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ANNUAL REPORT 2016-17

सत्यमेव जयते

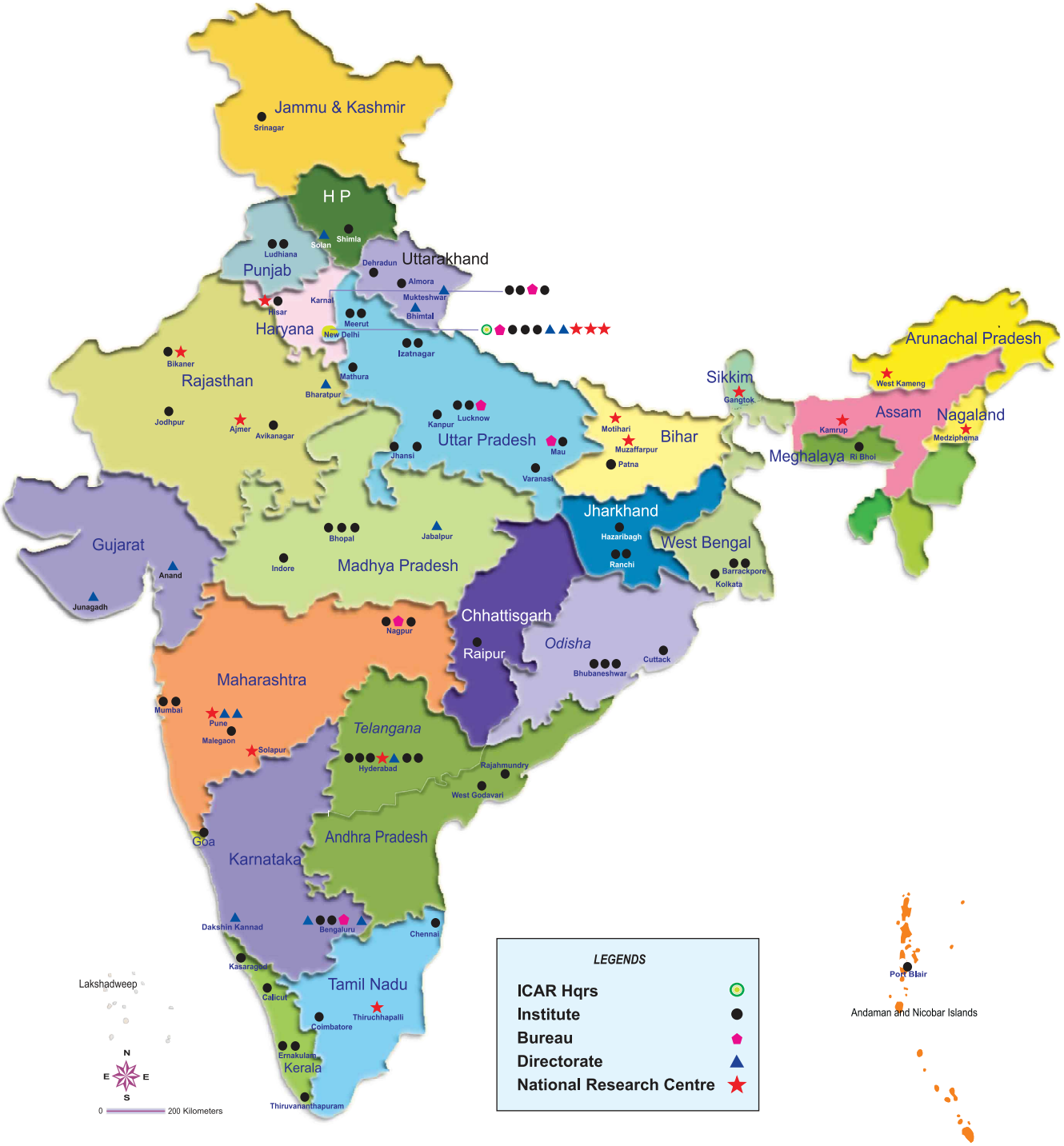
Department of Agricultural Research and Education
Ministry of Agriculture & Farmers Welfare
Government of India

भाकृअनुप
ICAR

Indian Council of Agricultural Research
New Delhi

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Institutes, Bureaux, National Research Centres and Directorates



• 68 Research Institutes • 6 Bureaux • 14 Directorates • 16 National Research Centres

Annual Report
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Foreword

I am happy to present the *DARE-ICAR Annual Report 2016-17* as the President of the ICAR Society and take pride in mentoring this organization that has contributed so much to the agricultural revolution in the country. Be it, development of varieties and technologies by constituent ICAR Institutes or substantial outreach by Krishi Vigyan Kendras (KVKs), the organization has been vibrant and vigilant and continuing to perform farmer-centric agricultural R&D for enabling Indian agriculture to not only be sustainable, but also climate-resilient.

During the reporting year, the ICAR has taken concerted efforts to implement some of the government flagship programmes such as 'more crop per drop', safeguarding soil health, establishment of seed hubs for pulses and oilseeds, promoting mechanization of small farms, enhancing production of pulses and oilseeds to meet the domestic demands, address information needs of farmers and transfer of technologies. The Council developed 310 new high-yielding/hybrid varieties of field crops and 51 horticultural crops that have been notified during 2016-17 and produced over 12,500 tonnes of breeder seeds. To enable small farm mechanization, 53 implements were developed. ICAR also registered 9 new livestock and poultry breeds and developed 3 new vaccines and 15 diagnostic kits.

In our efforts to promote digital agriculture, dedicated mobile app for rice (riceXpert) and a web-based application, pulseExpert were developed. A dedicated KVK Portal has been launched with user interface to enable monitoring and management of KVKs. Twenty new KVKs were established taking the total to 662 in the country. Likewise, in education sector, the Rajendra Agricultural University was upgraded into Dr Rajendra Prasad Central Agricultural University. Four new colleges were opened under Rani Laxmibai Central Agricultural University, Jhansi. In the northeast India, we opened 6 new colleges under Central Agricultural University, Imphal raising the total number of its constituent colleges from 7 to 13. To promote agricultural education among several students, we declared and celebrated December 3 as the National Agricultural Education Day. To appreciate the role of women in agriculture, we declared and also observed 15 October as Mahila Kisan Diwas. Two new awards, one for better performing KVK and the other for small and marginal farmer namely, the *Pt. Deen Dayal Rashtriya Krishi Vigyan Protsahan Puruskar* and *Pt. Deen Dayal Antyodaya Krishi Puruskar*, respectively, were introduced. With a focus on reaching out to the farmers, the Council adopted 10,700 villages under its 'Mera Gaon Mera Gaurav' programme benefitting about 3.5 lakh farmers. In order to take the technologies to different states, the Council convened Regional Committee meetings for effective Centre-State coordination and delivery. We have also fortified our dialogue process with other scientific organizations such as CSIR, ICMR, DST, DRDO, ISRO, IMD, etc. through discussion and by signing MoUs. The members of ICAR family deserve appreciation for their sincere efforts that enabled DARE/ICAR to achieve its mandate effectively.

While the challenges are many, the opportunities do exist for way forward. It is time that we become more responsive, proactive and innovative. Partnerships for integration, convergence and synergy are what the 'Team ICAR' must continue to stand for, in our endeavor to make Indian agriculture a proud profession of our farmers and a preferred destination for our youth, as we envision doubling of farmers' income by 2022.

I am also happy to record that the ICAR organized different activities to fulfill the objectives of the 'Swachh Bharat Mission' programme and is committed to be a proud partner of this national mission. I take this opportunity to also call upon all the members of the ICAR Family to ensure a clean and hygienic environment in their respective institutions and their surroundings, and establish themselves as role models for the others. With promotion of less cash economy, I also would urge all our Institutes to enable digital transactions in letter and spirit. In this endeavor, I also appreciate the efforts of our KVKs to have organized awareness programmes for farmers to practice digital banking. I hope, with strong linkages with developmental agencies and private sectors, we would enhance our collaboration, both nationally and at international levels to make India a global leader in agriculture. As part of global outreach, ICAR is providing requisite assistance in establishing Afghanistan National Agricultural Sciences and Technological University and also Advanced Agricultural Research Centre in Myanmar. A landmark MoU was signed among BRICS Nations to establish a BRICS Research Platform for Agriculture with its Coordinating Centre in India. To further strengthen and mainstream agricultural research through international collaborations, we discussed and finalized work plans with ICRISAT, IRRI, ICARDA, IFPRI, Bioversity International and with some foreign Universities.

With new and focused R&D programmes in

implementation, I am sure, the year to come would boost agricultural growth, explore new horizons and stride fast in agricultural research to make Indian agriculture productive, profitable and prestigious to our farming communities, and also enable the country to adequately address sustainable food and nutritional security.

We have given summarized salient activities and achievements of DARE/ICAR in the Annual Report 2016-17 with the hope that our diverse stakeholders will find the contents useful and provide us their constructive views to enable us to bring improvements in the programmes on agricultural research and human resource development, and to ensure agriculture as a profitable profession in the nation.

(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 S S Ahluwalia (Since 8 July 2016)** **Shri Sudarshan Bhagat (Since 8 July 2016)** **Shri Parshottam Rupala (Since 8 July 2016)** **Dr Sanjeev Kumar Balyan (Up to 7 July 2016)** **Shri Mohan Bhai Kundariya (Up to 7 July 2016)**
Secretary, DARE, and Director General, ICAR	:	**Dr Trilochan Mohapatra (Since 22 February 2016)** **Dr S. Ayyappan (Up to 21 February 2016)**
Additional Secretary and Financial Adviser, DARE/ICAR	:	**Shri Sunil Kumar Singh**
Additional Secretary, DARE and Secretary, ICAR	:	**Shri Chhabilendra Roul**

The Mandate of the Indian Council of Agricultural Research

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

1. Overview

The Indian Council of Agricultural Research has been contributing to the growth and development of the country by enabling food security. This year new records of highest ever food grain production are in the making as the *kharif* 2016-17 production is estimated at 135 million tonnes, which is 9% higher than that a year before. Also the total area sown under *rabi* crops as on 13th January 2017, as per preliminary reports, stands at 616.21 lakh ha as compared to 581.95 lakh ha sown by this time in 2016. Further, to address the present day challenges of malnutrition and climate change, the council is pursuing focussed research in the areas of biofortification, health foods and climate resilience in agriculture. The ICAR observed the year 2016 as the International Year of Pulses as declared by the United Nations. To this effect, we established 150 seed hubs for pulses to help increase the availability of quality seeds.

ICAR partners all the programmes of the Government of India and accelerates respective outcomes. For instance ICAR contributed significantly to soil health card scheme wherein the council issued 1.65 lakh cards to the farmers by testing the soil samples at KVKs and research institutes. A comprehensive water-resource planning was developed for several canal command areas, coastal areas etc. to support the *Pradhan Mantri Krishi Sinchai Yojana,* which aims to improve access to irrigation. Appropriate soil- and- crop management practices were developed for conjunctive use of fresh and saline water in irrigation to make *Per Drop More Crop* a success. Based on the criterion developed for qualitative assessment of groundwater recharge during monsoon, wheat growing areas were categorized at district level for recharging prospects and to issue advisories for suitable cropping patterns during *rabi*; this resulted in a substantial increase in cropped area under wheat during 2016 *rabi*. The Council organized 4.69 lakh extension programmes, involving 198.67 lakh participants for creating awareness among farmers about all the efforts being made to improve the condition of rural India. In this connection the '*Pradhan Mantri Fasal Bima Yojana*,' needs special mention as it covers risks to farmers from climatic vagaries.

The Council launched a new initiative "Pandit Deen Dayal Upadhyay Unnat Krishi Shiksha Yojana" for training of farmers in organic farming and sustainable farming. For this purpose 100 training centres have been identified across the country. The ICAR implemented e-mode of financial transactions across all its institutes. The KVKs helped in spreading awareness and gave training to farmers on digital banking. The farmers now have access to web-based 'KVK Portal and KVK App,' mobile based 'Kisan Mobile Advisory –KMA' SMS portal, 'toll free help lines', ICAR data Centre and mobile apps for different commodities, to realise Digital India vision in agriculture sector. To recognise the contribution of small and marginal farmers, the Council instituted Pandit Deen Dayal Upadhyay Antyodaya Krishi Puruskar at Zonal and National level. To motivate and inculcate healthy competition among Krishi Vigyan Kendras (KVKs) new award 'Pandit Deen Dayal Upadhyay Krishi Vigyan Protsahan Puruskar' have been instituted at Zonal and National Level. Twenty new Krishi Vigyan Kendras have been established to further deepen the outreach to farmers.

The changing times require all agriculture technology partners, entrepreneurs and institutions to start building strong viable linkages among themselves to enhance the effectiveness of the agricultural development process. To have effective dialogue with the states, meetings of seven Regional Committees were held where senior officials from line departments of states participated. New issues were identified and roadmaps to have effective collaboration and action plan were developed for different states. While we pledge to continue our R & D contributions to the growth of agriculture sector I take this opportunity to put forward the salient achievements of the ICAR system as follows.

Soil and water productivity: Landform maps, soil survey and soil map preparation were completed for 55 blocks comprising the southern region (17), Western regions (5), Central region (5), Eastern region (17), Northern region (6 blocks), and north-eastern region (5). Ecological niche modelling (ENM) of *Ceropegia bulbosa,* an endemic threatened plant species of Thar Desert, was done in the field, the species rehabilitation was successful under natural conditions. *Mridaparikshak,* mini lab for soil testing and fertilizer recommendation, was further upgraded for more soil parameters. The equipment is now IT enabled to provide soil and crop specific fertilizer recommendations directly to farmers on their mobiles. Nano-composites were developed by trapping novel biologically synthesized nanoparticles in aluminosilicate, which modifies its surface and pores making them ideal for varied aquaculture applications. Fertilizer-use efficiency increased by 42-67% for different crops under different drip-fertigation treatments than soil application. This observation led to the establishment of 14 dug-well drip-fertigation units in Cuttack and Dhenkanal districts of Odisha, and enhanced farmers' income.

A comprehensive water resource planning was developed for 3,900 ha, located within 15 km from the coast line in Mahakalapada of Odisha. Based on

the water availability in creeks and water harvesting structures, suitable crop planning was proposed for the region. In Haryana and Uttar Pradesh, salinity and sodicity mapping of canal commands, was done using geophysical survey technology (DUALEM-21) for developing salinity management improved strategies.

To harness productivity of Sharda Sahayak Canal seepage water a pond-based farming system module was initiated under farmers' participatory mode at Lucknow. In this module, vegetable system was found to be more profitable than rice-wheat and tomato-mustard systems. Napier grass strip of 2 m width was most effective in reducing runoff (30%), losses of soil (65%) and nutrients (70%), and in increasing crop yield up to 18%.

Under study on different farming systems for degraded lands of Shivalik range, intercropping of peach + circular trench + clusterbean combination was found to be the most compatible for resource conservation resulting in minimum runoff and soil loss, maximum fruit yield per plant, and B:C ratio of 5.25. As an innovative approach to boost brackishwater aquaculture farming, the ecosystem health card based on soil and water recceing was introduced in Tamil Nadu, Andhra Pradesh, West Bengal and Gujarat.

Climate change and resilient agriculture: Forecasting studies of rice yields using DSSAT (Decision Support System for Agrotechnology Transfer) rice model predicted that, all states in the Eastern region are likely to experience reduced yields of below or equal to 10% during mid-century climate change scenarios except Bihar. Net global warming potential (NGWP) and Greenhouse gas intensity (GHGI) were influenced by tillage and residue treatments. They increased with increase in crop residues in both the crops. The zero tillage led to reduction in fuel consumption by 58% in pigeonpea and 81 % in castor. Soil -organic carbon sequestration rate was positive in tillage and residue treatments with the highest rate in zero tillage, but sequestration rate was negative in conventional tillage with no residues. Temperature-based phenology model, developed for mango fruitfly using temperature change projections for the year 2050, indicated that at least a certain proportion of *Bactrocera zonata* population can establish and survive throughout the year. Hence, wide area management strategies are advised to restrict or slow down its incidence and population dynamics.

Assessment of green house gases (GHGs) emission from dairy farms, indicated that supplementation of combination of saponins, and condensed and hydrolysable tannins effectively reduced methane production in cattle. Addition of aspirin may partially ameliorate the adverse effects of high ambient temperature on growth, feed conversion and immunity in poultry. Estimation of emission of greenhouse gases from prawn (*Penaeus monodon* and *Penaeus vannamei*) and fish (catla and rohu) culture ponds revealed higher average emission of all GHGs in fish culture ponds compared to shrimp culture ponds. Aquaculture ponds acted as sink during low temperature conditions and rainy days. Changes in environmental parameters, viz. salinity, nutrient cycling, plankton and macro-zoo-benthos abundance, etc. have triggered changes in fin-fish and shell-fish diversities in the Sundarban estuary. Though, there is an increase in total fish landings from around 7,431.59 tonnes during 2009-10 to about 11,962.52 tonnes in 2015-16, the catch compositions indicated a gradual replacement of commercially important species by relatively low priced fish species.

