid-General to Central Agricultural University, Barapani			
020031	Grants in Aid General	–	–	–
020035	Grants for creation of Capital Assets	–	–	–
020036	Grants in Aid Salaries	–	–	–
	TOTAL	**25098.00**	**25145.00**	**28586.00**

MINISTRY OF AGRICULTURE & FARMERS WELFARE

Demand No. 2 Department of Agricultural Research and Education

(₹ in crores)

Schemes		Actual 2016-2017			B.E. 2017-2018			R.E. 2017-2018			B.E. 2018-2019		
		Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
Gross		*5995.21*	*...*	*5995.21*	*6800.00*	*...*	*6800.00*	*6992.00*	*...*	*6992.00*	*7800.00*	*...*	*7800.00*
Recoveries		–265.96	...	–265.96	...	...	...	...	...	...	...	...	...
Receipts		...	...	...	...	...	...	...	...	...	...	...	...
Net		**5729.25**	**...**	**5729.25**	**6800.00**	**...**	**6800.00**	**6992.00**	**...**	**6992.00**	**7800.00**	**...**	**7800.00**
A. The Budget allocations, net of recoveries, are given below:													
CENTRE'S EXPENDITURE													
I Establishment Expenditure of the Centre													
1. Secretariat	2415	5.89	...	5.89	6.53	...	6.53	7.09	...	7.09	6.24	...	6.24
	3451	7.22	...	7.22	7.45	...	7.45	7.36	...	7.36	8.06	...	8.06
Total-Secretariat		13.11	...	13.11	13.98	...	13.98	14.45	...	14.45	14.30	...	14.30
II.Central Sector Schemes/Projects													
2. Agricultural Extension	2415	753.86	...	753.86	220.11	...	220.11	220.11	...	220.11	228.17	...	228.17
	2552	...	...	...	12.40	...	12.40	12.40	...	12.40	13.64	...	13.64
Total-Agricultural Extension		753.86	...	753.86	232.51	...	232.51	232.51	...	232.51	241.81	...	241.81
3. Agricultural Engineering	2415	190.86	...	190.86	40.97	...	40.97	40.97	...	40.97	98.12	...	98.12
	2552	...	...	...	1.71	...	1.71	1.71	...	1.71	1.88	...	1.88
Total-Agricultural Engineering		190.86	...	190.86	42.68	...	42.68	42.68	...	42.68	100.00	...	100.00
Management of Natural Resources													
4. Natural Resource Management Institutes including Agro Forestry Research	2415	610.24	...	610.24	140.68	...	140.68	140.68	...	140.68	144.69	...	144.69
	2552	...	...	...	27.00	...	27.00	27.00	...	27.00	29.70	...	29.70
Total-Natural Resource Management Institutes including Agro Forestry Research		610.24	...	610.24	167.68	...	167.68	167.68	...	167.68	174.39	...	174.39
5. Climate Resilient Agriculture Initiative	2415	70.00	...	70.00	43.00	...	43.00	43.00	...	43.00	44.30	...	44.30
	2552	...	...	...	7.00	...	7.00	7.00	...	7.00	7.70	...	7.70
Total-Climate Resilient Agriculture Initiative		70.00	...	70.00	50.00	...	50.00	50.00	...	50.00	52.00	...	52.00
Crop Sciences													
6. Crop Science	2415	1347.93	...	1347.93	385.71	...	385.71	397.96	...	397.96	746.25	...	746.25
	2552	...	...	...	1.70	...	1.70	1.70	...	1.70	53.75	...	53.75
Total-Crop Science		1347.93	...	1347.93	387.41	...	387.41	399.66	...	399.66	800.00	...	800.00
7. Horticultural Science	2415	522.29	...	522.29	150.06	...	150.06	150.06	...	150.06	194.68	...	194.68
	2552	...	...	...	4.84	...	4.84	4.84	...	4.84	5.32	...	5.32
Total-Horticultural Science		522.29	...	522.29	154.90	...	154.90	154.90	...	154.90	200.00	...	200.00
8. National Agricultural Science Fund	2415	35.00	...	35.00	48.80	...	48.80	36.55	...	36.55	50.75	...	50.75

Schemes		Actual 2016-2017			B.E. 2017-2018			R.E. 2017-2018			B.E. 2018-2019		
		Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
Animal Sciences													
9. Animal Science		811.05	...	811.05	261.62	...	261.62	261.62	...	261.62	388.61	...	388.61
	2552	...	...	...	10.35	...	10.35	10.35	...	10.35	11.39	...	11.39
Total -Animal Science		811.05	...	811.05	271.97	...	271.97	271.97	...	271.97	400.00	...	400.00
10. Fisheries Science	2415	395.40	...	395.40	114.85	...	114.85	114.85	...	114.85	169.59	...	169.59
	2552	...	...	...	1.00	...	1.00	1.00	...	1.00	1.10	...	1.10
Total-Fisheries Science		395.40	...	395.40	115.85	...	115.85	115.85	...	115.85	170.69	...	170.69
Agricultural Education													
11. Agricultural Universities and Institutions	2415	660.79	...	660.79	633.37	...	633.37	628.37	...	628.37	651.70	...	651.70
	2552	...	...	...	30.00	...	30.00	30.00	...	30.00	33.00	...	33.00
Total-Agricultural Universities and Institutions		660.79	...	660.79	663.37	...	663.37	658.37	...	658.37	684.70	...	684.70
12. Economics Statistics and Management	2415	65.50	...	65.50	31.29	...	31.29	31.29	...	31.29	32.54	...	32.54
13. National Agricultural Higher Education Project		...	...	...	...	...	...	5.00	...	5.00	7.89	...	7.89
Total-Central Sector Schemes/ Projects		5462.92	...	5462.92	2166.46	...	2166.46	2166.46	...	2166.46	2914.77	...	2914.77
III Other Central Sector Expenditure													
b Autonomous Bodies													
14. ICAR Headquarters		319.21	...	319.21	4275.56	...	4275.56	4467.09	...	4467.09	4467.37	...	4467.37
	2552	...	...	...	107.00	...	107.00	107.00	...	107.00	132.00	...	132.00
		319.21	...	319.21	4382.56	...	4382.56	4574.09	...	4574.09	4599.37	...	4599.37
15. Central Agricultural Universities	2415	198.56	...	198.56	115.00	...	115.00	115.50	...	115.50	136.00	...	136.00
	2552	...	...	...	120.00	...	120.00	120.00	...	120.00	134.00	...	134.00
		198.56	...	198.56	235.00	...	235.00	235.50	...	235.50	270.00	...	270.00
16. National Academy of Agricultural Sciences	2415	1.41	...	1.41	2.00	...	2.00	1.50	...	1.50	1.56	...	1.56
Total-Autonomous Bodies		519.18	...	519.18	4619.56	...	4619.56	4811.09	...	4811.09	4870.93	...	4870.93
Others													
17. Actual Recoveries		–265.96	...	–265.96	...	...	...	...	...	...	...	...	...
Grand Total		5729.25	...	5729.25	6800.00	...	6800.00	6992.00	...	6992.00	7800.00	...	7800.00
B. Developmental Heads													
Economic Services													
1. Agricultural Research and Education		5722.03	...	5722.03	6469.55	...	6469.55	6661.64	...	6661.64	7368.46	...	7368.46
2. Secretariat-Economic Services		7.22	...	7.22	7.45	...	7.45	7.36	...	7.36	8.06	...	8.06
Total-Economic Services		5729.25	...	5729.25	6477.00	...	6477.00	6669.00	...	6669.00	7376.52	...	7376.52
Others													
3. North Eastern Areas		...	...	...	323.00	...	323.00	323.00	...	323.00	423.48	...	423.48
Total-Others		...	...	...	323.00	...	323.00	323.00	...	323.00	423.48	...	423.48
Total		5729.25	...	5729.25	6800.00	...	6800.00	6992.00	...	6992.00	7800.00	...	7800.00

1. Secretariat-The provision is for the expenditure on salary of DARE staff. 2. Agricultural Extension- The provision is for the activities to reach out to the farmers at grass root level through Krishi Vigyan Kendras to disseminate and refine frontline agricultural technologies. It includes training of farmers and extension personnel on local technologies, distribution

of seed and planting materials and testing of soil and water samples. 3. Agricultural Engineering- The provision is for research, development and refinement of farm equipment, process and value addition protocols. 4. Natural Resource Management Institutes including Agro-Forestry Research- The provision is for research to address low farm productivity and profitability, land degradation, low water productivity, soil health deterioration and low nutrient use efficiency, deterioration in ecosystem services, abiotic stresses, etc. It is necessary to encounter deteriorating natural resource base for long term sustainability. 5. Climate Resilient Agriculture Initiative- The provision is to conduct strategic research and technology demonstration to enhance resilience of Indian agriculture to climate change and climate vulnerability. The research on adaptation and mitigation covers crops, livestock, fisheries and natural resource management. 6. Crop Science-research provision is to develop trait- specific high yielding field crop varieties/hybrids having tolerance to pest and diseases, besides various abiotic stresses. The quality attributes are also given due importance with no yield penalty. The All India Coordinated Research Project (AICRPs)/Network Research Projects with active collaboration with State Agricultural Universities (SAUs) are engaged in the development of improved crop varieties/ hybrids, cost-effective production and environment-friendly protection technologies in different agro-climatic regions. 7. Horticultural Science-The provision is to address thrust areas of enrichment of horticultural genetic resources, development of new cultivation with resistance mechanism to biotic and abiotic stresses, appropriate production technology and health management system of horticultural and vegetable crops. 8. National Agricultural Science Fund—supports basic and strategic research in agriculture to address the prioritized research problems. 9. Animal Sciences-The provision is to develop new technologies to support production enhancement, profitability, competitiveness and sustainability of livestock and poultry sector for food and nutritional security. It will facilitate need based priority research in livestock and poultry sector in on-going and new emerging areas to support productivity increase, thereby reducing the gap between potential and actual yield. 10. Fisheries Science-The provision is to implement research and academic programmes in fisheries and aquaculture. It also provides technical, training, analytical, advisory support and consultancy services in the field of resources assessment and management, standardization of aquaculture hatchery and grow-out culture technologies, responsible fishing system and species diversification and utilization of inland saline soils for aquaculture, fish health monitoring, etc. 11. Agricultural Universities and institutions-The provision will provide financial support to all the agricultural universities in the country comprising State Agricultural Universities (SAUs), Deemed universities (DUs), and Central Universities (CUs) with Agriculture Faculty. The scheme is also responsible for maintainance and improvement of standard of agricultural education through (*i*) accreditation of educational institutions, (*ii*) providing International/ national fellowships both at post and undergraduate levels, (*iii*) organization of training and capacity building programmes for the scientists/faculty of National Agricultural Research System in cutting-edge areas. 12. Economics, statistics and management-The provision is for conducting research in the areas of agricultural economics and agricultural statistics to address the policy, management and database issues and accordingly provide need-based support to other schemes and agricultural stakeholders. 13. The provision is for National Agricultural Higher Education Project (NAHEP) which aims to develop resources and mechanism for supporting infrastructure, faculty and student advancement, and providing means for better governance and management of agricultural universities, so that a holistic model can be developed to raise the standard of current agricultural education system that provides more jobs and is entrepreneurship oriented and on par with the global agriculture education standards. 14. ICAR Headquarters—provision is primarily for the salaries, pensions and expenses on administrative and logistic support to different schemes under ICAR in order to implement them efficiently. The provision in BE 2017–18 goes up dramatically because of regrouping of salaries, pensions and office expenditure from all schemes in BE 2016–17 under ICAR headquarters. 15. Central Agricultural Universities-The provision is to strengthen the regional education, research and extension capabilities based on local agro-climatic situation. 16. National Academy of Agricultural Sciences-The provision is to provide a forum to Agricultural Scientists to deliberate on important issues of agricultural research, education and extension and present views of the scientific community as policy inputs to planners, decision/opinion makers at various levels.