Genetic resources: Seventeen explorations were undertaken and 1,115 accessions, including 531 of wild species were added to the germplasm collection. Herbarium specimens, 387, were added to the National Herbarium of Cultivated Plants. In the National Gene bank, germplasm for long-term storage comprised 10,224 accessions of orthodox seed species; along with cryopreservation of 14 shoot tips/ meristems of vegetatively propagated species and 14 accessions in the *in vitro* Gene bank. A total of 31,110 accessions were imported from 39 countries; the promising introductions were rice accessions having high yield (EC881897-903), and salinity (EC881904-1905) and submergence tolerance (EC881906 and EC887557) from the Philippines, and wheat with heat tolerance from the USA. Large scale studies involving characterization and evaluation of more than 18,601 accessions of wheat and rice for terminal heat and drought tolerance were completed leading to identification of 472 rice genotypes/lines as moderately resistant to biotic and abiotic stresses.

A total of 53 proposals comprising cereals and pesudocereals (23), millets (4), grain legumes (2), fibre and forages (4), vegetables (10), oilseeds (4), commercial crops (2), medicinal and aromatic plants and spices (2) and agro-forestry species (2) were approved for germplasm registration.

In mango, fifteen "farmers' varieties" were identified and collected from Malihabad, Uttar Pradesh. More than 176 accessions of vegetables, wild relatives of crop plants and land races belonging to 40 taxa and some unique collections like, *Abelmoschus tetraphyllus* var. *Pungens* and *Momordica subangulata* subsp. *Subangulata* were collected from Nagaland. New accessions of spices and medicinal and aromatic plant genetic resources comprising galoe, *Aloe barbadensis* (34); kalmegh, *Andrographis paniculata* (66); safed musli, *Chlorophytum borivilianum* (4); lemon grass, *Cymbopogon flexuosus* (33) and ashwagandha, *Withania somnifera* (122), *Piper* (193) and nutmeg (18) accessions, were collected.

The Geographical Information System (GIS) on Animal Genetic Resources (AnGR) of India was developed as a stand alone package by which the users can extract and highlight habitats of selected breeds on the map. Nine new breeds of livestock and poultry were registered taking the total number of registered breeds to 160. Phenotypic characterization of Kaunayen chickens of Manipur and donkeys in Andhra Pradesh

was completed. Genetic characterization of Kajali sheep, Sikkim goat, Kaunayen chicken and Ladakhi cattle was carried out. Out of 20 male fertility related miRNAs in other species, a few miRNAs were found differentially expressed in yak sperms, this information may help in further investigation of fertility in yak bulls. The yak found in Arunachal Pradesh are the unique in the world, but also one of the critical and endangered mountain species, which calls for an urgent attention for *in situ* and *ex situ* conservation as well as breed characterization.

A new fish species of Indian chub mackerel (*Scomber indicus*) was discovered from Gujarat coast. Likewise *Barilius torsie* (Cyprinidae: Rasborinae) was recorded from river Torsa of Brahmaputra drainage system, and *Rita bakalu* (Siluriformes: Bagridae) from the Godavari river basin.

Crop improvement: A total of 310 varieties of different crops were released comprising 155 high yielding varieties/hybrids of cereals, 68 of rice, 18 of wheat, 27 of maize, 17 of pearl millet, 10 of sorghum, 4 each of fingermillet and little millet, 3 of barley, 2 each of oat and kodo millet for cultivation in different agro-ecologies of the country during 2016. The first zinc-rich variety IET 23832 (polished rice has 22 ppm Zn), was released, notified, and recommended for Tamil Nadu, Andhra Pradesh, Telangana and Karnataka. New oilseed varieties (50) including 16 varieties of rapeseed-mustard, eight of groundnut, seven of linseed, five each of soybean and sunflower, four of sesame, three of castor and two of niger were released for different agro-ecological regions. First Canola-type Indian mustard variety, Pusa Double Zero Mustard 31 (PDZ-1), with less than 2% erucic acid in oil and less than 30 ppm glucosinolates in seed- meal was released for National Capital Region Delhi. Three high oleic safflower varieties ISF-1, ISF-2 and ISF-3 were developed for the first time by introgressing traits from exotic lines. Varieties (43) of pulses, including 10 of chickpea, 11 of mungbean, six of pigeonpea, four each of fieldpea and lentil and three each of urdbean and horsegram and two of cowpea were released for different agro-ecological regions. In commercial crops 42 varieties, including 23 of cotton, nine of sugarcane, three of jute, two each of mesta, kenaf and roselle and one of ramie were released. Co 06034 (Karan 11), a midlate maturing sugarcane clone, was released for commercial cultivation in Haryana, Punjab, Uttarakhand, Rajasthan, Central and Western Uttar Pradesh as a suitable alternative for replacing old varieties, viz. CoS 767 and CoS 8436. For the first time a variety of ramie, Hazarika (R 1411), was released in the country; it is suitable for a prevalent intercropping system of horticultural crops with ramie in north-eastern states and northern part of West Bengal. High yielding varieties/hybrids (20) of forage crops comprising two forage *bajra*, one napier bajra hybrid, five forage oat, two each of forage sorghum and guinea -grass, three each of forage cowpea and ricebean and 1 each of lucerne and sewan grass were released for boosting fodder cultivation.

Leaf rust of wheat is the most widespread among all rusts and causes maximum loss in India. A new leaf-rust resistance gene *LrLWH* in LWH-2 was identified in a bread wheat landrace (Hango-2), from Hango, Himachal Pradesh. This new leaf rust resistance gene can be utilized for selection of resistance to wheat leaf rust in wheat lines. Genomes of 15 strains (~1500 MB data) of wheat leaf-rust fungus were decoded. A very sensitive, specific and reliable multiplex bio-PCR protocol for simultaneous detection of bacterial pathogens, *Ralstonia solanacearum* and *Erwinia carotovora* sub sp. *carotovora* causing brown rot and soft rot diseases in potato was developed. A PCR-based marker ($KetoPstRA_{1500}$) for specific detection of pathogenic fungus, *Puccinia strii formistritici,* causing yellow rust of wheat was developed and validated. The complete whole genome sequencing of *Pseudomonas koreensis* P2 was achieved. The gene family members associated to phosphorus (P) metabolism, potassium (K) metabolism, zinc (Zn) metabolism, sulphur (S), iron (Fe), heavy metal remediation, antibiotic sensitivity/ resistance and stress were identified in P2 genome, and the study would allow this bacterium to be considered as a biological fertilizer in agriculture. It also showed a very high phosphorus solubilizing potential and plant growth-promoting activity.

Karnal bunt, caused by the fungus *Tilletia indica* (Syn. *Neovosia indica*), is of serious concern due to strict quarantine affecting international trade of wheat. Severe economic losses occur owing to quarantine restrictions. The draft sequence of the fungal strain is a major landmark to understand pathogen diversity, mating behaviour and early detection. A unique genic-SNP genotyping chip for genetic and evolutionary studies as well as molecular breeding applications in rice was designed and validated. A putative RuBisCo activase gene was cloned from heat-tolerant wheat cultivar HD 2985 towards basic studies for improving stress tolerance in wheat to mitigate effects of climate change. A novel alien leaf rust resistance gene (*Lr Sel.G12*) was mapped and linked to two microsatellite markers in *Triticum timopheevii* derivative, "Selection G12". Three new SSR (Simple Sequence Repeat) markers (DGR 308, DGR 508 and DGR 800) were found associated with late leaf spot (LLS) disease resistance in groundnut. Thirteen BC_3F_3 "*QTLs hotspot*" introgressed chickpea (DCP 92-3) lines were developed for drought tolerance. Multiple stress inducible chickpea WRKY transcription factor was identified and structure model of the protein was developed.

During the reported period, 1.25 lakh q of breeder, 1.49 lakh q foundation, 1.19 lakh q certified, 1.28 lakh q truthfully labelled seeds, and 0.37 lakh q sugarcane planting material, respectively, were produced. Further, more than 272 lakh of planting material and 13 lakh tissue cultured saplings were produced and distributed during the year.

New hybrids and varieties (51) were developed in different horticultural crops. These include – seedless jamun (CISH-J-42); Thar Malti ber (60 kg/plant); Thar Neelkanth bael (75 kg/plant fruit yield); coconut hybrid 'Kalpa Samrudhi' (Dwarf×Tall) and Kalpatharu (high-yielding, premium ball copra, coconut variety). NRCB-8 banana is an exotic introduction of cv. Saba (ABB) with 30 kg/ bunch. In vegetables, Arka Samrat tomato (~100 tonnes/ha yield potential) was recommended as bacterial wilt resistant tomato hybrid for Karnataka, Tamil Nadu, Andhra Pradesh and Kerala. Pea 'Arka Priya' was recommended as powdery mildew resistant pea variety for Zone I, IV and VIII. French bean, Arka Sharath**,** with no parchment was recommended for release by SVEC for Karnataka. It is suitable for both *kharif* and *rabi* seasons. The first Indian variety of muskmelon, Sel-3, is a selection with 31.60 tonnes/ha yield. Two antioxidant rich vegetable amaranth varieties, viz. Arka Samraksha and Arka Varna, were developed. Drumstick, Thar Harsha, is drought hardy and resistant to leaf eating caterpillar and moderately resistant to fruit fly under field condition. Potato variety, Kufri Mohan, recommended for release, produces high tuber yield, has field resistance to late blight (*Phytophthora infestans*) and is recommended for cultivation in Indo-Gangetic plains.

Livestock improvement: Under the Indigenous Breed Project, 26 breeding bulls of Gir, Sahiwal and Kankrej were inducted in the third set for progeny testing. Semen doses, 45,511, 44,521 and 11,890 were produced for Gir, Kankrej and Sahiwal, respectively. Under Field Progeny Testing Programme, 30 bulls were introduced for test mating. In herds of Murrah and Nili-Ravi buffaloes, average lactation milk yield during the reporting time was 2,598 kg and 2,564 kg, respectively, which were reportedly the highest ever since inception of the project.

A prolific triple breed cross of sheep 'Avishaan', with multiple births of 57.1% and average litter size of 1.6, indicated successful introgression of *FecB* gene. Under field conditions prolificacy was 50% and overall survivability 94%. For supply of improved germplasm, flocks of different breeds of sheep, viz. Chottanagpuri, Mandya, Mecheri, Sonadi and Malpura were built up Under Mega Sheep Seed Project. Rani and Asha, improved crossbred varieties of pigs were released. Rani crossbred attained 75 kg body weight at slaughter age of 8 months and Asha 80 kg. Crossing of indigenous birds Ankleshwar (AN) and Nicobari (NC) with exotic breed CARI Red (CR) resulted in the development of a new poultry strain, which has better growth, immune competence and feed efficiency in backyard poultry. Narmadanidhi, a dual purpose coloured bird, and Jharsim, a multi-coloured bird, were released for rural poultry production.

In fisheries, surrogate broodstock of common carp, *Cyprinus carpio* was produced with sterile gonads using heat-chemical method. These can be used as a recipient for transplantation of donor germ cells. Production of surrogate broodstock will help propagation of commercially important fishes that are difficult to breed in confinement and also aid in recovery of endangered fish populations. The technology for marine shrimp culture in inland saline affected areas was successfully field-demonstrated. This paved way for large-scale adoption of shrimp farming in Haryana, Punjab and Rajasthan with average productivity of about 7 to 10 tonnes/ha and a survival rate of 70-80%.

Crop management: Evaluation of Vivek QPM 9 maize variety for different plant geometries, plant densities and intercropping revealed that paired row planting of maize intercropped with soybean gave 23% higher yield than the yield of recommended geometry. Sprinkler irrigation, in mungbean, resulted in 27% reduction in water consumption, 67% higher water-use efficiency, and elevation of benefit: cost ratio over flood irrigation.

Micronutrients supplementation of $FeSO_4$ + 40kg $ZnSO_4$ along with recommended doses of $N:P_2O_5:K_2O$ to ratoon sugarcane resulted in 25-32 % higher mean cane yield in 27 sugarcane varieties. Plant growth hormones (ethrel and GA_3) potentially improved sett vigour, enhanced ability to sprout and established uniform and robust settlings in spring planted sugarcane crop. The application led to significant increase in cane yield of 255 tonnes/ha against a cane yield of 84.69 tonnes/ha in control.

A rapid technique (temporary immersion bioreactor), developed for mass production of quality planting material of banana showed four fold increase in cv. Namwa Khom and three fold in Udhayam, compared to the standard protocol. In tomato, drip fertigation with 80 kg K_2O/ha in nine splits registered 70% more fruit yield (2.38 kg/plant; 58.17 tonnes/ha), over conventional fertilization.

During 2016-17 crop season, the impending crop losses due to whitefly in cotton and armyworm in rice were significantly reduced through timely interventions. Efforts were intensified to manage invasive insect-pest *Tuta absoluta,* introduced into India, by IPM and fast-track regulations of effective molecules through nascent control measures. Proactive actions were taken to meet challenges of alien pests and diseases such as wheat blast, black rust (Ug99) etc., prevalent in other parts of the globe. Reverse transcription loop-mediated isothermal amplification (RT-LAMP) assay was developed for the detection of Tobacco Streak Virus, an emerging challenge to cotton and soybean in southern and central India.

A mechanized sett treatment device was developed, commercialized and recommended for use in nurseries and sugar industry. Fungicidal treatment of sugarcane setts effectively reduced red rots and smut infection in sugarcane. Attack of white fly in coconut plantation was recorded in Coimbatore (Tamil Nadu) and Pallakad (Kerala). The further spread was controlled by adopting IPM measures and sprey of predator. A robust protocol was developed for screening sorghum for resistance against pokkah boeng or twisted top (c.o. *Fusarium*

subglutinans), an emerging disease, causing considerable economic losses to sorghum. In trials on the direct-seeded rice (DSR), high B : C ratio (3.39) was observed as against lower B : C ratio in the transplanted paddy.

Multi-location field trials were conducted to evaluate persistence and dissipation of new and existing pesticides on various crops in different agroclimates. The data were used to fix maximum residue limit (MRL) for eight pesticide-crop combinations by the Food Safety and Standards Authority of India (FSSAI), while their safe waiting period and label claim on respective crops were approved by the Central Insecticide Board and Registration Committee. Use of bioacoustics equipment in crop fields in Telangana, reduced crop damage due to wild boar attack from 58% (before equipment installation) to nil.

Exclusive bee pollination with *Apis mellifera* in cherry-orchards at Solan at one colony/ha resulted in fruit-set of 70.95 % compared to 70.35 and 63.47 % in hand pollination and open pollination, respectively. Laboratory-reared bumble bee, *Bombus haemorrhoidalis* was successfully shifted from incubator to field, and survived one complete cycle. This is for the first time in India that *B. haemorrhoidalis* colonies could be reared around the year. *Psuedomonas* sp. and *Bacillus cereus*, isolated from the Indian bee *(Apis cerana)* colonies in Kerala, caused symptoms of a new disease. Feeding infected colonies with garlic @10 g/ 10 litre of sugar syrup (at 250 ml/col/week) for consecutive three weeks showed cent per cent recovery.

Prophylactic treatment of coconut, utilizing talc-coated cake with botanical extracts of *Clerodendrum infortunatum* and *Chromolaena odorata* reduced rhinoceros beetle-induced leaf damage by 54%. The IPM module was developed for the management of root grubs in arecanut gardens. A strain of *Trichoderma asperellum* inhibited the mycelial growth of *Pythium aphanidermatum*, *P. debaryanum* (causing damping off disease), *Sclerotium rolfsii* Sr1 and *S.rolfsii* Sr3 (causing collar rot disease). It also inhibited the mycelia growth of *Fusarium oxysporum* f.sp.*lycopersici* (causing wilt disease) and *Alernaria solani* (early blight disease).

Livestock management: To assure better livestock health management besides forecasting disese outbreaks, 3 vaccines and 15 diagnostic kits were developed. Disease events (977) were predicted for 13 livestock diseases in 33 states/UTs of India. Risk MAP (Risk mapping, assessment and planning), generated for HS potential predictors for disease in Karnataka, showed good correlation with past outbreaks. The risk MAPs were developed by planning vaccination, allocation of resources in high risk areas and also future surveillance of the disease in regions. A DNA Bank of different wildlife species was established in the Wildlife Centre of ICAR-IVRI, Izatnagar, to enable species identification in forensic investigations.

A duplex PCR was standardized for rapid identification and detection of methicillin resistant *Staphylococci*. The fluorescent polarization assay (FPA) for brucellosis was developed and used for differentiation of vaccinated and infected animals (DIVA). Documentation of persistence of West Nile virus (WNV) and JEV activity in wider areas in Kerala than previously reported, may help the public health authorities in formulating surveillance programmes in the region. Domestic ducks may be useful captive sentinels in monitoring WNV/JEV activity. Phylogenetic analysis typed the Indian border disease virus (BDV) isolate as BDV-3. This is the first identification of BDV in sheep in India, which highlights the need for continued pestivirus surveillance and assessing its impact on sheep and goat production.

Relaxin based pregnancy diagnosis protocol was used to evaluate the serum response of pregnant and non-pregnant bitches. A visual loop mediated isothermal amplification (LAMP), standardized for detection of *Brucella* in vaginal swabs, preputial swabs and milk, was highly sensitive and detected *Brucella* DNA as low as 10 femtogram. H gene of PPR was identified as the most diverse gene, hence, considered to be the most preferred candidate phylogenetic marker. Composite scaffolds for tendon repair showed the potential to support healing of damaged tendon. Echocardiography in calves showing signs of foot and mouth disease, revealed cardiac fibrillation as the most significant change because calves showing cardiac fibrillation could not be saved even after the institution of prescribed therapy.