(B) INDIAN COUNCIL OF AGRICULTURAL RESEARCH

APPENDIX 1

INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

4(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

4(ii) *Minister of State in the Union Ministry of Agriculture and Farmers Welfare dealing with ICAR*

2 Shri Gajendra Singh Shekhawat *Ex-officio*
Minister of State for Agriculture and
Farmers Welfare
Krishi Bhavan, New Delhi-110 001

4(iii) *Union Ministers holding charge of Finance, Planning, Science and Technology, Education and Commerce (in case the Prime Minister is holding any of these portfolios, the Minister of State in the Ministry / Department concerned).*

3 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 110001

5 Dr Harsh Vardhan *Ex-officio*
Minister of Science and 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 Commerce & Industry,
Government of India,
Udyog Bhavan, New Delhi-110 001

4(iv) *Other Ministers in the Union Ministry of Agriculture and Farmers Welfare*

8 Shri Parshottam Rupala, *Ex-officio*
Minister of State for Agriculture and Farmers
Welfare and Panchayati Raj
Krishi Bhavan, New Delhi-110 001

9 Smt. Krishna Raj *Ex-officio*
Minister of State for Agriculture and Farmers
Welfare
Krishi Bhavan, New Delhi-110 001

4(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 and Horticulture
Government of Andhra Pradesh,
A.P. Secretariat, Valagapudi,
Hyderabad, Andhra Pradesh-500 022

11 Ch. Adi Narayana Reddy *Ex-officio*
Minister for Animal Husbandry and Fisheries
Government of Andhra Pradesh,
A.P. Secretariat, Valagapudi,
Hyderabad, Andhra Pradesh-500 022

ARUNACHAL PRADESH

12 Dr Mohesh Chai *Ex-officio*
Minister for Animal Husbandry, Agriculture,
Horticulture and Fisheries,
Government of Arunachal Pradesh
CM Secretariat,
Itanagar, Arunachal Pradesh-791 111

ASSAM

13 Shri Atul Bora *Ex-officio*
Minister for Agriculture and Horticulture
& Animal Husbandry
Government of Assam,
Assam Secretariat, Dispur,
Guwahati-781 006, Assam

14 Shri Parimal Suklabaidya Ex-officio
Minister of Fisheries,
Government of Assam,
Assam Secretariat, Dispur,
Guwahati-781 006, Assam

BIHAR

15 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

16 Dr Prem Kumar *Ex-officio*
Minister for Agriculture and Horticulture
Government of Bihar,
Vikas Bhavan, New Secretariat,
Bailey Road, Patna, Bihar-800 015

CHHATTISGARH

17 Shri Ravindra Choubey *Ex-officio*
Minister of Agriculture, Animal
Husbandry and Fisheries,
Government of Chhattisgarh,
Mahanadi Bhawan, Mantralaya
Naya Raipur-492 002 (Chhattisgarh)

DELHI

18 Shri Gopal Rai *Ex-officio*
Minister for Development
Delhi Secretariat, I.P. Estate,
New Delhi-110 002

GOA

19 Shri Manohar Parrikar *Ex-officio*
Chief Minister holding the charge of
Ministry of Horticulture and Animal husbandry,
Government of Goa, Secretariat,
Panaji, Goa-403 001

20 Shri Vijai Sardesai *Ex-officio*
Minister of Agriculture
Government of Goa, Secretariat,
Panaji, Goa-403 001

21 Shri Vinoda Paliencar *Ex-officio*
Minister of Fisheries
Government of Goa, Secretariat,
Panaji, Goa-403 001

22 Shri. Shri. Mauvin Godinho
Minister of Animal husbandry
Government of Goa, Secretariat,
Panaji, Goa-403 001

GUJARAT

23 Shri Ranchhodbhai Chanabhai Faldu *Ex-officio*
Minister for Agriculture, Fisheries
Government of Gujarat,
Swarnim Sankul-I, New Sachivalaya,
Gandhinagar, Gujarat-382 010

24 Shri. Shri Kunvarjibhai Mohanbhai Bavaliya
Minister of 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 for Animal Husbandry and 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 Governor Rule *Ex-officio*

JHARKHAND

30 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

31 Managuli Mallapa Channaveerappa *Ex-officio*
Minister of Horticulture,
Government of Karnataka,
Vidhan Soudha, Bangalore
Karnataka-560 001

32 Shri Venkatarao Nadagouda *Ex-officio*
Minister of Animal Husbandry and Fisheries,
Government of Karnataka,
Vikasa Soudha, Vidhan Soudha,
Bangalore, Karnataka-560 001

33 Shri N. H. Shivashankara Reddy *Ex-officio*
Minister of Agriculture
Government of Karnataka,
Vikasa Soudha, Vidhan Soudha, Bangalore,
Karnataka-560 001

KERALA

34 Shri V. S. Sunil Kumar *Ex-officio*
Minister for Agriculture
Government of Kerala,
Secretariat Annexe
Thiruvananthapuram, Kerala-695 001

35 Shri K. Raju *Ex-officio*
Minister for Animal Husbandry
Government of Kerala
Secretariat Annexe
Thiruvananthapuram, Kerala-695 001

36 Smt. J. Mercykutty Amma *Ex-officio*
Minister for Fisheries,
Government of Kerala,
Secretariat Annexe Thiruvananthapuram,
Kerala-695 001

MADHYA PRADESH

37 Shri Sachin Subhash Yadav *Ex-officio*
Minister of Agriculture Development & Horticulture
Government of Madhya Pradesh,
Vallabh Bhavan,
Bhopal, Madhya Pradesh -423 006

38 Shri Lakhan Singh Yadav *Ex-officio*
Minister of Animal Husbandry and Fisheries
Government of Madhya Pradesh,
Vallabh Bhavan,
Bhopal, Madhya Pradesh -423 006

39 VACANT *Ex-officio*

MAHARASHTRA

40 Shri Chandrakant Patil *Ex-officio*
Minister for Agriculture and Horticulture,
Government of Maharashtra,
Mantralaya, Mumbai,
Maharashtra-400 032

41 Shri Mahadev Jagannath Jankar *Ex-officio*
Minister for Animal Husbandry and Fisheries Development
Government of Maharashtra,
Mantralaya, Mumbai,
Maharashtra-400 032

MANIPUR

42 Shri V. Hangkhanlian *Ex-officio*
Minister for Agriculture and Animal Husbandry,
Government of Manipur,
Secretariat, Imphal, Manipur-795 001

43 Shri Thounaojam Shamkumar *Ex-officio*
Minister for Horticulture
Government of Manipur,
Secretariat, Imphal, Manipur-795 001

44 Shri N. Kayishii *Ex-officio*
Minister for Fisheries
Government of Manipur, Secretariat,
Imphal, Manipur-795 001

MEGHALAYA

45 Sh. Banteidor Lyngdoh *Ex-officio*
Ministry of Agriculture and Horticulture
Government of Meghalaya,
Meghalaya Secretariat (C),
Shillong, Meghalaya-793 001

46 Shri Prestone Tynsong *Ex-officio*
Minister for Animal Husbandry
Government of Meghalaya,
Meghalaya Secretariat (C),
Shillong, Meghalaya-793 001

47 Sh. Comingone Ymbon *Ex-officio*
Minister for Fisheries
Government of Meghalaya,
Meghalaya Secretariat (C),
Shillong, Meghalaya-793 001

MIZORAM

48 Shri Pu Zoramthanga *Ex-officio*
Chief Minister & holding the charge of Ministry for Horticulture,
Government of Mizoram,
Aizwal, Mizoram-796 001

49 Shri Pu Tawnluia *Ex-officio*
Deputy Chief Minister
Minister of Animal Husbandry
Government of Mizoram,
Aizwal, Mizoram-796 001

50 Shri Pu C Lalrinsanga *Ex-officio*
Minister for Agriculture
Government of Mizoram,
Aizwal, Mizoram-796 001

51 Shri Pu K Lalrinliana *Ex-officio*
Minister of State for Fisheries,
Government of Mizoram,
Aizwal, Mizoram-796 001

NAGALAND

52 Sh. Neiphiu Rio *Ex-officio*
Chief Minister holding the charge of Ministry of Horticulture and Animal husbandry and Fisheries,
Government of Nagaland,
Civil Secretariat Complex
Kohima, Nagaland-797 004

53 Shri G. Kaito Aye *Ex-officio*
Minister of Agriculture,
Government of Nagaland,
Civil Secretariat Complex
Kohima, Nagaland-797 004

ODISHA

54 Shri Sashibhusan Behera *Ex-officio*
Minister for Agriculture, Fisheries and Animal Resource Development,
Government of Odisha,
Odisha Secretariat,
Bhubaneswar, Odisha-751 001

PUNJAB

55 Captain Amarinder Singh, *Ex-officio*
Chief Minister holding the Charge of Ministry of Agriculture,
Horticulture and Fisheries
Government of Punjab,
Punjab Civil Secretariat,
Chandigarh, Punjab

56 Sh. Balbir Singh Sidhu *Ex-officio*
Ministry for Animal husbandry
Government of Punjab,
Punjab Civil Secretariat, Chandigarh, Punjab

PUDUCHERRY

57 Shri. R. Kamalakannan *Ex-officio*
Minister for Agriculture Minister
Government of Puducherry,
Puducherry-605 001

58 Shri A. Namassivayam *Ex-officio*
Minister for Animal Husbandry
Government of Puducherry,
Puducherry-605 001

59 Shri Malladi Krishna Rao *Ex-officio*
Minister for Fisheries
Government of Puducherry,
Puducherry-605 001

RAJASTHAN

60 Shri Lal Chand Kataria *Ex-officio*
Minister for Agriculture,
Animal Husbandry and Fisheries,
Government of Rajasthan,
Rajasthan Secretariat, Mantralaya Bhawan, Jaipur, Rajasthan-302 005.

SIKKIM

61 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

62 Shri R. Doraikkannu *Ex-officio*
Minister for Agriculture and Horticulture
Government of Tamil Nadu,
Chennai, Tamil Nadu-600 009

63 Shri D. Jayakumar *Ex-officio*
Minister for Fisheries,
Government of Tamil Nadu,
Chennai, Tamil Nadu-600 009

64 Shri Udumalai Radhakrishnan *Ex-officio*
Minister for Animal Husbandry,
Government of Tamil Nadu,
Chennai, Tamil Nadu-600 009

TELANGANA

65 Shri Pocharam Srinivas Reddy *Ex-officio*
Minister of Agriculture, Horticulture
Room No.261, D-Block
Government of Telangana,
Telangana Secretariat
Hyderabad-500 022, Telangana

66 Shri Talasani Srinivas Yadav *Ex-officio*
Minister of Animal husbandry and Fisheries
Government of Telangana,
Room No.261, D-Block,
Telangana Secretariat
Hyderabad, Telangana-500 022

TRIPURA

67 Shri Biplab Kumar Deb, *Ex-officio*
Chief Minister, holding the charge of Ministry of Horticulture,
Government of Tripura, Civil Secretariat,
Agartala, Tripura-799 001

68 Shri Pranajit Singha Roy *Ex-officio*
Minister for Agriculture
Government of Tripura,
Civil Secretariat,
Agartala, Tripura-799 001

69 Shri Narendra Chandra Debbarma
Shri Pranajit Singha Roy
Minister for Fisheries
Government of Tripura,
Civil Secretariat,
Agartala, Tripura-799 001

70 Smt. Santana Chakma
Minister for Animal Resource Development,
Government of Tripura,
Civil Secretariat,
Agartala, Tripura-799 001

UTTARAKHAND

71 Shri Subodh Uniyal *Ex-officio*
Minister for Agriculture and Horticulture
Government of Uttarakhand,
Uttarakhand Vidhan Sabha Bhawan,
Dehradun, Uttarakhand

72 Smt. Rekha Arya *Ex-officio*
Minister for Animal Husbandry and Fisheries
Government of Uttarakhand,
Uttarakhand Vidhan Sabha Bhawan,
Dehradun, Uttarakhand

UTTAR PRADESH

73 Shri Dara Singh Chauhan *Ex-officio*
Minister of Horticulture
Government of Uttar Pradesh,
UP Civil Secretariat,
Lucknow, Uttar Pradesh

74 Shri Surya Pratap Shahi *Ex-officio*
Minister of Agriculture
Government of Uttar Pradesh,
UP Civil Secretariat,
Lucknow, Uttar Pradesh

75 Shri S. P. Singh Baghel *Ex-officio*
Minister of Animal Husbandry and Fisheries
Government of Uttar Pradesh,
UP Civil Secretariat,
Lucknow, Uttar Pradesh

WEST BENGAL

76 Dr Ashish Banerjee *Ex-officio*
Minister for Agriculture,
Government of West Bengal,
"NABANNA", HRBC Building,
Sarat Chatterjee Road,
Shibpur, Howrah
Kolkata, West Bengal-711 102

77 Sri Swapan Debnath *Ex-officio*
Minister of State for Animal Resources
(Independent Charge),
Government of West Bengal,
Prani Sampad Bhavan,
LB2, Sector-III, Salt Lake City
Kolkata, West Bengal-700 106

78 Sri Chandranath Sinha *Ex-officio*
Minister for Fisheries Department,
Government of West Bengal,
Benfish, I.T. Tower,
G.N. Block, Sector-V, Salt Lake,
Kolkata, West Bengal-700 106

79 Sri Janab Abdur Rezzak Mollah *Ex-officio*
Minister for Horticulture
Government of West Bengal,
Mayukh Bhavan, Salt Lake,
Kolkata, West Bengal-700 091

4(vi) *Member, NITI Ayog, In-charge of Agriculture*

80 Dr Ramesh Chand *Ex-officio*
Member (Agriculture)
NITI Ayog, Yojana Bhawan,
New Delhi-110 001

4(vii) *Six members of Parliament—four elected by Lok Sabha and two elected by Rajya Sabha.*

81 Shri Dushyant Chautala Till the expiry of
Member of Parliament (LS), term in Lok Sabha
222, Urban Estate-II,
Hisar, Haryana-125 005
Shri Dushyant Chautala
Member of Parliament (LS),
18, Janpath, New Delhi-110 001

82 Shri Sanjay Dhotre Till the expiry of
Member of Parliament (LS), term in Lok Sabha
Ranpise Nagar, Distt.
Akola, Maharashtra-444 005
Shri Sanjay Dhotre
Member of Parliament (LS),
AB-95, Shahjahan Road
New Delhi-110 013

83 Shri Raju Shetti Till the expiry of
Member of Parliament (LS), term in Lok Sabha
Arjunwad Road, Shrol,
Distt. Kolhapur, Maharashtra-416 101
Shri Raju Shetti
Member of Parliament (LS),
Flat No. 102, Narmada,
Dr Bishambar Das Marg,
New Delhi-110 001

84 Shri Ravneet Singh Till the expiry of
Member of Parliament (LS), term in Lok Sabha
Village-Kotla Afghana,
Distt. Ludhiana, Punjab-141 416
Shri Ravneet Singh
Member of Parliament (LS),
28, Dr Rajendra Prasad Road,
New Delhi-110 001

85 **VACANT**

86 **VACANT**

4(viii) *Director-General, Indian Council of Agricultural Research.*

87 Dr T. Mohapatra *Ex-officio*
Secretary, DARE and DG, ICAR,
Krishi Bhavan, New Delhi-110 001

4(ix) *All Secretaries in the Ministry of Agriculture and Farmers Welfare.*

88 Shri Sanjay Agarwal *Ex-officio*
Secretary, Department of Agriculture,
Cooperation and Farmers Welfare
Ministry of Agriculture and Farmers Welfare
Krishi Bhavan, New Delhi-110 001

89 Shri Tarun Shridhar *Ex-officio*
Secretary, Department of Animal Husbandry,
Dairying and Fisheries
Ministry of Agriculture and Farmers Welfare
Krishi Bhavan, New Delhi-110 001

4(x) CEO, NITI Ayog

90 Shri Amitabh Kant *Ex-officio*
CEO, Niti Ayog, Yojana Bhavan,
Sansad Marg, New Delhi-110 001

4(xi) Secretary, Department of Bio-Technology.

91 Dr Renu Swarup *Ex-officio*
Secretary,
Department of Biotechnology,
Block 2, 7th Floor, CGO Complex,
Lodhi Road, New Delhi-110 003

4(xii) *Director-General, Council of Scientific and Industrial Research.*

92 Dr Shekhar C. Mande *Ex-officio*
Director General,
Council of Scientific and Industrial Research,
Anusandhan Bhavan, 2-Rafi Ahmed Kidwai Marg,
New Delhi-110 001

4(xiii) *Chairman, University Grants Commission.*

93 Dr D. P. Singh *Ex-officio*
Chairman,
University Grants Commission
Bahadur Shah Zafar Marg,
New Delhi-110 002

4(xiv) *Chairman, Atomic Energy Commission (or Director, Bhabha Atomic Research Centre, if nominated by the Chairman, Atomic Energy Commission)*

94 Sh. Kamlesh Nilkanth Vyas *Ex-officio*
Chairman, Atomic Energy Commission
Department of Atomic Energy,
Anushakti Bhavan, Chhatrapati Shivaji Maharaj Marg,
Mumbai, Maharashtra-400 001

4(xv) *Member, Finance (Secretary/ Additional Secretary) in the Ministry of Finance, Government of India.*

95 Shri Pramod Kumar Das *Ex-officio*
Additional Secretary (Expenditure)
Department of Expenditure,
Ministry of Finance, North Block
New Delhi-110 001

96 Alternative member for ministry of Finance-AS and FA (DARE/ICAR) Shri B. Pradhan AS and FA (DARE/ICAR), Krishi Bhawan, New Delhi-110 001 — *Ex-officio*

4(xvi) *Five Vice-Chancellors of Agricultural Universities, nominated by the President.*

97 Dr Ramesh Chandra Srivastava, Vice-Chancellor, Dr Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar 848 125 — 13.11.2020

98 Dr V. Praveen Rao, Vice-Chancellor, Prof. Jayashankar Telangana State Agricultural University Rajendranagar Hyderabad, Telangana-500 030 — 24.07.2019

99 Dr A.K. Singh, Vice-Chancellor, Bihar Agricultural University, Sabour, Bhagalpur, Bihar — 23 May, 2019

100 Dr A.R. Pathak, Vice-Chancellor, Junagadh Agricultural University, Junagadh, Gujarat-362 001 — 28 December, 2018

101 Prof. Ashok Kumar Sarial, Vice-Chancellor CSK-Himachal Pradesh Agricultural University, Palampur, Distt. Kangra Himachal Pradesh-176 062 — 11 August, 2019

4(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*

102 Dr S.K. Malhotra, Agriculture Commissioner, Department of Agriculture and Cooperation, Ministry of Agriculture and Farmers Welfare, Krishi Bhavan, New Delhi-110 001 — *Ex-officio*

103 Dr B.N.S. Murthy, Horticulture Commissioner, Department of Agriculture and Cooperation, Ministry of Agriculture and Farmers Welfare, Krishi Bhavan, New Delhi-110 001 — *Ex-officio*

104 Dr Suresh S. Honnappagol, Animal Husbandry Commissioner, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Farmers Welfare, Krishi Bhavan, New Delhi-110 001 — *Ex-officio*

105 Dr P. Paul Pandian, Fisheries Development Commissioner Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Farmers Welfare, Krishi Bhavan, New Delhi-110 001 — *Ex-officio*

106 Dr Pankaj Asthana, Inspector General of Forests (NAEB) Ministry of Environment and Forests, Paryavaran Bhawan, B-Block CGO Complex, Lodi Road, New Delhi-110 003 — *Ex-officio*

4(xviii) *Fifteen scientists from within and outside the Council including one representative from the Indian Council of Medical Research*

107 Dr N.C. Gautam, Vice-Chancellor, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidhyalaya Chitrakoot, Satna, Madhya Pradesh-485 334 — 07.02.2021

108 Dr Kamala Kanta Saharia, Professor (Extension Education.) Department of Extension Education, College of Veterinary Science, AAU, Khanpara, Guwahati, Asom-781 022 — 07.02.2021

109 Dr T.V.R.S. Sharma, (Emeritus Scientist) Former Head, Field Crops, ICAR-Central Agricultural Research Institute, Garacharma, Port Blair, Andman-Nicobar Island-744 101 — 07.02.2021

110 Dr P.S. Rathore, Vice-Chancellor, SKN Agricultural University, Jobner, Jaipur, Rajasthan — 07.02.2021

111 Dr Prakash Shastri, Professor (Plant Pathology), College of Agriculture, RVSKVV, Khandwa, Madhya Pradesh-450 001 — 07.02.2021

112 Prof. Arun Kumar Das, Agricultural University, Bhubaneswar, Odisha Residence 159/3907, Bhakt Madhunagar, Gundamunda, Khandagiri, Bhubaneswar, Odisha-751 030 — 07.02.2021

113 Dr M. Premjeet Singh, Vice-Chancellor, Central Agricultural University, Imphal, Manipur — 07.02.2021

114 Dr Jitendra Kumar Chauhan, Professor and Chairman, School of Social Science, College of Post Graduate Studies, Barapani (Umiam), Shillong, Meghalaya-793 103 — 07.02.2021

115 Dr K.P. Viswanathan, Vice-Chancellor, Mahatma Phule Agricultural University, Rahuri, Maharashtra — 07.02.2021

116 Dr C.J. Dangria, Vice-Chancellor, Navsari Agricultural University, Navsari, Gujarat-396 450 — 07.02.2021

117 Dr P.M. Salimath, Former Vice-Chancellor (UAS, Raichur), 405, Raya Residency, Savmati Nagar, Dharwad-580001, Karnataka — 07.02.2021

118 Dr K.P. Singh, Director of Extension Chaudhary Charan Singh Agricultural University, Hisar, Haryana-125 004 — 07.02.2021

119 Dr M.S. Nataraju, Director of Extension University of Agricultural Sciences, Gandhi Krishi Vigyana Kendra, Hebbal, Bengaluru, Karnataka-560 065 — 07.02.2021

120 Dr Bharat S. Sontakki, Head, Extension Systems Management Division, ICAR-National Academy of Agricultural Research Management (ICAR-NAARM), Rajendranagar, Hyderabad, Telangana-500 030 — 07.02.2021

Representative from the Indian Council of Medical Research

121 Vacant

4(xix) *Three representatives of commerce and industry, nominated by the President.*

122 **VACANT**

123 **VACANT**

124 **VACANT**

4(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*

125 Sh. Bhuvan Vikram Dabral, Bhagwanpura, Post-Rajawala, Distt. Dehradun, Uttarakhand — 8 December, 2019

126 Sh. Kondela Saya Reddy — 8 December, 2019
H. No. 11/1/1815, Maruti Nagar,
Nizamabad, Telangana-503 002

127 Sh. Hurvi Zeliang — 8 December, 2019
Ekranipathar, Block 15, House No. 144,
Lhomithi Village, Dimapur-3,
Dimapur, Nagaland-797 112

128 Sh. Sarvajeet Singh — 8 December, 2019
Village-Baranti, Post-Bidupur R.S.,
Thana-Rajapakar,
District-Vaishali, Bihar-844 502