During the period, no incidence of FMD was reported in Punjab, Andhra Pradesh, Mizoram and Delhi. In serotype O, the vaccine strain INDR2/1975 covered 88% of the field isolates. This vaccine strain is able to provide optimal antigenic coverage over the field isolates. The r3A I-ELISA could be useful as a screening or confirmatory assay in the sero-surveillance of FMD in India irrespective of extensive bi-annual vaccination.

Genome sequencing and analysis of avian influenza H5N8 virus, isolated from water fowls for the first time in Delhi, Madhya Pradesh, Punjab, and Kerala in October 2016, revealed that it can be categorized as highly pathogenic to poultry. These viruses are closely related to the H5N8 viruses isolated from wild birds in Russian Federation suggesting dispersal of virus during southward winter migration of birds. The H7N9 influenza virus, considered as a major threat to poultry industry and public health, has not been reported from India, but was generated for its diagnostic preparedness through reverse genetics using synthetically prepared genes from genetic sequences available in public databases. An indirect ELISA test was developed for detection of antibodies against H7 avian influenza to provide a rapid and economical approach for early response to impending influenza virus pandemic.

The megaprimer-based reverse genetics technology was found useful for engineering chimeric vaccine strains for control and prevention of FMD in endemic countries. A fast and economical genotyping method for detection of BLAD (bovine leukocyte adhesion deficiency) and CVM (complex vertebral malformation) was developed

and application was filed for patent. An in-house built lamp assay was developed for rapid detection of cow components adulterated in buffalo milk/meat. Vaccine (therapeutic as well as prophylactic) against Johne's disease in cattle was successfully developed and commercialized. A nano gold based immuno-chromatographic test, lateral flow assay (LFA) was developed for detection of *Trypanosoma evansi* infection in camels at field level. A new indigenous indirect ELISA kit, was developed to detect the IgG antibodies in swine against Japanese encephalitis (JE) virus.

Organic Zn and Cu supplementation showed a positive role in growth of testicular biometry and expression of sexual behaviour in goats. Indigenous production of trace mineral products, namely Zn-Met, Cu-Met, Co-Met and Fe-Met was standardized. Supplementation of chelated trace minerals in grower crossbred pigs improved growth and reduced feed cost. Inclusion of *Saccharomyces cerevisiae* in ochratoxin contaminated diet ameliorated the ill effects of ochratoxin and improved the welfare aspects of stressed birds.

Buffalo cloning was taken to the farmers' field with the birth of cloned calf, Hisar-Gaurav. It was cloned from donor somatic cell isolated from the tail of a superior Murrah bull. Efforts were made to validate the traditional method of '*Doka*' for heat detection in buffaloes. Buffaloes expressing '*Doka'* were in majority (approximately 80%) cyclic and showed estrus behaviour after 2.22 days of occurrence of '*Doka'*.

In the fisheries sector, marine capture fisheries production from mainland of India in 2015 declined by 5.3% with respect to 2014. Gujarat remains by far the largest producer with an estimated landing of about 7.22 lakh tonnes and contributed one-fifth of the country's production. In all, about 735 species were captured, maximum species diversity was from Kerala and Tamil Nadu.

Mechanization and energy management: In the reporting year 53 types of implements and machines were developed for reducing drudgery and improving farm mechanization in the country. A few were: seed-cum-fertilizer drill for two stage placement of fertilizer; variable rate top dress urea application system integrated with spectral reflectance based sensor; seed-cum-fertilizer planters for minor millets (saves 90% and 70% of seed in comparison to that of broadcasting and drilling by traditional methods); pre-emergence herbicide strip applicator-cum-planter (same machine can be used as post-emergence herbicide/pesticide applicator); stem applicator as an attachment to power-weeder for cotton crop; loose straw chopper for paddy straw management for wheat sowing; light weight paddy thresher cum cleaner; mechanization package for sugarcane single bud technology; bullock drawn earthing-up cum inter-culturing implement for sugarcane and turmeric; package of animal drawn implements for cotton and soybean; package of single bullock operated implements for farm operations.

In 2016, the ICAR-CIFT, Kochi launched the 19.75 m multi-purpose energy efficient fishing vessel, FV Sagar Harita. The vessel is built under the project "Green Fishing Systems for the Tropical Seas". It is powered by 400 hp main engine and has 400 watt solar powered emergency lighting, acoustic trawl telemetry system with under-water sensor and fishing gear handling equipments.

Post-harvest management and value addition: An indigenous pilot plant for production of protein isolates from groundnut de-oiled cake (DOC) was designed. The DOC left after oil extraction from major oilseeds is about 10 million tonnes, which is either utilized as animal feed or exported. Protein-isolate from DOC can be incorporated into food products to combat protein malnourishment. Live fish carrier system, a battery operated three-wheeled vehicle, is useful for transporting live fish for short and medium distance (about 80 km) transportation as 95 % fish survived after storage for 48 h.

A portable fibre strength testing instrument, interfaced with the computer, was developed for testing tensile strength of coconut, sisal, and nylon fibres of different linear densities. A new seed extractor was developed, which reduced the drudgery and enabled fast extraction of seeds of ash gourd and cucumber. A pilot plant (50L capacity) was established for production of probiotic fruit juices from kinnow, mango and guava. These juices were successfully formulated with stable and viable beneficial lactic acid bacteria content in the recommended dose (10^6 cfu/ml), shelf-life of one month (Patent filed, No. 614/DEL/2013).

Mechanization package for rope making from the outer sheath of banana pseudostem was developed, which provided additional income from this waste. A method developed using nano zinc oxide particles for providing functional finishing of cotton fabrics, retained functionality even after 30 washes, exhibiting UV protection (UPF Value 40) and 99 % antibacterial properties against test organisms. Novel chemo-mechanical processes for production of nanocellulose from cotton linters/waste and cotton stalks were developed. Nanocellulose was used as additive for improving the functionality of natural rubber composite, kraft paper and cement concrete. Coating of capsicum with shellac resin significantly increased the shelf life up to 30-35 days during storage at 10°C. Dehydration of potato slices helped safe storage at ambient temperatures up to 9 months. The technology was registered for patenting as process for "Dehydration of potatoes". The industry rejects potato consignments owing to its higher glucose content at the time of marketing, leading to wastage of time and monetary losses for farmers. Highly sensitive, rapid and simple, dipsticks technology of glucose estimation, will help in taking appropriate decision for post-harvest marketing of potato. The technology has been filed for patent. A methodology was also developed to confirm the presence of lard in ghee to the tune of minimum 10%.

An antidiabetic nutraceutical "Cadalmin^{TM} antidiabetic extract (Cadalmin^{TM} ADe)" from seaweeds was developed and commercialised. The product contains 100% natural bioactive ingredients and is effective in combating type-2 diabetes without any side effects. Chitosan beads of uniform size were prepared from degrees of deacetylated (DA) chitosan. Chitosan beads with 86% DA had high sorption capacity (69%) at pH 8. Process for micro-encapsulation of squalene (an oily liquid hydrocarbon in shark liver oil) was developed. A seaweed enriched nutraceutical drink (NutriDrink), fortified with grape juice was prepared. A molecular source tracking study revealed that seafood gets contaminated with methicillin-resistant *Staphylococcus aureus* (MRSA) from environment and is transmitted to the retail fish markets.

Social science: The empirical evidences showed a significant declining trend in groundwater level in Punjab over time due to unrestricted withdrawal of groundwater over its replenishment level. The de-subsidization of energy will prompt farmers to improve groundwater use efficiency, which will result in 29-82 % saving in existing groundwater use in respect of different crops in the state. The price forecasts were developed along with validation of price expectations of stakeholders. Continuous efforts were made to strengthen the dissemination efforts for price forecasts to farmers and other stakeholders. Despite growing dairy industry in India, farmers' lack of access to organized markets and institutional credit remains one of the major hindrances in improving the scale and productivity of dairy. The farm-level performance indicated more profits for farmers in cooperative value chain. 'Dairy credit card' and 'contract as collateral' would enable them to adopt yield-enhancing technology and inputs and to scale up their dairy activity also.

E-tendering system introduced through e-NAM has contributed towards an increase in the market revenue. The National Marine Fisheries Census was conducted to facilitate formulation of fisheries related plans and policies in the marine sector. Web-based online software for uploading marine fish landings data directly from landing centres/ fisheries harbours was developed. This will enable fast data transmission and estimation of marine fish landings for all nine maritime states and union territories of Puducherry and Daman & Diu.

Empowering women in agriculture: A project for improving the quality of life of farm families was developed with a focus on assessment of nutritional status of farm families and suggestive interventions for the management of malnutrition; introduction of drudgery reducing technologies for enhanced efficiency; and need based technological empowerment of farm women for income generation and livelihood security. A Gender Knowledge Portal (http://icar-ciwa.org.in/gks/) was developed to engender agricultural research and extension for empowering farm women and girls, who are an important human resource in agriculture.

Statistics and computer application: The alternative methodology for estimation of area and production of horticultural crops was developed, and transferred to GoI to implement at national level. The estimates of seed, feed and wastage ratios of major food grains were obtained through a survey conducted in Uttar Pradesh, Karnataka, Madhya Pradesh, Rajasthan and Odisha. The data would be of immense use for planning and formulation of future policies. ICAR Research Data Repository for Knowledge Management in Agriculture called KRISHI (Knowledge based Resources Information Systems Hub for Innovations) portal (http://www.krishi.icar.gov.in) was launched.

Information, communication and publicity service: The ICAR- Directorate of Knowledge Management in Agriculture (DKMA) is mandated to act as the nodal centre of ICAR for information, communication and knowledge management related activities of the Council. The ICAR -DKMA is impending two projects 'Development of e- publication system for UG/PG e-textbook' and publication repository of 'KRISHI-Knowledge based Resources Information Systems Hub for Innovations in Agriculture'. The ICAR outreach through social media has gained good ground. The facebook page has attracted > 135,000 likes and twitter handle has 8,614 followers. Some of the popular documentaries on YouTube Channel of ICAR, have received more than 250,000 views each. Crucial advisories were developed and posted from time to time in view of natural calamities.

The ICAR website *(www.icar.org.in)* presents knowledge and information in bilingual mode (English and Hindi); on an average more than three lakh hits per month from visitors across the globe are recorded with a significant percentage of new visitors. The ICAR website attracted 5,282,012 visitors (2,539, 352 unique visitors) from 221 countries across the globe. The total registered users on the e-publishing platform of research journals are more than 75,000. In all the epubs platform Indian Agricultural Research Journals (http://epubs.icar.org.in/ejournal) hosts 36 research journals published by the Council or professional societies in agriculture. Viewership analysis revealed that on this portal—total sessions were 253,376 by 139,865 users, and they viewed 1,459,581 pages in 188 countries.

The Council organized and participated in 16 exhibitions for the showcasing of new technologies on the occasion of national and international events. The Consortium for e-Resources in Agriculture (CeRA) provided online access to scholarly literature by making available over 3,800 research journals to scientists, students and research scholars of 152 member institutions including ICAR research institutes and agricultural universities across the country. During the period over 25 lakh full text articles were downloaded by the users and over 4,000 Document Delivery Requests were successfully fulfilled by member libraries.

Technology assessment, demonstration and capacity building: Krishi Vigyan Kendras (KVKs) play a very important role as frontline extension system in the country and are mandated for technology assessment and demonstration for application and capacity development under different farming situations across the country. In the reporting year 20 new KVKs were opened taking the total number of KVKs to 662 in the country. As many as 48,983 training programmes were organized through which 13.21 lakh farmers and extension personnel were benefitted. Skill-oriented vocational training courses were organized for 1.74 lakh rural youth. Capacity development programmes were conducted for 1.042 lakh extension personnel, out of which 22,889 (22%) were women participants. KVKs organized 4.69 lakh extension programmes with 198.67 lakh participants for creating awareness among farmers about improved technologies and to provide timely advisory. During the year, 3.39 lakh q seeds, 820.31 lakh quality planting materials and bio-products like, bio-agents, bio-pesticides (609 q), bio-fertilizers (5,509 q), vermi-compost, mineral mixture etc., were produced at KVK and supplied to farmers. Technology week was organized by KVKs benefiting 20.60 lakh farmers, farm-women, extension personnel, rural youth and members of self-help groups. SMS (56,107) to extend advisories were sent to benefit 155.22 lakh farmers on various aspects of agriculture. Pulses seed hubs are being established at KVKs for producing quality seeds in participatory mode involving farmers. Under the sub theme-Technology Demonstrations and Dissemination for Climate Resilient Agriculture, 98,504 farmers were covered. The ICAR-Agricultural Technology Application Research Institutes (ATARIs), upgraded the knowledge and skills of 5,009 staff of KVKs by arranging capacity development programmes. The Agricultural Technology Information Centers (ATICs) in the country served as single window delivery system and provided technology information, technology services and technology inputs to 4.67 lakh farmers.

Soil Health Cards (1.62 lakh) were prepared and distributed to farmers by 599 KVKs. ARYA (Attracting and Retaining Youth in Agriculture), is a project launched by the Council in 25 districts of 25 states to train 5,000 youth in entrepreneurial activities through KVKs. Under *Mera Gaon Mera Gaurav* initiative, scientists visited 10,712 villages regularly and provided advisory to the farmers during the year. The Krishi Vigyan Kendras Knowledge Network Portal (http://kvk.icar.gov.in/) was launched for regular monitoring of KVKs and to provide information and advisories to the farmers. Farmers, scientists of KVKs and ATARIs, agricultural officers can register themselves on the portal and seek information related to activities and services of KVKs.

Agricultural human resource development: The Council continued to strive for maintaining and upgrading the quality and relevance of higher agricultural education by revising the curricula, supporting the development of infrastructure (approximately Rs 358 crore) in state agricultural universities, and providing for advanced training of faculty. The birth date of former President and first Agriculture Minister of India, Bharat Ratna Dr Rajendra Prasad i.e. 3 December, was declared as Agricultural Education Day. Financial support of Rs 242.25 crore was provided to different agricultural universities for the construction of 28 hostels (including 17 hostels for girls), three auditoriums and six examination halls and other facilities. A total of 69 students completed their research or Masters degree through Niche Area of Excellence (29, including three new) supported by ICAR. Twelve new modules were established for 'Experiential Learning' of UG students in eight universities. The Fifth Deans Committee completed the revision of course curricula for UG programmes making them more robust. National Talent Scholarship and Fellowships were revised to attract talent and support agricultural education. Admission of foreign students was facilitated for globalization of Indian agricultural education system. Capacity building programmes led to training of 3,200 faculty in 62 summer-winter schools, 55 short courses and 47 training programmes under 31 Centres of Advanced Faculty training. The numbers of slots for Emeritus Scientist Scheme were doubled from 50 to 100. Quality assurance of agricultural education was ensured through accreditation of 35 universities. Under e-Granth 18 new Universities were added taking the total number of member universities to 40. Presently the digital repository holds 32,298 theses (M.Sc. and Ph.D.) and more than 16 million pages in more than 56,000 titles (volumes) like old books, old journals, reports, proceedings, reprints, theses, research highlights, training manuals, and historical records.

Research for tribal and hill regions: Central Maize VL Sweetcorn 1 (FSCH 18) (first public sector bred sweetcorn single-cross hybrid); VL *Dhan* 156 (VL 7620, IET 20955); VL *Mandua* 348; soybean VLS 77 and VLB 201 (black soybean); VL *Gehun* 953; barley VLB 94 were released for hill state of Uttarakhand. Bacterial isolates, viz. W5Rp75, W4Rp74 and W2Rs25 isolated from rhizosphere/rhizoplane/endorhizosphere of wheat cultivars showed maximum Zn solubilization. Phenotypical screening for identification of tolerance/sensitivity to P-deficiency in rice varieties grown in Meghalaya, revealed that Swarna, a popular rice of India, is highly tolerant to P deficiency. Based on these results, marker assisted backcross breeding programme can be initiated for the development of P efficient rice for NEH region. RC Maniphou 13, a new rice variety, was found suitable for Manipur. It is photo-insensitive with yield potential of 7-8 tonnes/ha and is tolerant to leaf and neck blast diseases.

Under the ICAR Seed Project – Breeder and Truthfully Labelled Seed of paddy (69 q) and pulses (4 q) were produced at farmers' fields in North Andaman. In addition, 120 kg breeder seed and 600 kg TFL seed of recommended rice varieties and 3 kg

seed of CARI Brinjal 1 (bacterial wilt resistant) were also produced. Intercropping of pulses in coconut did not hamper the coconut productivity, and will help enhancing production of pulses in the islands. A new technique of propagation of jasmine was standardised using leaf as the propagule. Nicobari pigs were found disease resistant and having less pre-weaning mortality. *Aloe vera* based herbal eye drops (2-3 drops) reduced the microbial load, swelling and pus discharge of conjunctivitis affected eyes among backyard poultry in A&N Islands.