129 Sh. Ashok Parashar — 8 December, 2019
Kailash Nagar, Bridge No. 4,
P.O. Sujanpur,
Teh. and District-Pathankot, Punjab-145 023

130 Sh. Ratanlal Daga — 8 December, 2019
(Organic Farmer)
6, Radhika, Saloon House,
LIC Colony, Ummed Club Road,
Jodhpur, Rajasthan

131 Sh. Rashid Mohan Gavit — 8 December, 2019
At-Dhanrat Village, Tehsil-Navapur,
District-Nandurbar, Maharashtra-425 418

132 Sh. B.K. Ramesh — 8 December, 2019
Bembila House, Palthady, Putter Taluk,
Dakshina Kannada, Karnataka-574 210

4 *Representatives of Rural Interests*

133 Shri Sudhir Kumar Bhargava — 8 June, 2020
Director, Agroman Systems Pvt. Ltd.
25/2, Tardeo AC Market, Tardeo, Mumbai,
Maharashtra-400 034

134 Shri Pushp Jain — 11 April, 2021
Ex-member of Parliament,
53/54, Maa Kripa Housing Society,
Circuit House Road, Pali (Rajasthan)

135 Shri Suresh Chandel — 11 April, 2021
Ex-member of Parliament,
Village-Gandhi Ropa, Post-Beri Ropa,
Distt. and Tehsil-Bilaspur,
Himachal Pradesh-174 001

136 Shri Akhilesh Kumar — 11 April, 2021
Shyama Bhavan, Mathiya Zirat,
Motihari, East Champaran, Bihar

4(xxi) *Four Directors of the Indian Council of Agricultural Research Institutes, nominated by the President.*

137 Dr A.D. Pathak — 24 May, 2019
Director, Indian Institute of
Sugarcane Research, Lucknow
Uttar Pradesh

138 Dr K.K. Singh — 24 May, 2019
Director, Central Institute of
Agricultural Engineering,
Nabi Bagh, Berasia Road,
Bhopal, Madhya Pradesh-462 038

139 Dr P.C. Sharma — 24 May, 2019
Director, Central Soil Salinity Research Institute,
Zarifa Farm, Kachhwa Road
Karnal, Haryana-132 001

140 Dr P.K. Mishra, — 24 May, 2019
Director,
Indian Institute of Soil and Water Conservation,
Kaulagarh Road,
Dehradun, Uttarakhand-248 001

4(xxii) *Four representatives of State Governments to be nominated zone-wise on a rotational basis by Director General, ICAR*

141 Shri R. D. Dhiman — 15 June, 2020 /*Ex-officio*
Principal Secretary(Horticulture)
Room No. A-419A, Government of
Himachal Pradesh, H.P. Secretariat,
Shimla-171 002

142 Shri Alan Gonmei — 15 June, 2020 /*Ex-officio*
Secretary,
Veterinary and Animal Husbandry
Thizama Road, New Secretariat
Nagaland, Kohima-797 001

143 Shri Viswajeet Khanna — 15 June, 2020 /*Ex-officio*
Additional Chief Secretary,
Agriculture, Mini Secretariat,
5th Floor, Mini Secretariat Punjab,
Sector 9, Chandigarh-160 001

144 Shri Eknath Davale — 15 June, 2020 /*Ex-officio*
Secretary (Water Conservation
Department) holding the additional Charge
of Agriculture
Government of Maharashtra,
Agriculture Department, 5th floor,
Annex Bldg., Mantralaya,
Mumbai, Maharashtra-400 032

4(xxiii) *One representative of Agro and Agro-Processing Industries nominated by President*

145 **VACANT**

4(xxiv) *One representative from a distinguished Non-Governmental Organization dealing with Agriculture/ Extension nominated by President*

146 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

4(xxv) *Secretary, Indian Council of Agricultural Research-Member Secretary*

147 Shri Sushil Kumar
Secretary,
Indian Council of Agricultural
Research, Krishi Bhavan,
New Delhi-110 001

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-110 001

Rule 35(ii)
Member, Finance, Alternate member-Financial Adviser (DARE/ICAR)

2. Shri Pramod Kumar Das
   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 Sanjay Agarwal — *Ex-officio*
   Secretary (Agriculture and Cooperation)
   Department of Agriculture & Cooperation
   Ministry of Agriculture
   Krishi Bhavan, New Delhi-110 001

Rule 35(v)
Secretary, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture

5. Shri Tarun Shridhar — *Ex-Officio*
   Secretary (ADF),
   Department of Animal Husbandry,
   Dairying and Fisheries,
   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 — (Management Expert)
   Vice-Chancellor,
   Mahatma Gandhi,
   Chitrakaoot Gramodaya Vishwavidhyalaya,
   Chitrakoot, Satna-485 334 (M.P.)

7. Dr. Kamala Kanta Saharia
   Professor (Extension Education.)
   Department of Extension Education,
   College of Veterinary Science,
   AAU,Khanpara, Guwahati,
   Asom-781 022

8. Dr. Prakash Shastri
   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. Ashok Kumar Sarial
   Vice-Chancellor,
   CSK Himachal Pradesh Krishi Vishvavidyalaya
   Palampur, Distt. Kangra, Himachal Pradesh-176 062

10. Dr Ramesh Chandra Srivastava
    Vice Chancellor,
    Dr Rajendra Prasad Central Agricultural University,
    Pusa, Samastipur, Bihar-848 125

11. Dr V. Praveen Rao,
    Vice-Chancellor,
    Prof. Jayashankar Telangana State Agricultural University,
    Rajendranagar, Hyderabad, Telangana 500 030

12. Vacant

13. Dr Ajoy Kumar Singh
    Vice-Chancellor,
    Bihar Agricultural University,
    Sabour, Bhagalpur-813 210

Rule 35(viii) *Three Members of Parliament nominated by the President (Two from Lok Sabha and one from Rajya Sabha)*

14. Shri Sanjay Dhotre
    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

15. Shri Ravneet Singh
    Member of Parliament (LS)
    Village-Kotla Afghana,
    District Ludhiana, Punjab-141 416

    Shri Ravneet Singh
    Member of Parliament (LS)
    H.No. 28, Dr Rajendra Prasad Road,
    New Delhi-110 001

16. Vacant
    (one MP from Rajya Sabha)

Rule 35(ix)*Four Farmers/Representatives of Rural Areas nominated by the President*

17. Shri Sudhir Kumar Bhargava,
    Director, Agroman Systems Pvt. Ltd.
    25/2, Tardeo AC Market,Tardeo,
    Mumbai, Maharashtra-400 034

18. Shri Pushp Jain
    Ex-MP, Pali (Rajasthan)
    53/54, Maa Kripa Housing Society,
    Circuite House Road, Pali, Rajasthan

19. Shri Suresh Chandel,
Ex- Member of Parliament,
Village-Gandhi Ropa,
P.O. Beri,Tehsil & District, Bilaspur, Himachal Pradesh

Preferred contact:
Shri Suresh Chandel,
Ex-Member of Parliament,
House No. 70/5, Roura Sector-3,
Bilaspur, Himachal Pradesh

20. Shri Akhilesh Kumar
Shyama Bhavan,
Mathiya Zirat, Motihari,
East Champaran, Bihar

Rule 35(x)*Three Directors of Research Institutes of the Council nominated by the President*

21. Dr Ashwini Dutt Pathak
Director
Indian Institute of Sugarcane Research
Raebarieli Road, P.O. Dilkusha,
Lucknow, Uttar Pradesh-226 002

22. Dr K.K. Singh
Director,
Central Institute of Agricultural Engineering,
Nabi Bagh, Berasia Road,
Bhopal, Madhya Pradesh-462 038

23. Dr P.C. Sharma
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 R. D. Dhiman
Principal Secretary (Horticulture)
Room No. A-419A,
Government of Himachal Pradesh
H.P. Secretariat, Shimla, Himachal Pradesh-171 002

25. Shri Alan Gonmei,
Secretary,
Veterinary & Animal Husbandry
Thizama Road, New Secretariat,
Kohima, Nagaland-797 001

26. Shri Viswajeet Khanna
Additional Chief Secretary, Agriculture
Mini Secretariat, 5th Floor, Mini Secretariat Punjab,
Sector 9, Chandigarh, Punjab-160 001

27. Shri Eknath Davale
Secretary (Water Conservation Department)
holding the additional charge of Agriculture
Government of Maharashtra,
Agriculture Department,
5th floor, Annex Bldg.,
Mantralaya, Mumbai, Maharashtra-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
A-601, Vardhman Apartment,
Mayur Vihar, Phase-I, New Delhi-110 051

Rule 35(xiv)Secretary, ICAR- Member Secretary

30. Shri Sushil Kumr
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 Sushil Kumar**
   Secretary, ICAR and Additional Secretary to Government of India,
   Department of Agricultural Research and Education

Deputy Directors General

1. Dr K. Alagusundaram (Agricultural Engineering)
2. Dr A.K. Singh (Agricultural Extension)
3. Dr 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) (Acting)
2. Dr R.K. Singh (F&FC) (Acting)
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) (Acting)
2. Dr S.N. Jha (PE)

Animal Sciences

1. Dr R.S. Gandhi (AP&B) (Acting)
2. Dr Ashok Kumar (AN&P) (Acting)
3. Dr Ashok Kumar (AH)

Fisheries Science

1. Dr P. Pravin (MF)
2. Dr P. Pravin (IF) (Acting)

Agricultural Extension

1. Dr V.P. Chahal
2. Dr Randhir Singh

Agricultural Education

1. Dr G. Venkateshwarlu (EQA&R)
2. Dr G. Venkateshwarlu (HRD) (Acting)
3. Dr P.S. Pandey (EP&HS)

Others

1. Dr P.K. Katiha (PIM) (Acting)
2. Dr Shiv Prasad Kimothi (Cdn.)
3. Dr A.K. Vyas (HRM)
4. Dr Sanjeev Saxena (IPTM&PME)
5. Dr A Arunachalam (IR) (Acting)

National Agricultural Science Fund (NASF)

1. Dr 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 B.K. Pandey
2. Dr Manish Das
3. Dr Vikramaditya Pandey

Natural Resource Management

1. Dr P.P. Biswas
2. Dr R.K. Tomar
3. Dr Adlul Islam

Agricultural Education

1. Dr M.K. Agnihotri
2. Dr (Mrs) Vanita Jain
3. Dr (Mrs) Nidhi Verma
4. Dr K.P. Tripathi
5. Dr Neeraj Rana

Fisheries Science

1. Dr Prem Kumar
2. Dr (Mrs) Yasmeen Basade

Agricultural Engineering

1. Dr Devinder Dhingra
2. Dr Panna Lal Singh

Animal Sciences

1. Dr Rajan Gupta
2. Dr Vineet Bhasin
3. Dr (Mrs) Jyoti Misri

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 Sanjeev Panwar (Tech. Cdn.)
8. Dr Shiv Datt (IPTM)
9. Dr Ashok Kumar (NASF)
10. Dr S.K. Singh (DKMA)
11. Dr A.K. Mishra (IR)
12. Dr K.P. Singh (e-gov.)
13. Dr J.P Mishra

National Agricultural Higher Education Project (NAHEP)

1. Dr P. Ramasundaram, PS & NC
2. Dr R.B. Sharma, PS & NC
3. Dr P.K. Ghosh, PS & NC
4. Dr Prabhat Kumar, PS & NC

Agricultural Scientists' Recruitment Board

1. Dr A.K. Srivastava, Chairman (Additional Charge)
2. Dr A.K. Srivastava, Member

Directorate of Knowledge Management in Agriculture

1. Dr S.K. Singh, Project Director (Acting)
2. Sh Ravi Dobriyal, Under Secretary
3. Dr Himanshu, Scientist SS, AKMU
4. Dr V.K. Bharti, Chief Production Officer
5. Dr Aruna T Kumar, Incharge, English Editorial Unit
6. Sh Ashok Singh, Incharge, Hindi Editorial Unit
7. Sh V.S. Kaushik, Incharge, ARIC
8. Sh S.K. Joshi, Business Manager & I/C CeRA
9. Sh Anil Sharma, CP & PRO

APPENDIX 4

ICAR INSTITUTES AND THEIR DIRECTORS

National Institutes

1. Dr A.K. Singh (Acting)
   Indian Agricultural Research Institute,
   New Delhi-110 012
2. Dr Raj Kumar Singh
   Indian Veterinary Research Institute,
   Izatnagar-243 122, Uttar Pradesh
3. Dr R.R.B. Singh (Acting),
   National Dairy Research Institute,
   Karnal-132 001, Haryana
4. Dr Gopal Krishna
   Central Institute of Fisheries Education,
   Jaiprakash Road, Seven Bungalow (Versova)
   Mumbai-400 061, Maharashtra
5. Dr Ch. Srinivasa Rao
   National Academy of Agricultural Research Management,
   Rajendranagar, Hyderabad-500 030, Telangana
6. Dr 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-834 010, Jharkhand
8. Dr Jagdish Kumar (Acting)
   National Institute of Biotic Stress Management,
   Raipur-493 225, Chhattisgarh
9. Dr D. Maity,
   OSD, IARI, Hazaribagh-825 301, 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 & Kashmir
17. Dr R.K. Singh (Acting)
    Central Institute of Post Harvest Engg. and Technology,
    P.O. PAU Campus,
    Ludhiana-141 004, Punjab
18. Dr P.K.G. Patil
    Central Institute for Research on Cotton Technology,
    Adenwala Road, Matunga,
    Mumbai-400 019, Maharashtra
19. Dr 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, Telangana
22. Dr Alok Nath Roy (Acting)
    National Institute of Research on Jute & 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.R. Ojasvi (Acting)
    Indian Institute of Soil & Water Conservation,
    218, Kaulagarh Road,
    Dehradun-248 195, Uttarakhand
26. Dr D. Damodar Reddy
    Central Tobacco Research Institute,
    Rajahmundry-533 105, Andhra Pradesh
27. Dr (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-793 103, Meghalaya
31. Dr Lal Mohan Bhar (Acting)
    Indian Agricultural Statistics Research Institute,
    Library Avenue, Pusa Campus, New Delhi-110 012
32. Dr Khem Chand (Acting)
    Indian Grassland and 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, Uttarakhand
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, Telangana
47. Dr P. Ananda Kumar (Acting)
Indian Institute of Rice Research,
Rajendranagar, Hyderabad-500 030, Telangana
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 S.K. Srivastava (Acting)
Central Institute for Women in Agriculture,
Plot No.50, Mauza-Jokalandi,
P.O. Baramunda, Bhubaneswar-751 003, Odisha
51. Dr Anil Kumar (Acting)
Central Agro-forestry Research Institute,
Near Pahuj Dam, Jhansi-284 003, Uttar Pradesh
52. Dr M.S. Ladaniya
Central Citrus Research Institute,
P.B. No. 464, Shankar Nagar P.O.,
Amravati Road, Nagpur-440 010, Maharashtra
53. Dr Suresh Pal
National Institute of Agricultural Economics and Policy Research,
P.B. No. 11305, DPS Marg, Pusa, New Delhi-110 012
54. Dr Dinesh Kumar Agarwal (Acting)
Indian Institute of Seed Science
P.B. No. 11, Kusmaur, P.O. Kaithauli,
Mau Nath Bhanjan-275 101, Uttar Pradesh
55. Dr Vilas A. Tonapi
Indian Institute of Millets Research,
Rajendranagar, Hyderabad-500 030, Telangana
56. Dr V.S. Bhatia
Indian Institute of Soybean Research,
Khandwa Road, Indore-452 017, Madhya Pradesh

Animal Sciences and Fisheries

57. Dr A.B. Mondal (Acting)
Central Avian Research Institute
Izatnagar, Bareilly-243 122, Uttar Pradesh
58. Dr S.S. Dahiya (Acting)
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 (Mrs) B.R. Pillai (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-462 021, Madhya Pradesh
68. Dr Rajendra Prasad (Acting)
Central Institute for Research on Cattle,
P.B. No. 17, Grass Farm Road,
Meerut Cantt.-250 001, Uttar Pradesh
69. Dr B.R. Shome (Acting)
National Institute of Veterinary Epidemiology and Disease Informatics,
H.A. Farm Post, Hebbal,
Bengaluru-560 024, Karnataka

APPENDIX 5

NATIONAL BUREAUX AND THEIR DIRECTORS

Agricultural Sciences

1. Dr (Mrs) C.R. Ballal
   National Bureau of Agricultural Insect Resources,
   P.B. No. 2491, H.A. Farm Post,
   Bengaluru-560 024, Karnataka
2. Dr Anil Kumar Saxena
   National Bureau of Agriculturally Important
   Micro-organisms,
   P.B. No. 6, Kusmaur, Maunath
   Bhanjan-275 101
   Uttar Pradesh
3. Dr Kuldeep Singh
   National Bureau of Plant Genetic Resources,
   Pusa Campus,
   New Delhi-110 012
4. Dr 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

APPENDIX 6

PROJECT DIRECTORATES, AGRICULTURAL TECHNOLOGY APPLICATION RESEARCH INSTITUTES AND THEIR DIRECTORS

Agricultural Sciences

1. Dr Radhakrishnan T.
   Directorate of Groundnut Research,
   Post Box No. 5, Ivanagar 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 Satyajit Roy (Acting)
   Directorate of Medicinal and 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 and 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 (Acting)
    Directorate of Poultry Research,
    Rajendranagar, Hyderabad-500 030, Telangana
11. Dr D. Sharma (Acting)
    Directorate of Coldwater Fisheries Research,
    Anusandhan Bhawan, Industrial Area,
    Bhimtal-263 136, Uttarakhand

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 Avtar Singh (Acting)
    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, Telangana
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 M.J. Chandre Gowda
    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

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 Hans Raj Sardana (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 Jyotsana Sharma (Acting)
   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, Ajmer-305 206, 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, Telangana
12. Dr Abhijit Mitra
    National Research Centre for Mithun,
    Jharnapani, P.O.
    Medziphema-797 106, Nagaland
13. Dr S. Rajkhowa (Acting)
    National Research Centre on Pig,
    Rani, Guwahati-781 131, Asom
14. Dr Prithviraj Chakravarty (Acting)
    National Research Centre on Yak,
    Dirang, West Kameng-790 101,
    Arunachal Pradesh

APPENDIX 8

ALL INDIA CO-ORDINATED RESEARCH PROJECTS AND NETWORK PROGRAMMES

1. AICRP on Micro Secondary and Pollutant Elements in Soils and Plants, Bhopal
2. AICRP on Soil Test Crop Response, Bhopal
3. AICRP on Long Term Fertilizer Experiments, Bhopal
4. AICRP on Salt Affected Soils and use of Saline Water, Karnal
5. AICRP on Irrigation Water Management Research, Bhubaneshwar
6. AICRP Dryland Agriculture, Hyderabad
7. AICRP on Agrometeorology, Hyderabad
8. AICRP on Integrated Farming System, Modipuram
9. AICRP on Agroforestry, Jhansi
10. AICRP on Weed Management, Jabalpur
11. AICRP on Farm Implements and Machinery, Bhopal
12. AICRP on Ergonomics and Safety in Agriculture, Bhopal (ESA)
13. AICRP on Energy in Agriculture and Agro based Industries, Bhopal (EAAI)
14. AICRP on Animal Energy System, Bhopal (earlier UAE)
15. AICRP on Plasticulture Engineering and Technology, Ludhiana
16. AICRP on Post Harvest Engineering and Technology, Ludhiana
17. All India Coordinated Rice Improvement Project, Hyderabad
18. AICRP on Wheat and Barley, Karnal
19. AICRP on Maize, Ludhiana
20. AICRP Sorgum, Hyderabad
21. AICRP on Pearl Millets, Jodhpur
22. AICRP on Small Millets, Bangaluru
23. AICRP on Forage Crops and Utilization, Jhansi
24. AICRP on Chickpea, Kanpur
25. AICRP on MULLaRP, Kanpur
26. AICRP on Pigeon Pea, Kanpur
27. AICRP NSP(Crops), Mau
28. AICRP on Oilseed, Hyderabad
29. AICRP on Linseed, Kanpur
30. AICRP on Sesame and Niger, Jabalpur
31. AICRP on Groundnut, Junagarh
32. AICRP on Soybean, Indore
33. AICRP on Rapeseed and Mustard, Bharatpur
34. AICRP on Sugarcane, Lucknow
35. AICRP on Cotton, Coimbatore
36. AICRP on Nematodes in Cropping System, New Delhi
37. AICRP on Biocontrol of Crop Pests, Bengaluru
38. AICRP—Honeybees and Pollinators, New Delhi
39. AICRP Fruits (Tropical and Sub Tropical), Bengaluru
40. AICRP Potato, Shimla
41. AICRP Floriculture, Pune
42. AICRP Mushroom, Solan
43. AICRP Vegetables, Varanasi
44. AICRP Tuber Crops, Tiruvanthapuram
45. AICRP Palms, Kasargod
46. AICRP on Cashew, Puttur
47. AICRP Arid Zone Fruits, Bikaner
48. AICRP Spices, Calicut
49. AICRP on Medicianl and Aromatic Plants, Anand
50. AICRP on Cattle Research, Meerut
51. AICRP on Goat Improvement, Mathura
52. AICRP on Nutritional and Physiological intervention for enhancing reproductive performance in animal (including outreach methane)—earlier feed sources
53. AICRP ADMAS, Bengaluru
54. AICRP Foot and Mouth, Mukteshwar
55. AICRP on Poultry, Hyderabad
56. AICRP on Pig, Guwahati
57. AICRP Home Science

Network Projects

1. AINP on Soil Biodiversity—Biofertilizer, Bhopal
2. Network Programme on Organic Farming, Modipuram
3. Network project on Engineering Intervention in Micro irrigation system for Improving Water Productivity (new in EFC)
4. Network project on Harvesting, Processing and Value Addition of Natural Resins and Gums, Ranchi
5. Network Project on Conservation of Lac Insect Genetic Resources, Ranchi
6. AIC Research Network on Potential Crops, New Delhi
7. Application of Micro-organisms in Agriculture and Allied Sectors (AMAAS) + Microbial Genomic Resources repository network, Mau
8. Network Progject on Transgenics
9. AINP on Arid Legumes, Kanpur
10. All India Network Research Project on Tobacco, Rajamundry
11. AINP on Jute and Allied Fibres, Barrackpore
12. AINP on Soil Arthropod Pests, Durgapura, Rajasthan
13. AINP on Agricultural Acarology
14. AINP on Pesticides Residues, New Delhi
15. AINP on Vertebrate Pest Management, Jodhpur
16. Network O & G (included in Directorate)
17. Network Project on Buffalo Improvement, Hisar
18. Network on Sheep Improvement, Avikanagar
19. Network on Gastro Intestinal Parasitism, Izatnagar
20. Network Programme on Blue Tongue Disease, Izatnagar
21. All India Network Program on Neonatal Mortality in Farm Animal (NNM), Izatnagar
22. All India Network Program on Diagnostic Imaging and Management of Surgical Condition in Animals, Izatnagar
23. Network Project on Animal Genetic Resources, Karnal
24. AINP Mericulture
25. AINP on Fish health