Under Tribal Sub Plan (TSP), the empowerment of tribal population through training cum technology dissemination was carried out. In tribal areas of Kashipur in Rayagada, pesticides, farm tools, sprayers, fertilizers, etc. were provided to 450 farmers to promote mango cultivation in the region. Farmer self-help groups were trained to produce planting material in polyhouse nursery. Promotion of cultivation of medicinal plants was promoted for livelihood and health security in the tribal villages of Narmada and Jambugoda districts of Gujarat. Skill building was taken up and seed and planting material were made available. Under the North Eastern Hill (NEH) Regions programme a 'Village Incubation Centre for Value Addition of Tuber Crops' was initiated at Manipur.

Supporting basic and strategic research: The 'National Agricultural Science Fund' with an outlay of Rs 500 crore supports basic and strategic research in agriculture. Out of 996 Concept Notes, 18 projects were approved. Besides having 77 publications in reputed journals, NASF produced five patents and 29 technologies. Some selected projects are: Phenomics of moisture deficit and low temperature in rice; Genes for drought tolerance; Double herbicide tolerant transgenic rice for weed management; Understanding the mechanisms of non-host resistance against rust and blast in rice and wheat; Molecular mechanism of induction of biotic stress tolerance by *Trichoderma* spp. in castor; Infertility in crossbred bulls and early prediction of fertility; Development of parthenogenetic goat from embryonic stem cells; Regulation of fatty acid synthesis by RNAi in pig; Adaptive mechanisms and captive breeding in hilsa; Green fishing systems for the tropical seas; Studies on micro-algal triacylglycerols as source of biodiesel; Decision Support System for enhancing water productivity of irrigated rice-wheat cropping system.

Strengthening the research system: During the period, Agricultural Scientists Recruitment Board completed the recruitment process for 94 direct entry posts. Of these, 43% posts were Research Management Positions and 61 % posts were for Head of Divisions, Project Coordinators and Principal Scientists. Combined examination for NET and ARS (Prelims) 2015 was conducted in online mode at 22 centres across India. Out of 2,217 candidates, 363 candidates qualified for vacancies in 30 disciplines. NET 2016 (I) examination was conducted in 56 disciplines at 23 centres across India in online mode. All the advertised vacancies were duly filled under various categories i.e., General Category (172 including 5 Divyang candidates), followed by Other Backward Castes (72 including 3 Divyang candidates), Scheduled Caste (40) and Scheduled Tribe (25).

Training and capacity building: The system identified 128 training areas for scientists, 87 for technical, 49 for administrative and 36 for skilled supporting staff for training with the help of competent institutes. Special trainings were provided to about 2,710 (54.5%) scientists, 585 (10.5%) technical, 443 (11.5%) administrative staff and 73 (1.3%) SSS. First time, weekly in-house trainings for administrative staff of ICAR HQs were initiated. Overall, 3,446 employees (18.1 % of the total employees of ICAR) were trained.

Intellectual property and technology management: To protect new innovations, ICAR has filed 45 patent applications at Indian Patent Office (IPO), which were generated by 23 institutes. The cumulative figure of patent applications has now risen to 1,025 applications from 69 ICAR institutes. Ten copyright and twelve trademark applications were filed by ICAR institutes for products and processes. As the Protection of Plant Varieties and Farmers' Rights Authority notified new genera, applications for 135 varieties (107 extant; 27 new varieties and one Essentially Derived Variety) were filed at the Registry. For applications filed earlier, 56 varieties (51 extant and 5 new) were granted registration certificates during this period, raising the cumulative figure of registered varieties to 756. The cumulative total for plant variety protection applications rose to 1,186.

To create awareness and develop expertise in the domain area of intellectual property rights and technology management, 39 ICAR institutes organized 129 different programmes, which were attended by 10,421 participants. This year, 356 such partnership agreements were firmed up with 186 public and private organizations and 73 entrepreneurs by 43 ICAR institutes in different Subject Matter Divisions. These agreements were signed for 100 technologies of agriculture and its allied sciences.

Agri-business Incubation (ABI) centers (25) were supported/established in various institutes, which facilitated the business environment in the ICAR institutes by undertaking activities viz. Business Plan Development (75); Conferences/Seminars Organized (21); Consultancy (Short and Long Term) (104); Entrepreneurs Admitted for Incubation (163); Entrepreneurs Graduated from The Incubator (61); and Value Chain Development (40).

Partnership and Linkages: A landmark MoU was signed in October 2016 to establish a research platform in agriculture under BRICS. In addition, Memoranda of Understanding were signed between ICAR and Papua

New Guinea-University of Technology in the field of Horticultural Science Research; Horticultural Innovation, Australia; and Ministry of Agriculture and Rural Development of the State of Israel and the Ministry of Agriculture of the Republic of India (in DARE). Work Plans were also signed between ICAR and IWMI, CGIAR Center, and ICRAF. Total 17 international collaborative projects were approved during 2016. The programmes of DARE included foreign deputation cases, germplasm exchange, and monitoring of CAU- Imphal, Jhansi and Pusa.

AgrInnovate India Limited: AgrInnovate felicitated NBPGR in signing a memorandum of Agreement with M/s DSS Image Tech Private Ltd, Delhi to commercialize five DNA-based GMO screening technologies. The programmes of AgrInnovate India Ltd. included capacity building programmes such as two-days training-cum-demonstration on technical know-how of Aleuritic acid technology, West Africa Agricultural Productivity programme sponsored training on Fish breeding technology, Food Science and Technology, and Seed Technology etc.

Awards: To commemorate the 88th Foundation day of ICAR, the ICAR Awards-2015 ceremony was organized at Vigyan Bhawan, New Delhi on 16 July 2016 in which 114 awardees (77 scientists, including 13 women scientists and 7 journalists) were honoured. Three of the ICAR institutes, 2 AICRPs and 9 KVKs were also awarded for their excellence.

Technical Co-ordination: To have effective centre state relationship, seven ICAR Regional Committees Meetings (7) were organized during 2016-17, wherein inputs and expectations of different states emerged that warranted action-oriented R & D in agriculture to enhance productivity by reducing crop loss and also achieve climate resilience. During 2016-17, the Council provided financial support to 53 societies for the publication of Scientific Journals. In addition, 56 societies/associations/universities were supported for holding National Seminars/Symposia/Conferences and 27 societies/association/universities for holding International Seminars/ Symposia/ Conferences. The Council provided financial support to 265 Research Projects under this scheme during the year 2016-17. Annual Report (2015-2016) of DARE/ICAR was tabled in both the houses of the Parliament.

Finance: The Plan and Non –Plan allocation to DARE/ ICAR for 2015-16 were Rs 3,000 crore and Rs 2,586.00 crore respectively. An internal resource of Rs 227.20 crore (including interest on loans and Advances, income from revolving fund Schemes and interest on short Term Deposits) was generated by ICAR during the year 2015-16. The Plan and Non-Plan allocation (B.E.) for 2016-17 are Rs 3,700.00 crore and Rs 2,920.00 crore respectively.

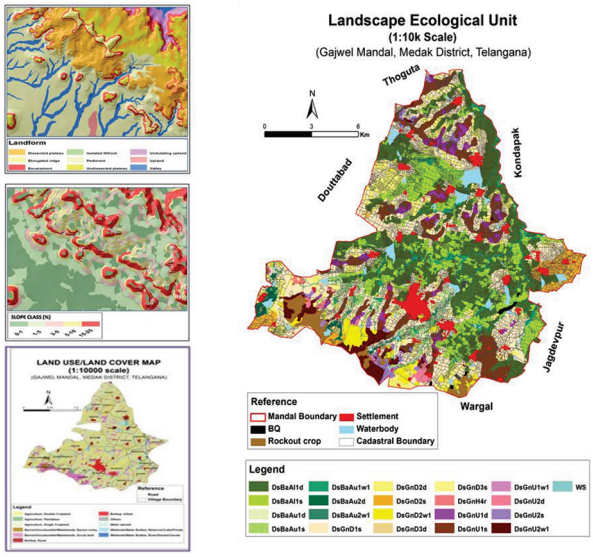
I wish to place on record our gratitude to the Hon'ble Union Minister of Agriculture and Farmers Welfare and President of the ICAR Society, and Hon'ble Union Ministers of State for Agriculture and Farmers Welfare, members of Governing Body and ICAR Society for their keen interest, valuable guidance, support and encouragement in all endeavours of the DARE/ICAR. I wish to thank the diverse stakeholders, especially the allied Ministries and Departments of the Government of India, State Agricultural Universities, National and International Organizations, Private Sector, Industry and Farmers for their association and cooperation in devising research planning of the Council. I urge the scientists to focus on farmer-centered research activities to further enhance the contribution of this sector to the national GDP while also resorting to doubling farmers' income. I look forward for partenership in developing varieties/breeds and technologies and also to take it to farmers. It is hoped that the report would be useful for policymakers, planners, development agencies, researchers, farmers and students and also sensitize them about the quantum of contributions by Indian Council of Agricultural Research.

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

2. Soil and Water Productivity

Soil-resource inventory and land-use planning

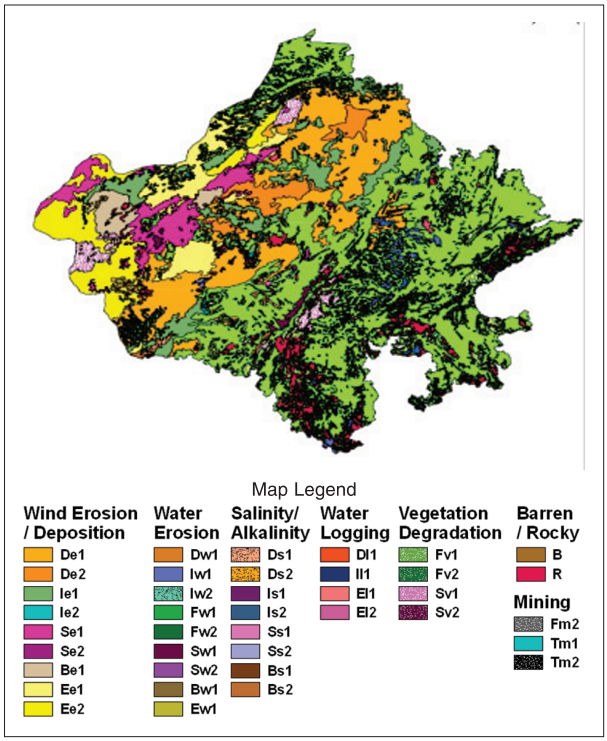
Land-resource inventory (1:10000): The Land-Resource Inventory (LRI) is basically meant for developing sustainable land- use plan, which is dynamic and dependent on the present climate and prevailing soil-forming processes. Using Landscape Ecological Unit (LEU) based methodology, preparation of landform maps, soil survey and soil map preparation in GIS have been completed for 55 blocks comprising 1.73 M ha. The region-wise distribution of these blocks is as follows: Southern region -17 blocks (365,828 ha); Western regions -5 blocks (718,410 ha); Central region -5 blocks (239,500 ha); Eastern region -17 blocks (178,541 ha); Northern region -6 blocks (136,964 ha); North-eastern region-5 blocks (93,962 ha)



Delineation of landscape ecological unit map

Fallow-land mapping in Goa: After extensive ground truthing, fallow land map (using high resolution remote-sensing data and cadastral map as base) covering 13,193 ha, constituting about 3.6% state area, was prepared. The current fallow lands (CFL) are 4,639 ha (35% of the total fallows and 1.25% of the total state area); culturable wastelands (CWL) are 4,621 ha (35% of the total fallows and 1.24% of the total state area), and fallow lands other than current fallows (FLOCFL) are 3,933 ha (30% of the total fallows and 1.1% of the total state area).

National- level mapping on desertification: GIS-based desertification status map (2011-13) of Rajasthan was prepared. The digital database (1:1 M scale map) of the state indicated 62.90% of its area under different land degradations. Compared to the 2003-05 database, decrease in total degraded area was about 100,000 ha. Maximum area was degraded by wind erosion/deposition (44.80%). Except for vegetal degradation (+10218 ha), there was substantial decrease under wind erosion (–134180 ha) and salinity (–1898 ha). While, areas affected owing to mining increased by 2,193 ha and by water erosion around 238 ha.



Desertification status map of Rajasthan (based on the interpretation of IRS-A WiFS images of 2011-13)

Identification of potentially critical waterlogging areas under the IGNP: Survey was conducted on waterlogging in Indira Gandhi Nahar Pariyojana (IGNP) (Bikaner district) Charanwala Branch (1-30 RD), Sagra Mal Gopa Branch and between Bajju to Pugal Head (828 to 860 RD and 976 to 985 RD). Severe problem of secondary salinization was recorded in Sesawa, Malio ki Golia, Purava, Alethi, Manki, Duthwa, Tapi and Semdawas villages under the Narmada canal command area. Area along the Bhimguda distributary was also

Web portal for soil-health management of Goa

A web portal – Soil-Health Management — Goa has been developed using base data of about 20,000 soil samples. The information is given on the parameters like soil *p*H, electrical conductivity, soil-organic carbon, soil-available nitrogen, phosphorus, potassium and micronutrients. This offers fertilizer recommendation based on the soil-fertility status, targeted yield and area, type of crop, age of crop and number of plants.

observed critically waterlogged (watertable between 1.0 and 1.5 m) to potentially sensitive to waterlogging (water table < 6.0 metre) due to canal irrigation. DTPA extractable Cu and Mn were sufficient in the soils, and zinc followed by iron were deficient in 55-60% of the area.

Recovery and rehabilitation of threatened desert species: Indian part of Thar Desert has 6.4% endemic plant species, and many of them are threatened largely due to anthropogenic and extrinsic reasons. Some of them are economical and are useful immensely as medicine. One such species is *Ceropegia bulbosa*. Modelling of its ecological niche (ENM) of occurrence revealed its possible presence in Rajasthan. But actual field searches revealed its very few and sparse populations only at three locations. Its plants were regenerated successfully from propagules under mist-house conditions. Nearly 3,000 saplings could be produced in four years. For rehabilitation, the plants were reintroduced into natural habitats predicted by the ENM. Introduced plants showed excellent survival, growth, flowering and seed- set. Observations on the build-up of its self-sustaining populations indicated its introduced rehabilitation successful under natural conditions.

Saplings of *Ceropegia bulbosa* ready-to-be reintroduced in the natural habitat; close-up of flower *(inset)*

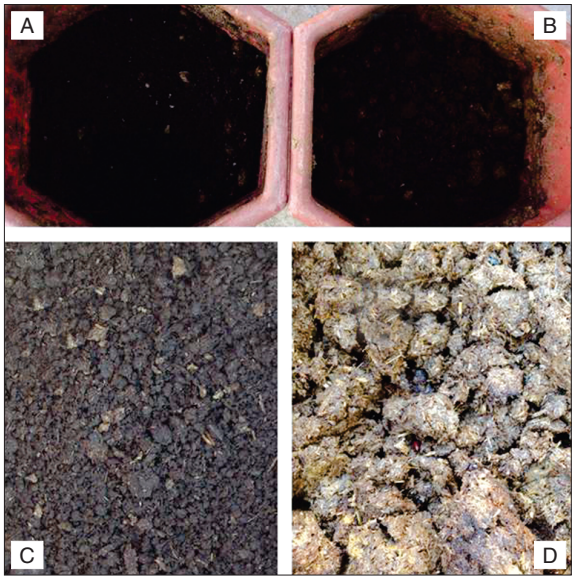
Soil and water productivity

Biochar (BC) reduced greenhouse gases from compost: Greenhouse gas (GHG) emission was measured from FYM amended with biochar in which fresh cow-dung was mixed with biochar at 2% w/w. Measurement was at regular interval using static chamber, and gas samples were analyzed by gas chromatograph. Addition of biochar significantly reduced GHG emission and enhanced rate of composting.

Proper management of compost also influences GHG emission. A study on the farmers' fields indicated that by maintaining 60% moisture in farmyard manure, CH_4 oxidation potential increased. The optimum CH_4 oxidation rate measured from well-managed compost was 0.32µg/g/d.

Upgraded *Mridaparikshak*

An upgraded version of *Mridaparikshak* mini lab for Soil Testing and Fertilizer Recommendation has been developed. This can estimate 15 important soil parameters — *p*H, EC, organic-carbon, available nitrogen, phosphorus, potassium, sulphur, zinc, boron, iron, copper, manganese, gypsum requirement (GR), lime requirement (LR) and calcareousness. It can give soil- and crop-specific fertilizer recommendations directly to farmers on their mobiles through SMS.