APPENDIX 9

AGRICULTURAL UNIVERSITIES

State Agricultural Universities

1. Acharya N.G. Ranga Agricultural University, Lam, Guntur (Andhra Pradesh) 522 034
2. Agriculture University, Jodhpur (Rajasthan) 342 304
3. Agriculture University Kota (Rajasthan) 324 001
4. Anand Agricultural University Anand (Gujarat) 388 110
5. Assam Agricultural University Jorhat (Assam) 785 013
6. Banda University of Agriculture and Technology Banda (Uttar Pradesh) 210 001
7. Bidhan Chandra Krishi Viswavidyalaya Mohanpur (West Bengal) 741 252
8. Bihar Agricultural University, Sabour Bhagalpur (Bihar) 813 210
9. Bihar Animal Sciences University, Patna
10. Birsa Agricultural University Ranchi (Jharkhand) 834 006
11. Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana) 125 004
12. Ch. Sarwan Kumar Krishi Vishvavidyalaya Palampur (Himachal Pradesh) 176 062
13. Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh) 208 002
14. Chhattisgarh Kamdhenu Vishvavidyalaya Durg (Chhattisgarh) 491 001
15. Dr Panjabrao Deshmukh Krishi Vidyapeeth Akola (Maharashtra) 444 104
16. Dr Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli (Maharashtra) 415 712
17. Dr Y.S. Parmar University of Horticulture and Forestry, Nauni-Solan (Himachal Pradesh) 173 230
18. Dr Y.S.R. Horticultural University Venkataramannagudem (Andhra Pradesh) 534 101
19. G.B. Pant University of Agriculture and Technology Pantnagar (Uttarakhand) 263 145
20. Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana (Punjab) 141 004
21. Indira Gandhi Krishi Vishwavidyalaya Raipur (Chhattisgarh) 492 006
22. Jawaharlal Nehru Krishi Viswavidyalaya Jabalpur (Madhya Pradesh) 482 004
23. Junagadh Agricultural University Junagarh (Gujarat) 362 001
24. Kamdhenu University Amreli (Gujarat) 382 010
25. Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar (Karnataka) 585 401
26. Kerala Agricultural University Thrissur (Kerala) 680 656
27. Kerala University of Fisheries and Ocean Studies Panangad (Kerala) 682 506
28. Kerala Veterinary and Animal Sciences University Wayanad (Kerala) 673 576
29. Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar (Haryana) 125 001
30. Maharana Pratap Horticultural University, Karnal (Haryana)
31. Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan) 313 001
32. Maharashtra Animal and Fishery Sciences University, Nagpur (Maharashtra) 440 001
33. Mahatma Phule Krishi Vidyapeeth Rahuri (Maharashtra) 413 722
34. Nanaji Deshmukh Veterinary Science University Jabalpur (Madhya Pradesh) 482 001
35. Narendra Deva University of Agriculture Technology, Faizabad (Uttar Pradesh) 224 229
36. Navsari Agricultural University Navsari (Gujarat) 396 450
37. Orissa University of Agriculture and Technology Bhubaneswar (Odisha) 751 003
38. 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 employees of Scheduled Castes, Scheduled Tribes and Other Backward Classes

S.No.	Class of post	Total posts sanctioned	Total employees in position	SC employees		ST employees		OBC employees	
				No.	% to total employees	No.	% to Total employees	No.	% to total employees
1	**Scientist Posts**								
a	Scientist	4229	4072	548	13.46	213	5.23	1050	25.79
b	Senior Scientist	1363	1034	65	6.29	16	1.55	115	11.12
c	Pr. Scientist	776	466	15	2.22	3	0.64	29	6.22
d	RMP	177	109	1	0.92	0	0	3	2.75
	Total	**6545**	**5681**	**629**	**11.07**	**232**	**4.08**	**1197**	**21.07**
2	**Technical Posts**								
a	Category **I**	3974	2527	458	18.12	237	9.38	351	13.89
b	Category **II**	2708	1619	263	16.24	125	7.72	253	15.63
c	Category **III**	755	410	64	15.61	42	10.24	70	17.07
	Total	**7437**	**4556**	**785**	**17.23**	**404**	**8.87**	**674**	**14.79**
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)/	379	345	48	13.91	23	6.67	27	7.83
b	Category 'B' posts :- AF&AO/AAO/PS/SO/ALA/ Assistant/PA/JAO	2632	2015	310	15.38	148	7.34	210	10.42
c	Category 'C' posts :- UDC/Steno/LDC	1873	1127	196	17.39	95	8.43	209	18.54
	Total	**4884**	**3487**	**554**	**15.89**	**266**	**7.63**	**446**	**12.79**
4	**Skilled Supporting Staff**								
	Total	**8364**	**4632**	**1281**	**27.66**	**421**	**9.09**	**734**	**15.85**

APPENDIX 11

ICAR AWARDS 2017

AWARDS	AWARDEES
Sardar Patel Outstanding ICAR Institution Award 2017	**Large institute** 1. ICAR-Central Arid Zone Research Institute, Jodhpur, Rajasthan 2. ICAR-Indian Institute of Pulses Research, Kanpur, Uttar Pradesh **Small institute** ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha **University** Punjab Agricultural University, Ludhiana, Punjab
Chaudhary Devi Lal Outstanding All India Coordinated Research Project Award 2017	**Best AICRP** All India Coordinated Research Project on Spices, Kozhikode, Kerala **Best Centre** All India Coordinated Research Project on Spices-Centre-KAU, Panniyur, Kerala
Vasant Rao Naik Award for Research Application in Agriculture 2017	1. **Dr M S Shirahatti,** Chief Scientist (Team Leader), AICRP for Dryland Agriculture, Regional Agricultural Research Station, Vijayapura under University of Agricultural Sciences, Dharwad, Karnataka 2. **Mr V S Surakod-Associate** Agronomist, AICRP for Dryland Agriculture, Regional Agricultural Research Station, Vijayapura under University of Agricultural Sciences, Dharwad, Karnataka 3. **Dr S T Hundekar-Associate** Soil Scientist, AICRP for Dryland Agriculture, Regional Agricultural Research Station, Vijayapura under, University of Agricultural Sciences, Dharwad, Karnataka 4. **Dr Vijayakumar A Giritamannavar** Associate, Plant Breeder, AICRP for Dryland Agriculture, Regional Agricultural Research Station, Vijayapura under University of Agricultural Sciences, Dharwad, Karnataka 5. **Dr Vivek V Angadi** Associate, Principal Scientist (Agronomy), AICRP on IFS-OFR Scheme, MARS, UAS, Dharwad-580 005, Karnataka 6. **Dr S B Kalaghatagi** Associate, Professor and Head, College of Agriculture, Vijayapura-586 101, Karnataka 7. **Dr S C Alagundagi** Associate, Professor of Agronomy, College of Agriculture, UAS, Dharwad, Karnataka 580 005 8. **Dr S B Devaranavadgi** Associate, Chief Scientist, Sadashivnagar, off the Bagalakote-Bengaluru Ring Road, Vijayapura, Karnataka 586 109
Jawaharlal Nehru Award for P.G. Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences 2017	**Crop Sciences** 1. **Dr Ranjith Kumar Ellur** Div. of Genetics, IARI, New Delhi-110 012 2. **Dr H B Mahesh** #1686, FF, 5th Main Road, Judicial Layout, GKVK Post, Bengaluru, Karnataka 560 065 **Animal Sciences** 1. **Dr Rajeev Ranjan** ICAR-International Centre for Food and Mouth Disease, Arugul Jatni, Distt. Khordha, Odisha 752 050 2. **Dr Sonika Ahlawat** D 11, ICAR-NBAGR, Karnal

AWARDS	AWARDEES
	Fisheries 1. **Dr Banya Kar** Flat No.301, C-Block, Pataliputra Garden Apptt., New Pataliputra Colony, Patna, Bihar 800 013 2. **Dr Anusree Velappan Nair** ICAR-CMFRI, P B.No.1603, Ernakulam North P.O., Cochin, Kerala 682 018 **Biotechnology** 1. **Dr Asha Sriniwasan** Sreenilayam, Jawahar Junction, Parippally PO, Kollam 691 574, Kerala 2. **Dr Amit Kumar Tripathi** Flat no.E-208, Comfort Heights, Apptt. Nayapura, Off New Jail Road, Bhopal-462 038 **Social Sciences** 1. **Dr Anindita Datta** Quar.No. 7, Krishi Niketan, A6 Block, Paschim Vihar, New Delhi 110 063 2. **Dr Hema Baliwada** ICAR-CTRI, Bhaskar Nagar, Rajahmundry-533 105, Andhra Pradesh **Crop Protection** 1. **Dr David Karamankodu Jacob** ICAR-NBAIR, P B No.2491, H A Farm Post, Bellary Road, Bengaluru, Karnataka 560 024 2. **Dr Somnath Kadappa Holkar** ICAR-IISR, Biological Control Centre, Pravarangar, Tahsil:Rahata, Distt. Ahmednagar 413 712 **Natural Resource Management** 1. **Dr Bappa Das** ICAR-CCARI, Old Goa, North Goa-403 402 2. **Dr Saritha M** Div.of Integrated Land use Management and Farming System, CAZRI, Jodhpur, Rajasthan 342 003 **Horticulture** 1. **Dr Brij Bihari Sharma** Div. of Veg, R.N.07, IARI, New Delhi-110 012 2. **Dr Selvakumar Raman** ICAR-CITH, KD Farm, Old Air Field, Rangreth, Sirnagar (J&K) 190 007 **Agricultural Engineering** 1. **Dr Deshmukh Prashant Sampatrao** Senior Scientist, ICAR-CIRCOT, Mumbai-400 019 2. **Dr Kale Sakharam Jagan** D-2, ICAR-CIPHET Campus, Malout, Hanumangarh Bye-Pass Road, Abohar, Punjab 152 116
Lal Bahadur Shastri Outstanding Young Scientist Award 2017	**Crop and Horticultural Sciences** **Dr B Kalyana Babu** Scientist (Senior Scale), Agricultural Biotechnology, ICAR-Indian Institute of Oil Palm Research, Pedavegi, West Godavari District, Andhra Pradesh **Natural Resource Management and Agricultural Engineering** **Dr P C Abhilash** Assistant Professor (Stage II), Institute of Environment and Sustainable Development, BHU, Varanasi **Animal and Fisheries Sciences** **Dr Rajendran Thomas** Sr. Scientist, ICAR-NRC on Pig, Rani, Guwahati, Asom **Social Sciences** **Dr Eldho Varghese** Scientist, ICAR-CMFRI, P. B. No.1603, Ernakulam North P.O., Kochi, Kerala

AWARDS	AWARDEES
Bharat Ratna Dr C. Subramaniam Award for Outstanding Teachers 2017	**Crop and Horticultural Sciences** **Dr Archana Sachdev** Principal Scientist, Division of Biochemistry, ICAR-Indian Agricultural Research Institute, New Delhi **Natural Resource Management and Agricultural Engineering** **Dr Tapan Jyoti Purakayastha** Principal Scientist, Division of Social Science and Agricultural Chemistry, ICAR-Indian Agricultural Research Institute, New Delhi **Social Sciences** **Dr Alka Singh** Professor and Principal Scientist, Division of Agricultural Economics, ICAR-Indian Agricultural Research Institute, New Delhi
Rafi Ahmed Kidwai Award for Outstanding Research in Agricultural Sciences 2017	**Crop and Horticultural Sciences** **Dr D K Yadava** Division of Seed Science and Technology, ICAR-Indian Agricultural Research Institute, New Delhi **Natural Resource Management and Agricultural Engineering** **Dr B S Dwivedi** Head, Division of Soil Science and Agricultural Chemistry, ICAR-Indian Agricultural Research Institute, New Delhi **Animal and Fisheries Sciences** **Dr Kajal Chakraborty** Senior Scientist, Marine Biotechnology Division, ICAR-Central Marine Fisheries Research Institute, Ernakulam, Kochi, Kerala **Social Sciences** **Dr Anjani Kumar** Principal Scientist, International Food Policy Research Institute, South Asia Office, CG Centre Block, NASC Complex, Dev Prakash Shastri Marg, Pusa, New Delhi
Panjabrao Deshmukh Outstanding Women Scientist Award 2017	**Dr Shelly Praveen** Head and Principal Scientist, Division of Biochemistry, ICAR-Indian Agricultural Research Institute, New Delhi **Dr Seema Jaggi** Principal Scientist and Professor (Agricultural Statistics), ICAR-Indian Agricultural Statistics Research Institute, New Delhi **Dr Neeru Bhooshan** Incharge, Zonal Technology Management and Business Planning and Development Unit, Indian Agricultural Research Institute, New Delhi **Dr P S Vimala Devi** Principal Scientist (Agricultural Entomology), ICAR-Indian Institute of Oilseeds Research, Rajendranagar, Hyderabad, Telangana
NASI-ICAR Award for Innovation and Research on Farm Implements-2017	**Dr Akhilesh Kumar Singh** Principal Scientist (FMP), ICAR-Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh **Dr Sukhbir Singh** Senior Scientist (FMP), ICAR-Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh
N.G. Ranga Farmer Award for Diversified Agriculture 2017	**Sh Sandeep Goel** Vill.-Jaitpur, Bazpur Road, P.O. Kundeshwari, Kashipur, Uttarakhand 244 713
Fakhruddin Ali Ahmed Award for Outstanding Research in Tribal Farming Systems 2017	**Dr Narendra Prakash (Team Leader)**, ICAR Research Complex for NEH Region, Manipur Centre, Imphal Dr Subhra Saikat Roy (Associate) Dr Meraj Alam Ansari (Associate) Dr Susheel Kumar Sharma (Associate)

AWARDS	AWARDEES
	Dr Narendra Singh (Team Leader), Defence Research and Development Organisation (DRDO), Defence Institute of High Altitude (DIHAR), Leh-Ladakh J&K Dr Dorjay Angchuk (Associate) Er Sarfraz Nazir (Associate) Ms. Suman Tiga (Associate)
Swami Sahajan and Saraswati Outstanding Extension Scientist Award 2017	**Dr I S Tomar** Senior Scientist and Head, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Krishi Vigyan Kendra, Jhabua, MP **Dr M Kumaran** Principal Scientist (Agricultural Extension), Social Science Division, ICAR-Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu **Dr D R Palsaniya** Senior Scientist, Agronomy, Crop Protection Division, ICAR-Indian Grassland Fodder Research Institute, Jhansi, Uttar Pradesh
Cash Awards Scheme 2017	**Administrative category** 1. **Sh Govind Prasad Sharma** Chief Finance and Accounts Officer, ICAR-Central Arid Zone Research Institute, Jodhpur, Rajasthan 2. **Sh Rajesh Kumar Jha** Under Secretary, Office of the Hon'ble Union Ministerof Agriculture and Farmers Welfare, Krishi Bhawan, New Delhi 3. **Sh N V R N Murty** Finance and Accounts Officer, ICAR-ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar, Odisha **Technical category** 1. **Dr Ravi Kant** Assistant Chief Technical Officer, Animal Biochemistry Division, ICAR-National Dairy Research Institute, Karnal, Haryana 2. **Sh Devinder Singh** Technical Assistant (T-3), Division of Genetics, ICAR-Indian Agricultural Research Institute, New Delhi 3. **Dr Dhananjay Kumar Verma** Assistant Chief Technical Officer, Aquaculture Production and Environment Division, ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar, Odisha 4. **Sh Om Parkash** Technical officer, ICAR-Indian Institute of Wheat and Barley Research, Karnal, Haryana **Supporting category** 1. **Sh B Ashok** Skilled Support Staff, ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana 2. **Sh Aman Kumar** Skilled Support Staff, ICAR-Indian Institute of Wheat and Barley Research, Karnal, Haryana
Nanaji Deshmukh ICAR Award for Outstanding Interdisciplinary Team Research in Agricultural and Allied Sciences, 2016–17	**Crop and Horticultural Sciences** 1. **Dr B P Singh (Team Leader)**, Ex-Director, ICAR-Central Potato Research Institute, Shimla, Himachal Pradesh 2. **Dr Sanjeev Sharma** Principal Scientist (Plant Pathology), ICAR-Central Potato Research Institute, Shimla, Himachal Pradesh 3. **Dr P M Govindakrishnan** Principal Scientist (Agronomy), ICAR-Central Potato Research Institute, Shimla, Himachal Pradesh

AWARDS	AWARDEES
	4. **Dr Shashi Rawat** Principal Scientist (Computer Applications), ICAR-Central Potato Research Institute, Shimla, Himachal Pradesh 5. **Dr R K Arora** Ex-Principal Scientist (Plant Pathology), ICAR-Central Potato Research Institute, Regional Station, Jalandhar, Punjab 6. **Sh Islam Ahmad** Chief Technical Officer, ICAR-Central Potato Research Institute, Regional Station Modipuram, Uttar Pradesh 7. **Dr Mehi Lal, Scientist** ICAR-Central Potato Research Institute, Regional Station, Modipuram, Uttar Pradesh 8. **Dr V S Pundhir** Ex-Professor (Pant Pathology) and Incharge, AICRP (Potato), G B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand 9. **Dr Ashis Chakraborty** Associate Professor (Plant Pathology), and Incharge, AICRP (Potato), BCKV, Kalyani, West Bengal **Natural Resource Management and Agricultural Engineering** 1. **Dr M Madhu (Team Leader)**, Head (Acting) and Principal Scientist, ICAR-Indian Institute of Soil and water Conservation Research Centre, Sunabeda, Koraput, Odisha 2. **Dr P P Adhikary** Scientist, ICAR-Indian Institute of Soil and Water Conservation Research Centre, Sunabeda, Koraput, Odisha 3. **Dr D C Sahoo** Senior Scientist, ICAR-Indian Institute of Soil & water Conservation Research Centre, Sunabeda, Koraput, Odisha 4. **Dr (Smt) Ch Jyotiprava Dash** Scientist, ICAR-Indian Institute of Soil and Water Conservation Research Centre, Sunabeda, Koraput, Odisha 5. **Dr H C Hombegowda** Scientist and Incharge Head, ICAR-Indian Institute of Soil and Water Conservation Research Centre, Sunabeda, Koraput, Odisha 6. **Dr Praveen Jhakar** Scientist (Senior Scale) ICAR-Indian Institute of Soil and Water Conservation Research Centre, Sunabeda, Koraput, Odisha 7. **Sh G B Naik** Senior Technical Officer, ICAR-Indian Institute of Soil and Water Conservation Research Centre, Sunabeda, Koraput, Odisha 8. **Dr Karm Beer** Scientist, ICAR-Indian Institute of Soil and Water Conservation Research Centre, Sunabeda, Koraput, Odisha 9. **Dr P K Mishra** Director, ICAR-Indian Institute of Soil and Water Conservation, Dehradun, Uttarakhand. **Animal and Fisheries Sciences** 1. **Dr K Ambasankar (Team Leader)** Principal Scientist, Nutrition Genetics and Biotechnology Division, ICAR-Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu 2. **Dr J.S. Dayal** Principal Scientist, ICAR-Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu

AWARDS	AWARDEES
	3. **Dr K.P. Kumaraguruvasagam** Senior Scientist, ICAR-Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu 4. **Late Sh S Stanline** Technical Officer (T-6), ICAR-Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu 5. **Dr P N Rekha** Principal Scientist, ICAR-Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu 6. **Dr Debasis De** Principal Scientist, ICAR-Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu 7. **Sh K P Sandeep** Scientist, ICAR-Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu 8. **Dr T K Ghoshal** Principal Scientist, ICAR-Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu 9. **Dr K K Vijayan** Director, ICAR-Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu **IV. Social Sciences** 1. **Dr K V Prabhu (Team Leader)** Joint Director (Research), ICAR-Indian Agricultural Research Institute, New Delhi 2. **Dr R K Sharma** Principal Scientist and Head (Plant Breeding and Genetics), ICAR-Indian Agricultural Research Institute, New Delhi 3. **Dr G P Singh** Director, Indian Institute of Wheat and Barley Research, Karnal 4. **Dr Rajbir Yadav** Principal Scientist (Plant Breeding and Genetics), Indian Agricultural Research Institute, New Delhi 5. **Dr Anju M Singh** Principal Scientist (Plant Breeding and Genetics), Indian Agricultural Research Institute, New Delhi 6. **Dr Vinod** Professor (Genetics), Indian Agricultural Research Institute, New Delhi 7. **Dr J B Sharma** Principal Scientist (Plant Breeding and Genetics), Indian Agricultural Research Institute, New Delhi 8. **Dr P K Singh** Principal Scientist (Plant Breeding and Genetics), Indian Agricultural Research Institute, New Delhi 9. **Dr Niharika Mallick** Scientist (Plant Breeding and Genetics), Indian Agricultural Research Institute, New Delhi. 10. **Dr Kiran Gaikwad** Scientist (Plant Breeding and Genetics), Indian Agricultural Research Institute, New Delhi 11. **Dr Neelu Jain** Senior Scientist (Plant Breeding and Genetics), Indian Agricultural Research Institute, New Delhi

AWARDS	AWARDEES
	12. **Dr P Ramya** Scientist (Plant Breeding and Genetics), Indian Agricultural Research Institute, New Delhi 13. **Dr S V Saiprassad** Principal Scientist and Officer-in-charge (Plant Breeding and Genetics), Indian Agricultural Research Institute, R.S, Indore 14. **Dr J B singh** Senior Scientist (Plant Breeding and Genetics), Indian Agricultural Research Institute R.S., Indore 15. **Dr Divya Ambati** Scientist (Plant Breeding and Genetics), Indian Agricultural Research Institute R.S., Indore 16. **Dr Dharam Pal** Principal Scientist (Plant Breeding and Genetics), Indian Agricultural Research Institute R.S, Shimla 17. **Dr Madhu Patial** Scientist (Plant Breeding and Genetics), Indian Agricultural Research Institute R.S. Shimla 18. **Dr I S Solanki** ADG (F&FC), ICAR, Krishi Bhawan, New Delhi 19. **Dr T R Das** Scientist (Plant Breeding and Genetics), Indian Agricultural Research Institute, R.S., Pusa, Bihar 20. **Dr M Sivasamy** Principal Scientist and Head (Plant Breeding and Genetics), Indian Agricultural Research Institute, R.S., Wellington 21. **Dr P Jayaprakash** Principal Scientist (Plant Breeding and Genetics), Indian Agricultural Research Institute, R.S., Wellington 22. **Dr V K Vikas** Scientist Sr. Scale (Plant Breeding and Genetics), Indian Agricultural Research Institute, R.S., Wellington 23. **Dr Rashmi Aggarwal** Principal Scientist and Head (Plant Pathology), Indian Agricultural Research Institute, New Delhi 24. **Dr Robin Gogoi** Principal Scientist (Plant Pathology), Indian Agricultural Research Institute, New Delhi 25. **Dr A N Misra** Former Principal Scientist (Plant Pathology), Indian Agricultural Research Institute, New Delhi 26. **Dr T L Prakasha** Scientist (Plant Pathology), Indian Agricultural Research Institute R.S. Indore 27. **Dr J Kumar** Principal Scientist (Plant Pathology), Indian Agricultural Research Institute, R.S. Wellington, Shimla 28. **Dr Ajay Arora** Principal Scientist (Plant Physiology), Indian Agricultural Research Institute, New Delhi 29. **Dr D C Saxena** Former Senior Scientist (Plant Physiology), Indian Agricultural Research Institute, New Delhi 30. **Dr Sanjay Kumar** Principal Scientist and Incharge (Seed Production), Indian Agricultural Research Institute, New Delhi