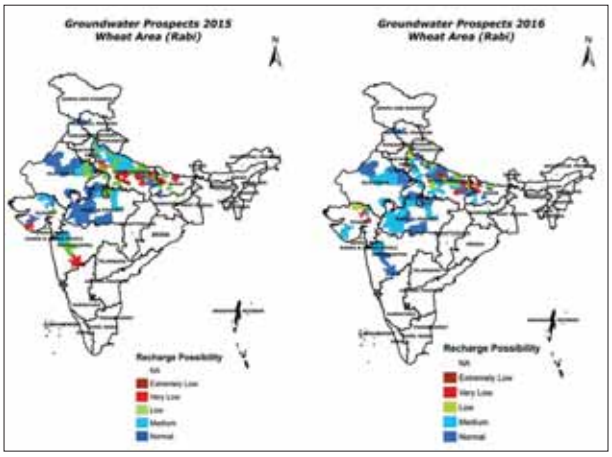


Biochar influenced GHG emission from FYM: Panels B, D represent FYM without biochar; panels A, C represent FYM with biochar. Biochar reduced greenhouse gas emission and enhanced composting process (A, C)

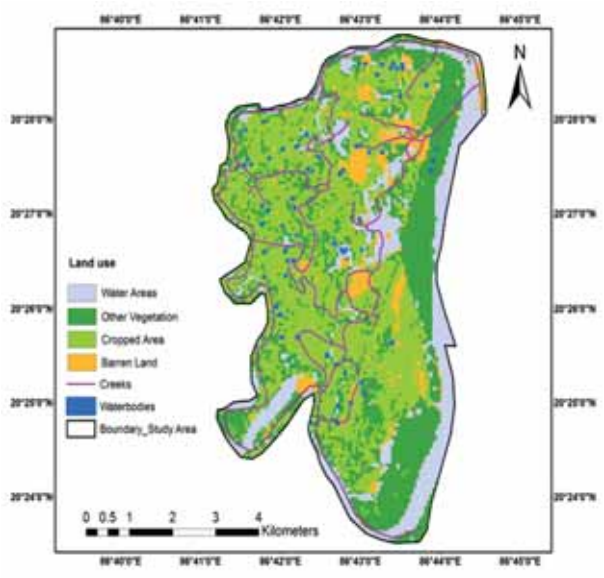
Spent- wash effect on *murum* disintegration: Poor productivity of degraded lands is one of the major constraints limiting crop yields. *Murum* disintegration was in the following decreasing order: Sugarcane- spent wash > Napier grass> Lucerne> Subabul > Sugarcane > Soybean- Wheat-spent wash> Maize-sorghum> Soybean+ Wheat > Control + spent wash > control in the irrigated areas; and Subabul >Anjan > Sorghum fodder in the rainfed areas. Treatment enhanced ion-exchange process and also produced organic acids (humic acid, fulvic acid) and others, which accelerated process of chemically induced physical weathering of rocks through improved ion- exchange phenomenon. Sugarcane equivalent yield was recorded maximum in Sugarcane-spent wash; which was significantly superior to all other treatments.

Nano-composites for multiple stress resilience in aquaculture: Nano-composites were developed by trapping novel biologically synthesized nanoparticles in aluminosilicates. Modification of the surface and pores of the aluminosilicates makes them ideal for varied aquaculture applications.

Groundwater-recharge assessment in wheat-growing areas: Based on the criterion developed for qualitative assessment of groundwater recharge during monsoon, districts were categorized for recharging



Groundwater recharge during 2015 and 2016 for wheat growing areas



Land-use classification in the study area

prospects and for issuing advisories for suitable cropping patterns during *rabi*. About 170 districts were identified for growing wheat; among them, 62 were in Uttar Pradesh, 32 were in Madhya Pradesh, 16 each were in Punjab, Haryana and Rajasthan, and 13 were in Bihar and Gujarat, Himachal Pradesh, Jammu and Kashmir. Among them, canal irrigation was predominant in 45 districts of Punjab, Haryana, Rajasthan and Uttar Pradesh. Wheat grown under well- irrigated system was located in 95 districts of Uttar Pradesh, Madhya Pradesh, Rajasthan, Bihar and Gujarat.

During 2015, out of the 95 districts, 19 districts, where groundwater plays a dominant role in wheat cultivation, spread in Uttar Pradesh (14 districts), Bihar (3 districts), one district each in Gujarat and Maharashtra, showed extremely low to very low groundwater recharge during monsoon, which impacted wheat cultivation and production. And 27 districts (17 in Uttar Pradesh, 3 each in Rajasthan and Bihar, 2 in Madhya Pradesh and 1 each in Gujarat and Maharashtra) had low prospects for groundwater recharge. About 49 districts were with medium to normal recharge prospects, and indicated opportunities for better wheat cultivation under well-irrigated areas.

During 2016, in 95 districts, 67 districts in Uttar Pradesh (25 districts), Bihar (4 districts), Madhya Pradesh (21), Rajasthan (11), Gujarat and Maharashtra (3 district each) had medium to normal ground-water recharge prospects. Fifteen in Uttar Pradesh (13), 1 district each in Bihar and Gujarat had low prospects for recharge. With better prospects of groundwater recharge in 67 districts, cropped area under wheat could increase substantially during 2016 *rabi*. In 11 districts, where groundwater recharge was extremely low to very low, *rabi* pulses could be promoted.

Water-resource management in non-exploration zone of coastal Odisha: A comprehensive water-resource planning was developed for 3,900 hectares, located within 15 km from the coast-line in Mahakalapada block of Kendrapra district of Odisha. A Linear Programming Model with simplex algorithm was used for optimum land allocation for 3 major crops— paddy (497 ha), pulses (289 ha) and vegetables (238 ha) — for maximum production. To meet crop water demand, existing water- harvesting structures were standardized for average capacity up to 7,000 cu m with depth constraint within 2.5 to 2.8 m below ground surface. Ingression of saline water through creeks and drainage of excess water were checked through construction of sluice-gate in mouth of Sunity creek. Hydraulic design of creeks at different sections was proposed to carry discharge of 25 m^3 of water / sec. Based on the water availability in creeks and water-harvesting structures, crop planning has been proposed for the region.

Improved productivity of salt- affected soils with limited freshwater irrigation: Appropriate soil- and-crop management practices were developed for conjunctive use of fresh and saline water for irrigation. Conservation tillage, deficit irrigation and crop residue mulching approaches were employed for managing intra/inter seasonal root-zone salinity for increasing production of low-water requiring crops. Grain yield of wheat (KRL 210) in saline soils (EC_2 3.1-3.4 dS / m) irrigated with saline water (8.0 dS/ m) was 4.69 tonnes/ ha. Wheat yields obtained at 80% (4.6 tonnes/ ha) and 100% (4.69 tonnes/ha) irrigation supply of

Zero-tilled wheat-crop in mulched saline soil

Success story

Dug-well-based drip-fertigation for vegetable farming

In Odisha, on-farm drip fertigation (1000% RDF) experiments yielded 2.4 tonnes/ha, 5.9 tonnes/ha and 4.6 tonnes/ha more of chilli, potato and ladies' finger, respectively, than drip irrigation and soil application of fertilizers (100% RDF). Fertilizer-use efficiency was found to be increased by 42-67% for different crops under different drip-fertigation treatments than soil application.

This observation led to the establishment of 14 dug-well drip-fertigation units in Cuttack and Dhenkanal districts of Odisha, and farmers' income enhanced from mere ₹ 10,000/ha to ₹ 2.5 lakh/ha from light-textured lateritic soil fields. Due to enhanced water and nutrient use efficiency, this technology has also helped develop climate- resilient agriculture.

Salinity and sodicity mapping in 3D

A geophysical survey technology (DUALEM-21) under the Australia-India Council Collaborative Project was tested at two sites in Haryana (Nain in Panipat district and Mokhra Kheri in Rohtak district) and one in Uttar Pradesh (Shivari in Lucknow district) to map salinity and sodicity in 3D.

Manual surveys with DUALEM-21 and Novatel GPS were carried out in January 2016 for EM (electromagnetic) data recording where crops (mustard/ wheat) were on the field. The same instruments mounted on a cart pulled by car were used in Mokhra Kheri field.

After calibration, 3D salinity images with seven profile layers were generated.

DUALEM technology makes possible digital salinity mapping of canal commands both spatially and vertically for developing salinity management improved strategies.

crop water requirement were statistically at a par. Mulching (5 tonnes/ha) under deficit irrigation (60% WR) enhanced wheat yield by 7.5% as compared to non-mulched plots (4.0 tonnes/ha). Rainfed fodder sorghum yielded significantly higher forage when irrigated with saline water at 60% water requirement (6.42 tonnes/ha) in *rabi* season as compared to saline water irrigation at 100% WR. Effects of mulching were more pronounced in surface as compared to subsurface layers. A similar trend was observed for soil salinity. Throughout the year, surface soil salinity was lowest in 60% WR + mulch (60W RM). Decrease in soil salinity was associated with increased soil *p*H; the maximum increase was observed in soils irrigated with good quality water (EC_{iw} <1 dS/ m). It was found that although EC_2 and SAR are major determinants of soil *p*H, but cationic and anionic ratio also modulated soil *p*H at the micro level. Biomass production of the salt-tolerant wheat KRL210 was not affected by different soil- solution parameters indicating its adoptive mechanisms in the tested range.

Harnessing productivity of waterlogged sodic soil through farming system module: Sharda Sahayak Canal provides irrigation to 17.80 lakh ha arable lands in 16 districts of Uttar Pradesh, which suffers from waterlogging and sodicity. Shallow water-table severely limited productivity of about 0.12 to 0.18 million ha of sodic land. To overcome constraints in gypsum-based reclamation of waterlogged sodic soils, a pond-based farming system module (0.80 ha) was initiated under farmers' participatory mode at Patawakhera, Lucknow, to harness productivity of canal seepage water. Rice-wheat, tomato-mustard, vegetables and fodder crops were grown on raised beds and fish were raised in the pond. The fertility status of the soil increased over the initial value. The amount of seepage water coming to pond was initially high, and thereafter receded. Rice and wheat yields were 4.02 and 4.26 tonnes/ha, respectively, with B: C ratio of 2:1. Vegetable system was more profitable than rice-wheat and tomato-mustard systems. The B: C ratio for fodder system was highest among all. Availability of fodder throughout the year except in extreme winter and summer enhanced average milk productivity by 1.5 to 2.0 litres. The highest income (₹ 180,000) was generated by fish production with a B: C ratio of 5:1. Significant improvement in the B: C ratio (1.33) indicated potential of land-modification technology in integration with different cropping systems in augmenting farmers' income and nutritional security.

Forage grass strips for resource conservation: Grasses — para grass, guinea grass and napier grass— were tested for their efficacy in preventing soil and

High-value grass strips in crop fields

Water-hyacinth management in Moti lake at Motihari (Bihar)

Moti lake of about 450 acres in Motihari (Bihar) was severely infested with water-hyacinth (more than 75% area). Infested 6 acres was identified for water-hyacinth management. Initially, spray of 2, 4-D and glyphosate was done on different patches of water-hyacinth. After about a month, when water- hyacinth dried owing to herbicide action, biomass was removed manually with JCB. Approximately 20 tonnes of vermi-compost was prepared from removed biomass.

Severly infested lake (*left top*); treatment with herbicides (*right top*); mechanical removal of water-hyacinth (*left bottom*); cleaned lake (*middle bottom*); vermicompost-making (*right bottom*)

nutrients losses from runoff water, coming from crop fields and waterways. Grass strips were planted at the downstream end of cotton field. Napier grass strip of 2m width was most effective, reducing runoff, soil and nutrient losses up to 30%, 65%, 70%, respectively, and in increasing crop yield up to 18%.

In waterways, para grass filters were most effective and reduced outflow up to 18% with 100% grass cover. Grass-filter strips were able to reduce sediment concentration in runoff water by 5.5 times (from 3.05 to 0.55 g/litre).

Peach-based agri-horticulture land-use system for degraded Shivaliks: Peach (*Prunus persica)* cultivation in degraded lands along with most compatible intercrop (fodder crop) and moisture- conservation practice can be implemented in Shivaliks of Jammu, Punjab, Haryana, Himachal Pradesh, Chandigarh (UT) and Uttarakhand, which experience sub-tropical climate with low-chilling hours during winter. There is also a good scope for shade-loving crops — turmeric, colocasia and ginger— after 4-5 years of plantation. Peach + circular trench + clusterbean combination was found most compatible for resource conservation resulting in minimum run off and soil loss, maximum fruit yield per plant, maximum B:C ratio of 5.25 (gave gross revenue of ₹ 20.48 lakh in 7 years).

Underutilized fruit species in Chambal ravines: Four underutilized fruit species — Bael (*Aegle marmelos*), Lasoda (*Cordia myxa)*, Custard-apple (*Annona squamosa)* and Karonda *(Carissa carandas)*— with four interspaces managements — Clean tilled, Clean tilled with half-moon, half-moon with *Cenchrus ciliaris* and half-moon with *Dicanthium annulatum*— were planted on hump top of the ravines with recommended spacing. Over all, fruit production and maximum economic returns were obtained through bael with half-moon shaped moisture retention management technique.

Bael tree with half-moon moisture retention measure (*top*); Beal with half-moon structure supported bulky and bumper fruit harvest at Chambal ravines (*bottom*)

A view of underutilized species (bael) at Chambal ravines in south-eastern Rajasthan

Integrated fish farming: Cattle-fish integration resulted in highest fish productivity of 4.50 tonnes/ha, followed by poultry-fish integration at Patna. Fish rearing with concentrate feed increased fish yield only by 760 kg/ ha as compared to productivity of cattle-fish integration.

Mango: Productivity in mango (cv. Dashehari) as a function of soil management system was maximum (13.96 t/ha) due to application of NPK + Zn, Cu, Mn, B (50% soil + 50% foliar application) as compared to untreated check – basin irrigation (6.44 tonnes /ha). Improvement in yield of mango was 116.9% in NPK

+ Zn, Cu, Mn, B (50% soil + 50% foliar application) with maximum (0.90) Sustainable Yield Index (SYI).

Significantly maximum fruit yield (80.4 kg/tree) in mango (cv. Dashehari) and water- use efficiency (12.56 kg/m^3)were recorded due to 100% recommended dose of fertilizer (RDF) applied at different critical phenological stages as compared to 59.4 kg and 9.28 kg/m^3, respectively in untreated check.

Similarly in mango cv. Dashehari, drip irrigation (60% PE) coupled with polythene mulching, resulted in 10.9 tonnes /ha fruit yield with 45-58% water saving compared with rainfed check (6.9 t/ha).

Guava: Drip irrigation coupled with polythene mulching in high-density plantation of guava cv. Allahabad Safeda (80% Pan Evaporation Replenishment) resulted in fruit yield of 16.92 kg/m^3 along with 47.52% water saving as compared to 8.21 kg/m^3 in untreated check.

Grape: In Fantasy Seedless vines, pan evaporation based growth stage-wise irrigation schedule with 262.4 mm of applied irrigation along with rainfall (691 mm) produced yield on par with highest treatment (332.3 mm).

Use of subsurface irrigation and recommended irrigation schedule through surface drip irrigation led to 46.8% and 25.9% savings in irrigation water respectively at Jath. At Palsi, use of partial root zone drying (PRD) technique resulted in saving of 19.1-26.6% irrigation water.

Pomegranate: The application of water soluble NPK fertilizers with irrigation water at 75% of RD at 7 days interval recorded highest amount of available N and K content of soil, while application of the same at 50% of RD at 15 days interval recorded highest available soil P content. Further, application of 75% of RD of N-P-K through fertigation at both 7 and 15 days interval recorded significantly higher DTPA extractable Mn content of soil, while 50% of RD of N-P-K applied through fertigation at 15 days interval noted higher DTPA extractable Fe and Zn content of soil. Fertigation of 75% of RD of NPK at 15 days interval resulted in significantly higher DTPA extractable Cu content of soil.

Okra: In spring-summer okra (March - May), drip irrigation at 100% PE (pan evaporation) coupled with organic mulch (pea straw @ 12 t/ha) yielded maximum (125.33 q/ha) fruits giving 64.8% higher yield over surface irrigation without mulch. Maximum water-use efficiency (WUE, kg yield/mm water) of 31.53 was recorded under drip irrigation at 60% PE + organic mulch, besides saving 49% of water. Organic mulching registered 23.9% and 39.3% higher yield, respectively over black-silver polyethylene (B-S) mulch and un-mulched control. The WUE in organic mulch, B-S mulch and un-mulch were 22.78, 18.37 and 15.84 kg/mm water, respectively. The maximum WUE of 24.84 kg/mm water was recorded with 80% PE.

Thus, it could be concluded that okra during spring-summer should be irrigated at 80% PE with organic mulch for realization of higher yield, besides saving considerable quantity of water.

Cucumber: The cucumber responded positively with water application from 50% (9.85 t/ha) to 100% ET (27.5 t/ha) through SDI. The yield realized under SDI with 100% ET was 1.38 times higher than control. However, it declined faster with decreasing amount of water and reduced to one-third with 50% ET compared to 100% ET. Water-use efficiency (WUE) under SDI with 50, 60, 80 and 100% ET was 65.23, 93.55, 97.80 and 91.17 kg/mm, respectively.

Potato: The productivity of selected potato varieties, viz. Kufri Garima, Kufri Khyati, Kufri Sadabahar, Kufri Pukhraj and Kufri Bahar, were maximum at higher soil moisture regime when irrigations given at IW:CPE ratio of 2.5 and was lower with irrigations applied at critical stages of crop growth. The productivity of all varieties was maximum @ 210 kg N /ha and at par with 180 kg N/ha.

Tuber crops: Maximum corm yield (51.15 t/ha) in elephant-foot yam was obtained with irrigation at 50% CPE along with crop residue mulching followed by irrigation at 50% CPE with plastic mulching (48.9 tonnes /ha) as compared to rainfed crop (26.5 t/ha).

Fertigation studies in cassava indicated that different levels of N and K (75,100 and 125kg/ha) were on par with respect to tuber yield. The interaction, 125kg/ha N and 75kg/ha K produced maximum tuber yield (50.3 t/ha).

Spices

Maximum seed yield of different seed spice crops was recorded under drip fertigation and lowest with surface irrigation. Maximum yield was recorded in fennel (2449.5 kg/ha), followed by fenugreek (2316.8 kg/ha), dill (1908.7 kg/ha), coriander (1558.4 kg/ha) and celery (718.7 kg/ha) under drip fertigation method.

Horticulture

Farming Systems

Mango: Mango-based cropping system standardized for enhanced income using a shade-loving fern (*Nephrolepis tuberosa*). It was found most remunerative intercrop for mango orchards with production of 8,55,000 leaves/ha, fetching ₹ 2-3 lakh of additional income per hectare. Ferns are planted at 45-60cm × 45-60 cm (row- to-row × plant-to-plant) on bunds in tree interspaces leaving 2m from the tree trunk of fully-grown up (40 year old) trees of mango cv. Dashehari.

Plantation crops

In coconut plantations, pulse, *viz*. pigeonpea, mung bean and urd bean under storey crops recorded seed yield of 554, 410 and 390 kg/ ha. These pulse crops produced 1.5 (pigeonpea) to 2.7 t/ha (mung bean and urd bean) stover that could serve as potential fodder to livestock. Introduction of pulses in coconut did not hamper coconut productivity despite a built-up of soil N by 23 kg/ha owing to biological N fixation.

Based on mean price of ₹ 45,000/t, gross and net income of coconut plantation was improved by ₹ 20,250 and ₹ 8,000/ha due to introduction of pulse crops. Thus, wide deficiencies in production of pulses in islands can be offset by their intercropping in coconut.

Coconut-based mixed farming system involving, coconut, black pepper, fodder, fishery, poultry and goats gave higher net return of ₹ 7,17,955/ha. Among components, dairy, coconut and black pepper contributed 80% of the total returns. Inclusion of fodder legumes and organic supplements was helpful in maintaining soil fertility and productivity.

Organic nutrient management was standardized for cultivation of Hybrid Napier var. CO3 fodder intercrop in coconut plantations, with application of cow dung slurry, vermicomposting, *Azospirillum* and *Phospho bacteria* at bimonthly interval, resulting in high fodder yield of 139 t/ha.

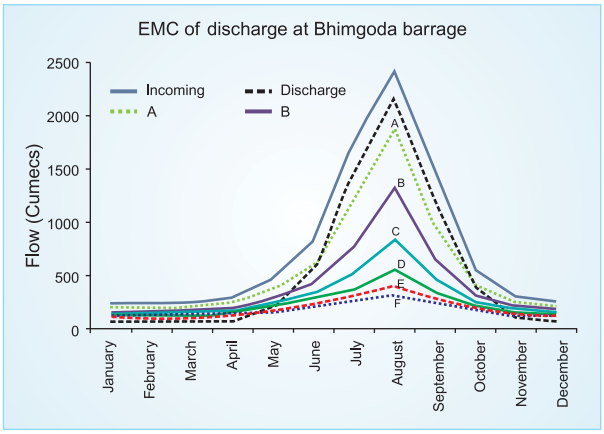
Arecanut-based cropping system model involving arecanut, black pepper, acid lime and turmeric recorded higher system productivity with black pepper contributing 67-70% and the main crop arecanut contributing only 22-26% to total system productivity.

Tuber crops: A study on cropping systems involving tuber crops showed rice (var. Kanchana), short-duration cassava (var. SreeVijaya)+blackgram (Co-7) resulted in higher energy equivalent, tuber equivalent yield (38.86 tonnes/ha), production efficiency (107.94kg/ha per day) and profitability (added profit of ₹ 52,107/ ha over sole cassava) besides saving nutrients (half FYM and; N and full P).

Medicinal and aromatic plants: The cultivation of patchouli (*Ipogostemon cablin*) as a shade crop in mango orchards with 45cm × 45 cm spacing, application of 100:50:50 NPK kg/ha + 2.5 t vermicompost + 20 ppm GA resulted in 56.03% higher oil yield over the control.

Fish

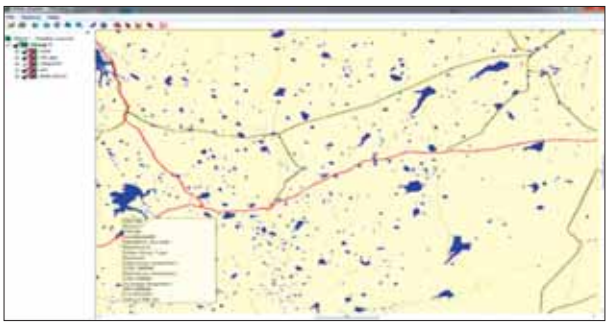
Environmental flow estimation of river Ganga at Haridwar: Constructions of dams and barrages and severe water abstraction and diversions have threatened river ecology and fisheries. Environmental flow pattern of river Ganga at Bhimgoda barrage, on the basis of past hydrological data suggests requirement of 26.6 to 76.0% of mean annual runoff (6,258.58 to 17,875.96 million cubic metres) to maintain the downstream ecology and fisheries between seriously modified environmental management class (E) to natural/pristine condition or minor modification of in-stream and riparian habitats (A). The incoming and discharge pattern from Bhimgoda barrage during flood season is sufficient enough to maintain the ecological condition of river but the discharge during lean season (December to March) remains far below requirement of environmental management class (F). To revive depleting fishery in affected stretches, the discharge should be maintained at least in Class D during lean season between 132.48 and 140.84 Cumecs.



Soil and Water Health Card

ICAR-CIBA developed soil and water health card for aquaculture farmers. The card provides data of essential soil and water parameters required for fish farming. Regular updating of the card will help to record long term trends in soil and water parameters. The card is based on data of 280 soil and water samples from Tamil Nadu, Andhra Pradesh, West Bengal and Gujarat. It also captures the demographic details of farmers, farms, and fish culture details on the front page and optimum values of essential soil and water parameters on the back page.

e-Atlas for water bodies of Gujarat: Electronic Atlas (e-Atlas) of water bodies of more than 0.5 ha was developed based on IRS imageries for Gujarat. The water bodies can be visualized along with roads, important places, rail networks, etc. The delineated water bodies can also be viewed by compatible GIS



e-Atlas for water bodies of Gujarat

software like TNT Mips, ArcGIS, and other open source GIS software's.

Biomarkers for aquatic pollution: Heat shock protein (*hsp*) transcript profiles are potential biomarkers of aquatic pollution. Gene expression analysis of a battery of heat shock proteins (*hsp27*, *hsp47, hsp60, hsp70*, and *hsp90*) and their regulatory molecules (*hsf1*) in gill and liver tissues of *Rita rita* collected from different stretches of river Ganga revealed up-regulation of *hsp47, hsp70, hsc70* genes and down-regulation of *hsp27* gene. Up-regulation is correlated with decreasing dissolved oxygen content. This could be mediated by organic pollutants and heavy metal pollution, suggesting *hsp70* and *hsp47* could be possible biomarkers of contamination by organic pollutants and heavy metals, and *hsp 27* for coliform contamination in aquatic environment.

❑

3. Climate Change and Resilient Agriculture

Climate change impact on rice production in eastern India: Regional analysis of rice yields using DSSAT– (CERES) rice model for eastern region was done with different varieties and in soil series under the A1B climate-change scenario by subsuming 367 grid point spread over 170 districts, representing Bihar (54/37), Chhattisgarh (64/16), Jharkhand (35/17), Odisha (62/30), Uttar Pradesh and West Bengal (112/68 and 40/18). Weather data of baseline (1961–1990), middle (2021–2050) and future (2071–2098) climate-change scenarios of the A1B with four CO_2 levels of 380, 420, 550 and 680 ppm were applied to calibrate and validate genotype coefficients of rice cultivars, Sarjoo 52 (Uttar Pradesh), MTU 1010 (Bihar), Mahamaya (Chhattisgarh) and Vandana (Jharkhand). Agro-ecological sub region-wise 13 soil series data derived from INFO-CROP were also used in the analysis. Late-sown rice yields increased in A1B scenario. Sarjoo 52, Mahamaya and MTU 1010 varieties are likely to maintain normal to enhanced yields in future in Uttar Pradesh, Chhattisgarh and Bihar. Except Bihar, all states in eastern region are likely to experience reduced yields of below or equal to 10% during mid-century climate-change scenario.

Mitigation of climate change in rainfed regions: An experiment was initiated in pigeonpea and castor system with different tillage practices and also residue levels, by managing harvesting heights (0 cm, 10 cm and 30 cm) to increase residue contributions in the field. The GHG emissions (considering both indirect emissions from farm operations and input use) were reduced by 26 and 12 % in zero tillage and reduced tillage over conventional tillage. The percentage contributions of N_2O based CO_2 emissions were higher to total GHG emissions in both pigeonpea and castor.

Net global warming potential (NGWP) and Greenhouse gas intensity (GHGI) were influenced by tillage and residue treatments. They increased with increase in crop residues in both the crops. The fuel consumption in zero tillage was reduced by 58 and 81% as compared to conventional tillage in pigeonpea and castor, respectively. The results indicated scope to reduce GHG emissions by reducing one tillage operation (reduced tillage) and by harvesting crop residues at 10- and 30-cm height with minimal impact on crop yields. Soil-organic carbon sequestration rate was positive in tillage and residue treatments with highest rate in zero tillage with 10- and 30- cm anchored residues but it was negative in conventional tillage with no residues.

Prediction of future of mango fruit-fly (*Bactrocera zonata*): Temperature-based phenology model was developed for mango fruit-fly by constructing thermal reaction norms for cohorts of single life stages at both constant and fluctuating temperatures within ecologically relevant range (15–35°C) for its development. The model was implemented in the Arc GIS to examine potential future pest status of *B. zonata,* using temperature change projections from the SRES A1B climate-change scenario for year 2050. Geographical regions on the map with the establishment risk index (ERI) value 1.0 indicated that at least certain proportion of *B. zonata* population could establish and survive throughout the year. The areas where ERI was less than 1.0, likelihood of permanent establishment of *B. zonata* was reduced considerably. Major areas of mango cultivation are predicted as optically suitable for establishment, abundance and spread of *B. zonata*. *B. zonata* is predicted to complete average of 8-10 generations (GI) per year under the current climatic conditions in most of the mango-production areas. Owing to climate change, *B. zonata* may complete additional two more generations per year in most of the mango-growing belt of the country. Further, being highly polyphagous pest, chances of incidence and population dynamics into new areas are greater. Hence, wide-area management strategies are advised to restrict or slow down its incidence and population dynamics.

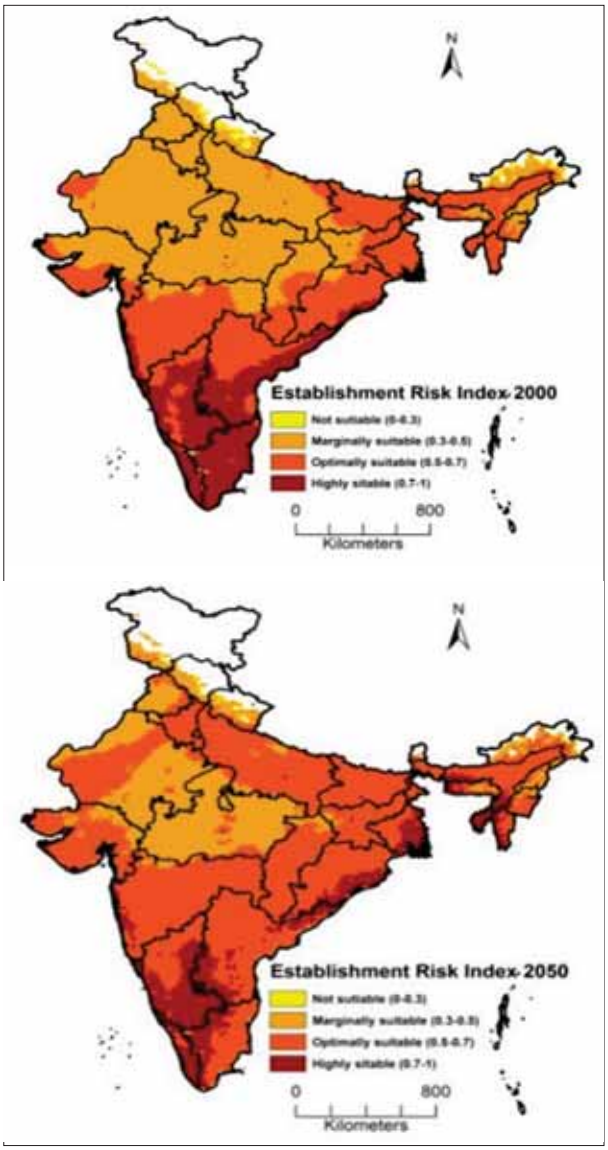
Modelling and forecasting establishment of bioagent *Zygogramma bicolorata*: A study was conducted to model and forecast establishment of *Zygogramma bicolorata* (a bioagent used for biological control of *Parthenium* weed) in different parts of India. Weather parameters for July, August, September and October from 2001–2010 were considered for modeling and forecasting. Results revealed temperature between 23.3 and 24.1°C would be suitable for beetle establishment. A place which satisfy weather indices of temperature 24.17°C (24.17–26.20°C), rainfall <= 191.23 (102.33–191.23) and RH <= 77.27 (54–77.27) would be highly suitable. It is also inferred that places with high rainfall are not good for beetle establishment.

Coconut: Coconut seedlings grown in open top chamber (OTC) had high biomass and seedling growth in response to elevated CO_2 (700 ppm), while it significantly declined under increased temperature (3ºC above ambient). Similar decline in growth was also observed under water deficit stress.

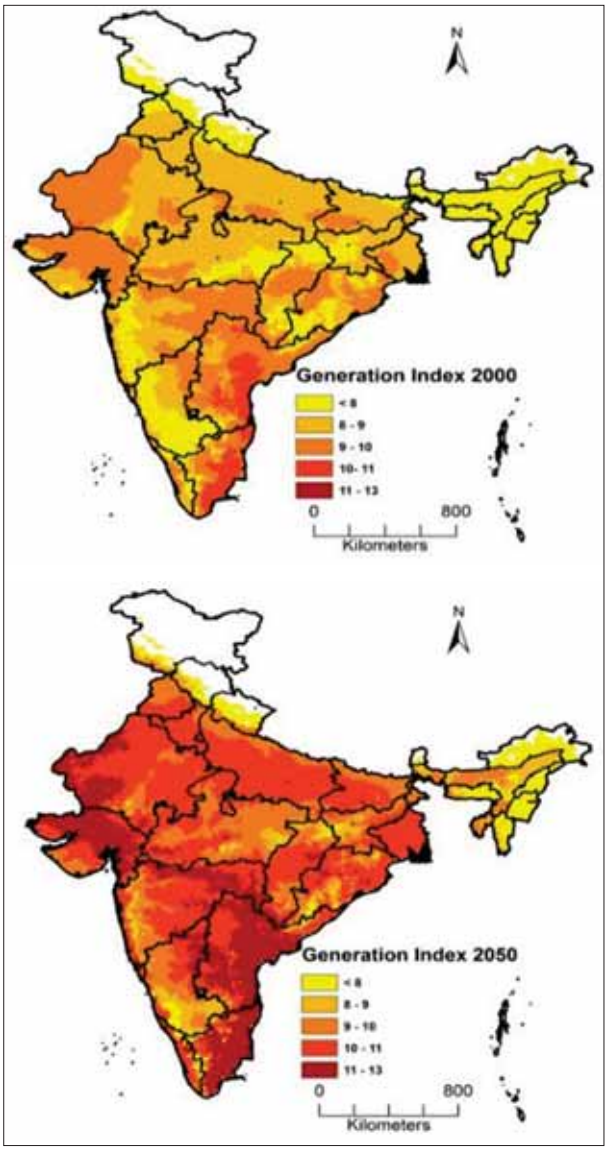
As a mitigation potential, coconut could sequester 31 t CO_2/ha/year, which is higher as compared to other plantation crops.

Pollen germination technique was refined to screen the genotypes for high temperature tolerance.

Grafting in tomato for alleviating excess soil moisture (waterlogging) stress: Grafting of improved



Change in establishment and future distribution of *Bactrocera zonata* in India, based on the establishment risk index (ERI) for current and future climatic (2050) conditions



Change in number of generations per year of *B. zonata* in India, based on the generation index (GI) for current and future climatic (2050) conditions

tomato cultivars Arka Rakshak, ArkaSamrat and Kashi Aman as scion on four brinjal rootstocks viz. IC-354557, IC-111056, IC-374873 and CHBR-2 revealed no leaf chlorosis and wilting, and less reduction in chlorophyll content (CCI), chlorophyll fluorescence yield (Fv/Fm) in scion stock. The non-grafted plants registered 39.6–41% reduction in Fv/Fm and 41–100% reduction in CCI at four days after relieving from waterlogging stress.

Non-grafted plants completely wilted and died in four to five days after relieving from stress, whereas, the grafted plants recovered completely from 96 hours of waterlogging stress, at three days after relieving from the stress.