AWARDS	AWARDEES
	31. **Dr R N Yadav** Principal Scientist (Seed Production), Indian Agricultural Research Institute, R.S., Karnal 32. **Dr S D Misra** Principal Scientist (Agronomy), Indian Agricultural Research Institute, New Delhi 33. **Dr K C Sharma** Principal Scientist (Agronomy), Indian Agricultural Research Institute R S, Indore 34. **Dr A K Singh** Principal Scientist (Extension), IARI, New Delhi 35. **Dr Vaibhav Kumar Singh** Scientist (Plant Pathology), Indian Agricultural Research Institute, New Delhi
Pandit Deen Dayal Upadhyay Antyodaya Krishi Puruskar 2017	**National** **Sh Raghupat Singh** Vill: Smathal, Billari, Distt. Muradabad, Uttar Pradesh **Zone I** **Sh Aparpal Singh Mahal** S/o G.S Mahal, Distt. Bathinda, Punjab **Zone II** **Smt Mukesh Devi** Vill: Malikpur, P O Achhej, Distt. Jhajjar, Haryana **Zone III** **Sh Ramesh Verma** Village & Post Kasimpur Viruha, Block: Gosaiganj, Distt Lucknow, UP **Zone VI** **Sh K S Meitei** Saitapur Mayai Leikai, Kumbi, Bishnupur, Manipur **Zone VII** **Sh B L Majumder** S/o Sri Arabinda Majumder,6/244/1, Batappura Para, Village East Ramchandra Ghat, PO. North R.C. Ghat, Mauja-Laxmi Narayanpur, Distt. Khowai, Tripura **Zone VIII** **Mrs N S Chaudhari** Vill:Parvat, Post:Regama, Ta. Mandvi, Distt. Surat, Gujarat **Zone IX** **Sh Sitaram Nigwal** Vill: Awalia, Post-Nalcha, Tehsil-Dhar, Distt. Dhar, MP **Zone X** Sh Katta Rama Krishna S/o K Anjaneyulu Obannapalem Naguluppalapadu, Post Prakasam, Andhya Pradesh **Zone XI** **R Raveendran** Reji Bhavan, KRA 172 Panachavila Lane, Uloor Med. Clg. PO Thiruvananthapuram, Kerala
Jagjivan Ram Abhinav Kisan Puruskar/ Jagjivan Ram Innovative Farmer Award (National/ Zonal) 2017	**National** 1. Sh Ciby George, S/o Sh.K.V. Varghese Kallingal House, Pattikad P.O., Thrissur, Kerala-680 652 2. **Sh Agya Ram Verma,** S/o Sh. Bhagwati Prasad Village-Kharkadewri, Post-Kodia, District-Basti, UP-272 131 **Zone I** **Sh Hariman Sharma, S/o Sh. Daya Ram** Village-Paniyala, PO Kothi, Tehsil Ghumarwin, District Bilaspur, H.P.

AWARDS	AWARDEES
	Zone II **Sh Ibne Hasan, S/o Sh. Ali Hedar,** Village-Rabibarod District-Baran, Village-Ranibarod, Post-Kisanganj, Tehsil-Kisanganj, Rajasthan-325 216 **Zone IV** **Smt Binita Kumari, W/o Sh. Vijay Kishor Baidh**, Village-Jhirwa, PO-Chutia, PS + Block-Banka-813 102, Bihar **Zone IV** **Smt Rinku Devi, W/o Sh. Pawan Kumar** Village-Jhirwa, PO-Chutia, PS + Block-Banka-813 102, Bihar **Zone V** **Sh Ajay Bauri, S/o Sh.Late Habu Bauri** Vill. & PO. Cheliyama, PS-Raghunathpur, District-Purulia, West Bengal **Zone VI** **Sh Gazeeur Rahman, S/o Late Sh. Mofazzal Mondal** Vill.-Pundibari, P.O.-Dompara, District-Bongaigaon, Assam-783 392 **Zone VII** **Sh Kynshew Dapsuk Kharkrang, S/o Sh. Sidrowel Nongrang**, Vill: Umeit, Block: Umsning, B.P.O: Bhoirymbong, RiBhoi District, Meghalaya **Zone VIII** **Sh Dhirendra Kumar Bhanubhai Desai, S/o Sh. Bhanubhai Gordhanbhai** Desai, Panetha, Ta. Jhaghadiya, District-Bharuch-393 120, Gujarat **Zone IX** **Sh Rajpal Singh Narwariya**, **S/o Sh. Prem Narayan Singh** Narwariya, Village Jamakhedi, District Ashoknagar, M.P. **Zone XI** **Sh Rajanarayanan T.V S/o Sh. N.V.S. Manilyer** Venkita Nivas, Kaniyarcode P.O., Thiruvilwamala, Thrissur, Kerala-680 594
Pandit Deen Dayal Upadhyay Krishi Vigyan Rashtriya Protshahan Puraskar (National/Zonal) 2017	**National** KVK Kanker, Jiwalamari, Chhattisgarh **Zone I** KVK Mandi at Sundernagar, CSK Himachal Pradesh Krishi Vishwavidyalaya, Himachal Pradesh **Zone II** KVK Kurukshetra, CCS Haryana Agriculture University, Hisar, Haryana **Zone III** 1. KVK, ICAR-Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh 2. KVK, Kaushambi, Dr Bhim Rao Ambedkar Welfare Society, Uttar Pradesh **Zone IV** KVK Siris, Aurangabad, Bihar Agricultural University, Sabour, Bihar **Zone V** KVK Bhadrak, Orissa University of Agriculture and Technology, Odisha **Zone VI** KVK Sonitpur, Assam Agricultural University, Assam **Zone VII** KVK Ri Bhoi, ICAR Research Complex for NEH Region, Umiam, Meghalaya **Zone VIII** KVK Navsari Agricultural University, Tapi, Gujarat

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	Zone IX KVK Datia, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Madhya Pradesh **Zone X** 1. KVK Tamil Nadu Agricultural University, Dharmapuri, T N 2. KVK Venkataramannagudem, Dr Y S R Horticultural University, West Godavari, Andhra Pradesh **Zone XI** KVK Christian Agency for Rural Development (CARD), Pathanamthitta, Kerala

Acronyms

AARDO	: African-Asian Rural Development Organization
ABI	: Agri-business Incubation
ACI	: Adaptive Capacity Index
AER	: Agro-ecological Region
AES	: Agriculture Expert System
AESR	: Agro-ecological Sub-region
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
AKAP4	: A-kinase Anchor Protein 4
AKMU	: Agricultural Knowledge Mangement Unit
ALV	: Avian Leukosis Virus
AMAAS	: Application of Micro-organisms in Agriculture and Allied Sectors
AMPs	: Antimicrobial Peptides
ANASTU	: Afghan National Agricultural Sciences and Technology Unit
APCTT	: Asia-Pacific Centre for Technology Transfer
ARYA	: Attracting and Retaining Youth in Agriculture
ASAM	: Alkaline Sulfite Anthraquinone Methanol
ASEAN	: Association of South-East Asian Nations
ASRB	: Agricultural Scientists' Recruitment Board
ATARI	: Agricultural Technology Application Research Institutes
ATIC	: Agricultural Technology Information Centre
ATP	: Annual Training Programme
BAT	: BAIT Application Technique
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
CFLD	: Cluster Frontline Demonstration
CFT	: Complement Fixation Text
CGIAR	: Consultative Group on International Agricultural Research
CHAMAN	: Co-ordinated Programme in Horticultural Assessment and Management
CHC	: Custom Hiring Centres
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
CPGRAM	: Centralized Public Grievance Redress and Monitoring System
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
DI	: Drip Irrigation
DRWA	: Directorate of Research on Women in Agriculture
DSn	: Diagnostic sensitivity
DSS	: Decision Support System
DSWP	: Defatted Silkworm Pupae Meal
EAS	: Extension and Advisory Services
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
FFP	: Farmers FIRST Project
FINE	: Festival of Innovation and Entrepreneurship
FLD	: Frontline Demonstrations
FMD	: Foot-and-Mouth Disease
FPT	: Field Progeny Testing Project
FSH	: Follicle-stimulating Hormone
FWKGs	: Farm Women Knowledge Groups
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
GHGs : Greenhouse Gases
GI : Glycemic Index
GIS : Geographical Information System
GO : Gene Ontology
GPA : Global Plan of Action
GPS : Global Positioning System
HAB : Hyper Ammonia Producing Bacteria
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
IDM : Integrated Disease Management
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 : Internal Fibosomal Entry Site
IRR : Internal Rate of Return
ITK : Indigenous Technical Knowledge
IWMI : International Water Management Institute
JE : Japanese Encephalitis
JNKVV : Jawaharlal Nehru Krishi Vishwa Vidyalaya
KAP : Knowledge, Awareness and Practice
KKA : Krishi Kalyan Abhiyan
KVAFSU : Kerala Veterinary, Animal Sciences and Fisheries University
KVK : Krishi Vigyan Kendra
LAMP : Loop Mediated Isothermal Amplification
LAT : Latency Associated Transcript
LC-MS/MS : Liquid chromatographs Mass spectrometry
LD : *Longissmus dorsi*
LDF-Mobile App : Livestock Disease Forewarming-Mobile App
LEU : Lanscape Ecological Unit
LFA : Lateral Flow Assay
LRI : Land Resource Inventory
MABB : Marker Assisted Backcross Breeding
MAS : Molecular Marker-assisted Selection
MAT : Macroscopic Agglutination Test
MAT : Male Annihilation Technique
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
NAV : Nolm of Absolute Value
NBSS&LUP : National Bureau of Soil Survey and Land Use Planning
NDF : Non-detergent Fibre
NDMI : Normalized difference moisture index
NDRI : National Dairy Research Institute
NDVI : Normalized difference vegetation index
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
NLS : Nano-lignocellulosie
NNV : Nervous necrosis virus
NPC : Net Present value
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
OMF : Organo-mineral Fertilizer
OTC : Open Top Chamber
PBMCS : Peripheral Blood Mononuclear Cells
PCA : Principal Component Analysis
PCP-FMP : Progressive Control Pathway for Foot-and-Mouth Disease
PCR : Polymerase Chain Reaction
PCZ : Potentila Crop Zone
PDDUUKSY : Pandit Deen Dayal Upadhyay Unnat Krishi Shiksha Yojana
PFA : Pschological First Aid
PGDTMA : Post-graduate Diploma in Technology Management in Agriculture
PGFM : Prostagladin F_2 Alpha Metabalite
PGRC : Plant Germplasm Registration Committee
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
PPV : Porcine Parvovirus
PRRSV : Porcine Reproductive and Respiratory Syndrome Virus

PSVs : Peer Support Volunteers
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
RIL : Recombinent Inbred Line
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
SCS-CN : Soil conservation Service-Curve Number
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
SSR : Simple Sequence Repeat
SWYMOD : Surface-Water Yield Model
TDC : Technology Demonstration Component
TEM : Transmission Electron Microscope
TFP : Total Factor Productivity
TiLv : Tilapia lake virus
TKP : Tamarind Kernel Powder
TLCV : Tomato Leaf Curl Virus
TLR-1 : Toll Like Receptor-1
TMY : Total Milk Yield
TNA : Training Needs Analysis
TNFU : Tamil Nadu Fisheries University
TOT : Transfer of Technology
TSP : Tribal Sub-Plan
TSS : Total Soluble Solids/Sugars
TTV : Transfusion Transmitted Virus
UAN : Urea Ammonium Nitrate
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
WDCM : World Data Centre for Microorganisms
WNF : West Nile Fever
WNV : West Nile Virus
WSSV : White Spot Syndrome Virus
WUE : Water Use Efficiency

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