Potato: The impact of climate change on potato productivity in West Bengal was assessed using WOFOST crop growth model. The model has projected the highest decline of 6.1% in productivity of Kufri Pukhraj, followed by 5.9% in Kufri Jyoti and 5.1% in Kufri Badshah in year 2020 with corresponding figure of 12, 10.5 and 8.8%, respectively in 2055 without adaptation. The negative impact can be counter balanced to some extent by change in date of planting and selection of suitable cultivar.

Livestock

Impact of climate change on livestock: Preliminary results of life cycle assessment (LCA) of green house gas (GHG) emission from the selected dairy farms in Karnataka, indicated that the CH_4 emission from enteric fermentation (IPCC tier II) in dairy HF cross cows

In vivo enteric methane emission measurement in cattle and sheep

was 93.7 to 100.4 g/head/d. The CH_4 emission from manure management system was 1.51 to 1.56 g/head/d and nitrogen excretion was 96.7 to 116.6 g/head/d.

Supplementation of tamarind seed husk significantly reduced methane production *in vitro* and *in vivo* in cattle. Supplementation of condensed tannin (CT) and hydrolysable tannin (HT) at moderate levels significantly reduced methane production without altering digestibility *in vitro*. Similarly, supplementation of saponins at low level significantly reduced methane production *in vitro*. Further, supplementation of the combination of saponins, CT and HT was found most effective than individual supplementation in reducing methane production *in vitro*.

Cattle: Differential expression profiling of bovine NOD1/2 and certain acute inflammatory cytokine genes during thermal stress among native and crossbred cattle revealed that during thermal stress NOD1/2 as well as certain cytokine gene expressions are significantly higher in native cattle compared to crossbred counterparts.

Mitigating climatic stress through dietary approaches: Addition of magnesium sulphate @ 1.2 or 2.4 g/kg basal diets improved body weight, feed conversion, immuno-competence, cost economics and other welfare parameters during both hot (Apr–May, 31.0±0.70 to 37.0±1.4°C, RH, %: 58.0±1.3–70.1±0.6) and hot-humid (Aug-Sep, 26.0±0.10–34.2±0.36°C, RH,%: 76.3±0.9–86.1±0.1) summer but results were more encouraging at level 2.4 g/kg during hot-humid summer. Similarly, the adverse effects on growth, feed conversion and immunity caused by high ambient temperature during extreme summer (hot and hot-humid) could partially be ameliorated by addition of aspirin (500 mg/kg) in diet.

Thermal adaptability of yak: Heat shock protein (HSP70) profile in blood plasma of yaks ranged from 0.2409 to 0.2513 ng/ml during winter. The HSP70 concentration was significantly higher during summer in comparison to winter. The HSP60 concentration was significantly higher during winter in lactating yaks.

Fish

Estimation of greenhouse gases: Emission of greenhouse gases (GHGs) was estimated from prawn (*Penaeus monodon* and *Litopenaeus vannamei*) and fish (catla and rohu) culture ponds. Average emission of all GHGs (g/ha/day) was higher in fish culture ponds (CH_4 –3.62 to 7.86; CO_2 – 1056 to 1758; N_2O – 0.31 to 1.11) compared to shrimp culture ponds (CH_4 – 1.88 to 5.14; CO_2 – 423 to 883; N_2O – 0.07 to 0.35). GHGs emission in terms of CO_2 eq. in nursery (up to 300 g), growout 1 (up to 1 kg) and growout 2 (up to 3 kg) ponds of *Lates calcarifer* ranged from 78 to 190, 118 to 224 and 155 to 245 kg/ha, respectively. Overall, emission was higher during summer compared to winter and significantly reduced during rainy season. Aquaculture ponds acted as sink during low temperature conditions and rainy days.

Shift in fish catch structure along lower Sundarbans: Changes in environmental parameters, viz. water and sediment quality, salinity, nutrient cycling, plankton and macro-zoo-benthos abundance, etc. have triggered changes in finfish and shellfish diversity in Sundarban estuary. Though, there is an overall increase in total fish landings from 7,431 tonnes during 2009-10 to 11,962 tonnes in 2015-16, the catch compositions indicated a gradual replacement of commercially important species by relatively low priced fish species with short life span. The percentage contribution of *Harpadon nehereus*, a most dominant species in winter bag net fishery, has reduced from 27.25% in 2009–10 to 12.33% in 2015–16. The winter fish catch is dominated by low priced species, *Secutor insidiator,* which recorded a marked increase in landings from 0.09% in 2009–10 to 17.90% during 2015–16. Similarly, increase in catches of sardines (*Sardinella gibbosa*, *S. longiceps* and *S. fimbriata*) was recorded from 0.48% in 2009–10 to 10.66% in 2015–16. The bag net catches are dominated by invertebrates (73.5%) comprising prawns (58.5%), crabs (11.65%), stomatopods (2.10%) and cephalopods (1.26%). Non-penaeid prawns (mainly *Acetes* spp.) have emerged as one of the most dominant fisheries.

❑

4. Genetic Resources

Crops

Germplasm augmentation, conservation and use: Seventeen explorations were undertaken in eight states and 1,115 accessions, including 531 of wild species, were collected. Three hundred and eighty-seven herbarium specimens were added to the National Herbarium of Cultivated Plants. The National Gene bank germplasm for long-term storage comprised 10,224 accessions of orthodox seed species; along with cryopreservation of 14 shoot tips/ meristems of vegetatively propagated species and 14 accessions in *in-vitro* Gene bank. A total of 31,110 accessions were imported from 39 countries, which included international trial material (32,684 accessions). Promising introductions were: **rice** with high yield (EC 881897-903), salinity (EC 881904-1905) and submergence tolerance (EC 881906 and EC 887557) from the Philippines; **maize** with red coloured cob (PI 550473 and PI 558532) with genes *Vip3Aa20*, *Cry2A.127* (Mod E) and *Cry1A.88* (EC 866742-69) from the USA, varieties protected by US Patent for use in new line development (EC 881923-2007) from the USA; **wheat** with heat tolerance (EC 870177-247) from the USA; **oilpalm** with rich carotene, drought tolerance, low free fatty acid (EC 869395-414) from Malaysia; **cotton** with high yield, high ginning outturn, big bolls, short-duration varieties (EC 881780-2431) from the USA; **cabbage** with red, purple, pickling, drum-headed types (EC 889990- 90015) from the UK; **tomato** wild species (EC 870961-1137, EC 879895-905) from the USA; **mango** rootstocks (EC 890387-9) from Israel; **grapes** promising hybrids (EC 873363-75) from the USA; **eucalyptus** wild species (EC 881243-50) from Israel; **sesbania** wild species (EC 882381-97) from Ethiopia; **orchard grass** with late maturity, excellent forage quality and increased winter tolerance (EC 871140) from the USA; **coffee** hybrids with large beans, drought and rust resistance (EC 884110, 14 and 16) from the USA.

(a) (b) (c)

Variability (a) in fruits of snake-gourd; (b) panicles of sorghum; (c) fruits of kalingada

A total of 18,601 accessions characterized and evaluated were of wheat and rice for terminal heat and drought tolerance; 4,163 accessions were supplied for research and crop improvement within the country. Phytochemical characterization enabled identification of promising genotypes such as three varieties of ricebean [Palam Rajmung l; RBHP 43 rich in protein

Rice genotypes tolerant to biotic and abiotic stresses

Stress	Resistant/moderately resistant accessions
Abiotic	
Heat	DRRH 106, DRRH 107, IET 24075, Somali, IET 23979, IET 24082
Drought	IET 25108, IET 24679, Narendra 97, IET 25134, IET 25141, IET 25104
Cold (seedling stage)	RP 5434 RAU 26-4, RP 5433 RAU 27-17 and RP 5433 RAU-19-2
Salinity	IET 23216, Somali, IR 8-2635 B-B 347-1, IET 24674
Biotic	
Leaf blast	IC 211168, Punshi, Moirang-Phou-khokngangbi, Thangjing-Phou
Brown spot	IC 211168, IC 217196
Sheath blight	SM 801, Ngonolasha, Wazuho Phek, Gumdhan, BG 380-2, RP 2068-18-3-5, Phougak, Thangmoi
Brown plant hopper	PTB 33, RP 2068, T 12, IC 216750
Root-knot nematode	LD 24, Khao Pahk Maw
Gall midge	RP 5588 B-B-B- 32, Aganni
White-backed plant hopper	AC 34222, AC 34264, AC 38468, AC 42425

Promising wheat genotypes identified for different value-added products

Product	Genotype
Chapati (>8.0/10.0)	K 1317, HI 1605, HD 2888, C 306, K 8027, MACS 6478, HD 2932, NIAW 1415
Bread (>575ml loaf volume)	HI 1605, MACS 6222, MACS 6478, HD 2932, Raj 4083, NI 5439, NIAW 1415, DBW 93
Biscuit (>10 spread factor)	HS 490
Pasta (>7.0/9.0)	HI 8759, MACS 3949, MPO 1215, UAS 446
Extraction rate (%)	K 1317, HI 1605, HD 2888, C 306, K 8027, NI 5439, NIAW 1415

Registered germplasm

Crop	National identity	INGR No	Novel unique features
Rice*(Oryza sativa)*	IC0390780	15037	Spikelets with long sterile glumes. Length of sterile glume is as long as lema length
	IC0390772	15038	Clustered spiklets 2-10
	IC0617119	16001	Resistance for brown plant hopper (BPH) and white-backed plant hopper (WBPH) at vegetative and reproductive stages
Wheat (*Triticum aestivum*)	IC0616061	15039	Karnal bunt resistance
	IC0616062	15040	Karnal bunt resistance with high 1000-grain weight
	IC0616063	15041	Karnal bunt resistance with high number of tillers/m
	IC0616064	15042	Karnal bunt resistance with high number of grains/spike
	IC0616065	15043	Karnal bunt resistance
	IC0616066	15044	Karnal bunt resistance with high number of tillers/m
	IC0616067	15045	Karnal bunt resistance with high 1000-grain weight
	IC0616571	15046	Leaf and stripe rust resistance. Carries *Lr57* and *Yr40* genes; transferred from *Ae. geniculata* acc. pau 3547
	IC0616573	15047	Leaf and stripe rust resistance. Carries new genes *LrU* and *YrU* from *Ae. umbellulata* accession 3732
	IC0616574	15048	Leaf and stripe rust resistance. Carries new leaf and stripe rust resistance genes from *Ae. peregrina* accession 3519
	IC0617118	15049	Leaf and stripe rust resistance. Leaf rust and stripe rust resistance(APR) genes introgressed from wild 'A' genome species into wheat cv. WL711
	IC0616575	15050	Leaf and stripe rust resistance. Carries new leaf and stripe rust resistance genes from *Ae. caudata*
	IC0616577	15051	Leaf and stripe rust resistance. Carries *Lr57* and *Yr40* genes; transferred from *Ae. geniculata* acc. pau 3547
	IC0616578	15052	Leaf and stripe rust resistance
	IC0611477	15060	Resistance for leaf blight
	IC0611476	16013	Resistance for leaf blight
Barley (*Hordeum vulgare)*	IC0616068	15053	High beta glucan content in grains
	IC06160298	15054	Combination of high 1000 grain weight and high protein
Guinea grass (*Megathyrsus maximus*)	IC0616375	15055	Rare self-compatible plant with obligate sexual mode of reproduction
Lentil (*Lens culinaris*)	IC0616579	15056	High grain iron and zinc; 136.91 and71.69 mg/kg respectively
Chilli (*Capsicum annuum*)	IC0615423	15057	Tallest in land/pot; pungent-PPM-red 18300, green 17300; high yield
Indian mustard (*Brassica juncea*)	IC0511389	15058	Salinity tolerant up to Eciw 12 dS/m, high level of alkalinity tolerance, up to *p*H 9.4
	IC0598624	15066	Drought tolerance (high water-use efficiency under rainfed conditions)
Potato (*Solanum tuberosum*)	IC0616582	15059	Suitable for cold chipping; resistant to cold- induced sweetening
	IC0616580	16022	A photo-insensitive hybrid with high resistance to late blight
	IC0616581	16023	High resistance to late blight; low cold-induced sweetening (6 months cold storage)
	IC0618556	16010	Multicolour chips; tuber flesh multicoloured
Cotton(*Gossypium* spp.)	IC0617407	15061	This genetic male sterile line produces 50 % male fertile and 50 % male sterile plants. Petals are cream in colour and anther colour is yellow with spot
	IC0610389	15062	Genetic male sterility: produces 50 % male fertile and 50 % male sterile plants; leaves are okra type; petal colour is yellow, anther colour is cream; and has good fibre quality
	IC0618569	16005	Tallest and perennial
Sorghum (*Sorghum bicolor*)	IC0612149 & IC0612150	15063	MS line with bold seed
	IC0612157 & IC0612158	15064	MS line with compact head
Kidney bean (*Phaseolus vulgaris*)	IC0341862	15065	Resistance for anthracnose
Barley(*Hordeum vulgare*)	IC0617170	16002	Two -row malt barley immune/ highly resistant to yellow rust
	IC0617171	16003	Six-row feed barley immune to yellow rust
Pearl millet (*Pennisetum glaucum*)	IC0617290	16004	High iron content (91 mg/kg) and zinc content (78 mg/kg)
Onion(*Allium cepa*)	IC0616539	16006	Early multiplier; suitable for both *rabi* and *kharif*; early maturity with six uniform bulblets/bulb
Safflower (*Carthamus tinctorius*)	IC0618568	16007	Non-spiny marker-linked genetic male sterility
Sugarcane *(Saccharum* spp.)	IC0618560	16008	Resistance for whip smut
	IC0618562	16009	Resistance for whip smut
Sweet bamboo/Asper bamboo (*Bambusa* spp.)	IC0618554	16011	Tolerance to waterlogged conditions

Crop	National identity	INGR No	Novel unique features
Malla Bamboo (*Bambusa vulgaris*)	IC0618555	16012	Tolerance to waterlogging
Fingermillet (*Eleusine coracana)*	IC0614156	16014	High calcium content (452.8 mg/100g)
Cauliflower (*Brassica oleracea* var. botrytis)	IC0614417	16015	Cytoplasmic male sterility (CMS); good seed yield; cream-coloured flowers
	IC0614418	16016	Maintainer line
	IC0614419	16017	Cytoplasmic male sterility (CMS); cream-coloured flowers
	IC0614420	16018	Maintainer line
Groundnut	IC0616376	16019	Spanish bunch with extra-large kernels
Lemon grass (*Cymbopogon citratus*)	IC0619026	16020	High herbage yield with high essential oil content
Java citronella (*Cymbopogon winterianus*)	IC0619027	16021	High herbage yield with high essential oil content

(19.1%) and low tannin (595mg/100g)]; kalingada [GK2; SKNK1102 with high seed protein (51.5%)] and fababean (HFBl, HB82, high-yielding and fertilizer-responsive).

Germplasm registration: A total of 53 proposals comprising cereals and pesudocereals (23), millets (4), grain-legumes (2), fibres and forages (4), vegetables (10), oilseeds (4), commercial crops (2), medicinal and aromatic plants and spices (2) and agroforestry species (2) were approved for germplasm registration.

Germplasm evaluation: ***Cereals:*** A total of 472 rice genotypes/lines were identified as moderately resistant to resistant against different biotic and abiotic stresses. Some of the the important donor accessions for different traits are in table p. 22.

Useful donor accessions for various value-added traits in wheat were also identified (Table, p. 22).

Oilseeds: *Groundnut:* Eight advanced breeding lines— ICGVs' 07268, 02206, 00387, 97058, 03056, 07223, NRCGCS 363, RG 595; four interspecific derivatives, VGs 0411, 0502, 0507 and 1012; and one released variety GPBD 4 exhibited resistance (<10% incidence) to stem-rot disease at harvest. Fatty acid profile of accessions (n=113) was studied using GCMS. The oleic acid (O) content was in the range of 38.1%-65.6% with an average of 49.2% and linoleic acid (L) was 15.1%-38.5% with an average of 28.8%. The O/L ratio was between 0.99 and 4.4 with an average value of 1.88. The accessions with high O/L ratio were in Spanish bunch type—TKG 19A (3.3); in Virginia bunch type— GG 20 (4.4); and in Virginia runner type— UF 70 (4.1).

Three RILs progenies (5-8, 15-1 and 15-3) from cross GG 20 × CS 19 were found highly resistant to stem-rot disease with less than 10% mortality.

Soybean: A core set of 710 accessions was developed using 8 agro-morphological traits as variables following Principal Component Score (PCS) and Power Core method. This core set constitutes about 20.62% of 3,443 accessions.

Castor: Four castor entries, RG 43, RG 631, RG 2661 and RG 3060, were confirmed for resistance to leafhopper (hopper burn grade 0 to 1) on a 0-4 scale.

Linseed: Flax genotype JRF 4 was identified for better fibre quality based on the strength and fineness. Three temperature-tolerant lines A 98, GS 54 and GS 428 were found promising based on the stay- green colour and seed yield.

Leafhopper resistant acession of castor, RG 3060

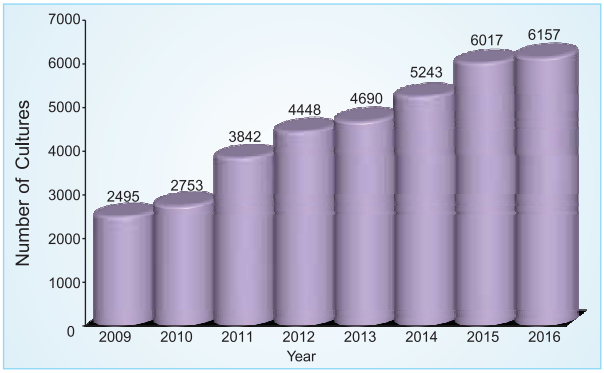
Bradyrhizobial cultures from root nodules of drought- tolerant soybean

Five bradyrhizobial cultures were obtained from the root nodules of drought- tolerant soybean varieties and characterized based on the fatty acid methyl ester (FAME) profile and 16 S rRNA gene sequence; and were identified through NCBI BLAST.

Scientific name	Genbank accession number/MTCC number	Source
B. daqingense	KX230052	Soybean variety PK 472
B. liaoningense	KX230053	Soybean variety Cat 2911
B. liaoningense	KX230054	Soybean variety PK 472
B. japonicum	MTCC-10751	Soybean rhizosphere soil
B. liaoningense	MTCC-10753	Soybean rhizosphere soil

Agriculturally important microbial cultures

The national collection holds 6,157 microbial accessions, which include 2,200 bacteria; 3,729 fungi and 228 cyanobacteria. A total of 328 microbial cultures were preserved in a long-term storage during the year.



Microbial cultures at NAIMCC

Among bacteria, conserved biofertilizer and plant-growth promoting strains of *Rhizobium* (1), *Bacillus* spp. (41), *Pseudomonas* spp. (4), *Paenibacillus* spp. (1) and *Enterobacter* spp. (4); plant-pathogenic bacterial strains (10) like *Ralstonia* spp. (6) and *Xanthomonas* spp. (4); and many other bacterial strains like *Citrobacter* spp., *Holorubrum* spp., *Achromobacter* spp. were preserved in the culture collection. Nitrogen-fixing cyanobacteria (103) predominanted in North-East India, like *Nostoc* spp., *Anabaena* spp., *Westelliopsis* spp., *Scytonema,* and many others were accessioned and conserved in the culture collection. During the year 2015–16, NAIMCC supplied 189 cultures of bacteria and fungi to different organizations, including private firms for research purposes.

Horticulture

Fruit crops: Eight 'Appemedi' (whole pickle mango variety) and two table varieties of mango were collected for their aroma, good quality pickle and easy removal of stone from fruit. Besides, four mango accessions were added in field gene bank. Fifteen farmers' varieties of mango were identified and collected from Malihabad, Uttar Pradesh and adjoining areas. Twenty-eight guava germplasm consisting of two guava cultivars and one *Psidium* species were augmented in field gene bank. Two wild species of *Vitis* were located in Himachal Pradesh for further observation and assessing their potential as sources of desirable traits. Thirteen grape accessions for source of disease resistance and berry characters were imported from USDA, USA for augmenting the germplasm base and further strengthening the breeding programme on yield, quality and resistance. Litchi germplasms namely, Piyazi, Pickling, Early Bedana, Pant Selection, Ajhauli, Indira Sel-2, Hongkong, Dam Dam, Ambika Litchi-1, Bombay Selection, Pantnagar-1 and Rose Scented, were collected.

Fourteen germplasm accessions of banana were collected from western parts of Meghalaya (Tura and William Nagar districts). Five genotypes of pomegranate were screened for their tolerance to soil salinity. Sodium chloride treatment @ 160 milli moles resulted in reduction in growth of above ground biomass in all the five germplasm. The minimum growth reduction was recorded in IC 318707 (1.57%), followed by IC 318706 (8.50%) as compared to Bhagwa (24.00%). Hence, IC 318707 is identified as salinity tolerant rootstock. Three germplasm accessions of date palm from ICARDA, Jordan, and 144 plants of date palm cv. Medjool as a diplomatic gift to the Honourable President of India from State of Palestine were received and conserved. In addition, 25 accessions of Manila tamarind (*Pithecellobium dulce*), four accessions of mulberry (*Morus* sp.), 25 accessions of phalsa (*Grevia subinaequalis*) were collected and added to the field gene bank. Four apple cultivars, viz. Gala Red Lum, Super Chief, Golden Delicious Reindeers and Red Velox were imported from Italy. The promising apple rootstocks, viz. M-9 T337, M9 T339, Pajam-1, M-27, p-22, MM111 MM-AAA and MM-106 were imported.

Vegetable crops: During the exploration conducted in Nagaland, 176 accessions of vegetables, wild relatives of crop plants and land races belonging to 40 taxa and including some unique collections like, *Abelmoschus tetraphyllus* var. *Pungens* and *Momordica subangulata* subsp. *Subangulata* were collected. In addition, a total of 395 germplasm accessions in 16 vegetable crops were collected from diverse sources. These are brinjal (64), tomato (102), chilli (11), pointed gourd (11), cowpea (3), radish (3), garden pea (8), okra (12), cauliflower (2), carrot (2), sponge gourd (4), basella (48), amaranth (110), bitter gourd (10), bottle gourd (4) and quinoa (1).

Twenty *Allium* germplasm lines were collected from North-East region and Kullu region. Similarly, 24 garlic local varieties were collected from Tamil Nadu, Mandsore etc. and added in garlic germplasm stock for initial evaluation.

Plantation crops: A total of 17 trait-specific coconut accessions, 16 from Car Nicobar Island and one from South Andaman, for specific traits, viz. dwarfness, large fruit size, high copra, robust stem, high nut production, fruit colour, soft-cum-easy peel husk, sweet kernel and high tender nut water content were collected. A total of five distinct areca nut accessions, three from Karnataka and one dwarf accession and a wild type from Andaman and Nicobar Islands were collected. Twenty oil palm germplasm accessions were imported from Malaysia. The performance of germplasm was evaluated by MPOB, Malaysia and 10 *dura* types from Sierra Leone and 10 from Senegal were selected based on individual palm performance. The screened accessions were imported to India. These germplasm were exchanged with *dura* types of Guinea Bissau and Zambia available in India.

Tuber crops: A total of 34 germplasm accessions of tuber crops were collected from Karnataka, Rajasthan, Kerala and West Bengal. They were 6 accessions of sweer potato, 8 of greater yam, 3 of lesser yam, 1 of potato yam, 7 of taro, 4 of elephant-foot yam and 2 of tannia (*Alocasia macrorhizus*).

Ornamental crops: A total of 59 germplasm

accessions of orchids, 8 of anthurium, 14 of daffodils, 3 of alstromeria and 5 of asparagus were collected.

Medicinal and aromatic plants: In all, 259 germplasm accessions of medicinal and aromatic plants comprising aloe, *Aloe barbadensis* (34); kalmegh, *Andrographis paniculata* (66); safed musli, *Chlorophytum borivilianum* (4); lemon grass, *Cymbopogon flexuosus* (33) and ashwagandha, *Withania sommnifera* (122) were collected.

Spices: A total of 193 *Piper* accessions including 134 cultivars and 59 wild types were collected. Eighteen accessions of nutmeg were collected. These unique collections include high-yielding types, bold nut type, thick and entire mace types, monoecious types, erect growing types and clusters-bearing fruits.

Mushrooms: About 365 collections were made and 206 specimens deposited in the Gene Bank with passport data and a total of 165 specimens have been assigned accession numbers.

Livestock

Livestock information system: The Geographical Information System (GIS) on Animal Genetic Resources (AnGR) of India was developed as a stand alone package on MS-Windows based computer. A user can extract and highlight habitats of selected breeds on map. There is option of extracting one or more states in the map of India. Animal genetic resources can be classified and displayed on the basis of values of traits such as body length, heart girth, etc. The maps along with legend can be saved as PDF or image files. The figure displays a saved image of habitats of buffalo genetic resources. Nine new breeds of indigenous livestock and poultry were registered, taking the total number of breeds to 160.

Phenotypic characterization

Kaunayen chicken: Kaunayen chickens of Manipur are distributed in whole of the Imphal valley comprising Thoubal, Imphal west, Imphal east and Bishnupur districts of Manipur. These birds have elongated body with long neck and long legs. The predominant plumage colour is black followed by brown (or red). Comb is mainly red and pea type. Neck, breast and thighs are generally bare, hard and rose red in fighting cocks. Spur is long and sharp in cocks. Shank is yellow, sometimes grayish. Broodiness is usual. Body weight of an adult cock ranges from 2.4 to 3.8 kg and that of an adult hen from 1.0 to 2.9 kg. Annual egg production is around 35 eggs/ year. A hen produces about 10-12 eggs in a laying period of 10-15 days. Kaunayen birds are reared in the backyard-free range system and are used mainly for game (fighting) purpose.


Kaunayen chicken

Donkeys: Donkeys in Andhra Pradesh are predominantly distributed in Prakasam, Guntur, Kurnool and Anathapur districts. Their coat is generally of light brown to brown. The bellies of the brown type animals are lighter than the dorsal aspect of the body. Some animals have white markings around muzzle and eyes. The eyes are black. The dorsal cross is present in all brown type animals which extends backwards as dorsal line in majority of the animals. The mean height at wither of brown type male and female donkeys is 94.12 ± 4.8 and 89.82 ± 3.36 cm and the body length are 91.21 ± 5.27 and 88.36 ± 3.36 cm respectively. The male and female animals of brown type donkeys of Andhra Pradesh showed significant differences in most of the biometric parameters. These animals are mainly used as pack animals.


Donkey from Andhra Pradesh

Genetic characterization

Kajali sheep: In genetic diversity analysis of Kajali sheep, 140 distinct alleles were identified across 18 markers. A set of 24 microsatellite markers was used for genetic diversity analysis of Kajali sheep. The estimates of allele diversity and gene diversity indicated the presence of substantial amounts of genetic variability in Kajali sheep population. Phylogenetic study revealed that the Kajali sheep is clustering in the same node with Munjal sheep, another mutton type sheep in the near vicinity. However, Kajali and Munjal sheep were phenotypically distinct from each other.

Sikkim goat: Genetic characterisation of Sikkim goat revealed higher observed number of alleles than the effective number of alleles across all the loci. All microsatellites were polymorphic and 203 alleles were detected across these loci. The average observed heterozygosity was lesser than expected heterozygosity. The lower heterozygosity pointed towards lower genetic diversity in the population. There was no recent bottleneck in the existing Sikkim population. Within Sikkim goat population, Singharey and Sikkim black goat sub-populations showed similar genetic trends. To explore the possibility of differentiation between Sikkim black and Singharey goats, the multi-locus FST value of breed differentiation was only 3.6% of the total genetic variation.


Sikkim goat

Kaunayen chicken: Genetic characterization of Kaunayen chicken found in Manipur was carried out. Genotype data on 24 microsatellite loci, distributed ubiquitously revealed that mean number of alleles observed in Kaunayen chicken were 8.83±0.64 and ranged between 4 (MCW250 and LEI174) and 15 (LEI120). Phylogenetic analysis revealed that the Kaunayen chicken is a distinct population with respect to other poultry breeds of India, the closest was Red Jungle fowl.

Ladakhi cattle: Complete D loop sequence of mitochondrial DNA (mtDNA) was characterized in 50 Ladakhi cattle and 15 haplotypes were observed with haplotypic diversity of 0.942 ± 0.00186. No significant deviations from neutrality were identified in the observed haplotypes. The haplotypes identified in Ladakhi cattle were compared with other native cattle breeds. A total of 110 polymorphic sites were detected in D-loop region across 21 native cattle breeds. The haplotypic diversity values ranged from 0.837 in Sahiwal to 1.00 in Deoni. No significant deviations from neutrality were identified in these haplotypes. Other than Sahiwal and Umblachery, all the breeds showed more than 10 haplotypes. In terms of nucleotide diversity, Ongole, Kangyam, Khillar, Amritmahal and Umbalcherry breeds showed higher values.

Ex situ conservation

Epididymal sperm banking was initiated at National GeneBank of the Institute through cryopreserving the caprine and ovine epididymal sperms. Six thousand frozen semen doses of cattle (Hariana and Sahiwal) were procured during this year. The National Gene Bank now has 135,174 frozen semen doses belonging to 44 breeds of 7 species (cattle, buffalo, goat, sheep, camel, equine and yak).

Cattle

The differential expressions of interferon stimulated genes [2-5 oligoadenylate synthetase 1 (OAS1), Myxovirus resistance gene 1 (MX1) and 2(MX2), and interferon-stimulated gene 15 kDa protein (ISG15)] were evaluated at 18th day post AI in peripheral blood mononuclear cells. In the nulliparous pregnant animals, the expression of OAS1, ISG15, MX2 and MX1 was higher than the non-pregnant animals. However, pregnant and non-pregnant multiparous cows showed similar expression of interferon stimulated genes on day 18 post AI.

An RT LAMP assay based bovine HSP70 gene profiling was developed as an alternative to quantitative assay.

Poultry

Genomic profiles of chicken lines: The bone morphogenetic protein 3 (BMP3) and BMP4 genes were analysed in control broiler (CB) and control layer (CL) chicken to determine polymorphism in the promoters. The haplogroups of the BMP3 promoter showed significant effect on body weights at 28th and 42nd day of age.

Expression of troponin C type 1 (TNNC1) and myoglobin (Mb) were explored in different tissues in Indian native chicken breeds. The TNNC1 was predominantly expressed only in muscle and heart, whereas expression of Mb was observed in gizzard, heart and muscle tissues. At day 1st and 28th day, Mb was highly expressed in gizzard and heart followed by muscle as compared to bursa. In muscle tissue, at 28th day expression of Mb was 9-fold higher than that of day-old age. Among all the tissues, Mb was found expressed at the highest magnitude in gizzard — 80 folds higher expression at day-old age in Ghagus breed as compared to Aseel breed of chicken. Expression of TNNC1 was higher in heart, spleen and muscle at day-old age, whereas at day 28th, heart and muscle showed the higher expression. In spleen, at day-old age, expression of TNNC1 was 19 folds

Characterization of Arunachali yak: Animal Genetic Resources of India

Yaks are reared at 3,000-5,000 m above mean sea level in trans-Himalayan region of Ladakh, Arunachal Pradesh, Sikkim, Himachal Pradesh, West Bengal and Uttarakhand of India. Although Indian yaks are sparsely characterized at phenotypic level, no systemic documentation has been done to demonstrate the population of yaks as breed. Based on the available information, yak found in Arunachal Pradesh are the most pure and unique in the world. Present study systematically documented phenotypic characteristics of Aruanchali yaks, which are reared under semi-migratory system and 85% of yaks are black. Lactating females are producing on an average 1.3 kg milk/day which is primarily used to prepare products due to high fat (8.0%) percentage. The first calving for Arunachali yak is observed at the age of 43-45 months. Although yak milk and wool products are treated as valuable entity for its uniqueness, however, decreasing population trend of yak is of serious concern. The yak, which is recognized as one of the critical and endangered mountain species, needs urgent attention for *in situ* and *ex situ* conservation as well as breed characterization.

higher than that of 28th day of age across the breeds. At 28th day of age, 4 folds higher expression of TNNC1 in muscle was noticed in Aseel breed as compared to Ghagus breed. On 1st and 28th day, higher expression was found in heart tissue in Aseel compared to Ghagus. It is concluded that the expression of TNNC1 and MB genes varied between breeds and expressed differentially in the tissues within the native chicken breed.

Mithun

Muscle transcriptome analysis: To identify the genes associated with muscle growth potential, the transcriptome of *Longissimus* muscle from two divergent lines, having differential growth rates, viz. high and low, was analysed. The muscle transcriptome analysis revealed 297 differentially expressed genes and among them 173 and 124 were up-regulated and down-regulated unigenes, respectively.

Yak

Identification of fertility related spermatozoa miRNA: Expression profiling of sperm and testis miRNA are hypothesised as fertility indicator to dissect fertile and subfertile yak spermatozoa. Out of 20 male fertility related miRNAs in other species, a few miRNA were found differentially expressed in yak sperm. The findings may be used as a non-invasive and a quantifiable measure to assess reproductive competency in yak bulls and may be used in conjunction with current predictors of semen quality for investigation of fertility in yak bulls. The Amelogenin Gene was identified as sex determination marker in yak. Distinct and specific product size of 279bp in both male and female yaks, with an additional 216bp amplicon were identified in yak with a single primer. Validation of the test was done by qPCR for quantifying the DNA copy number of the *Amelogenin* gene in male and female genomic DNA. In addition, the obtained sequences of *AMELX* and *AMELY* showed an unexpected high level of polymorphism.

Conservation

Lines/varieties of Japanese quails namely, CARI Uttam, CARI Ujjawal, CARI Pearl, CARI Sweta, CARI Suneheri, CARI Brown, Cross Line and Control Line were conserved.

Fish

Discovery of new fish species: ICAR-CMFRI described a new species of mackerel, *Scomber indicus* (Indian chub mackerel) from the coastal waters of India. The new species is different from other members of the mackerel family both morphologically and genetically. The species was first found along Gujarat coast in 2015, later it appeared all along the west coast of India up to Kanyakumari. Since July 2016, shoals of juveniles of the species were caught along Kerala coast, indicating that a viable population of this species is getting established in the region.


Scomber indicus


Barilius torsie


Rita bakalu

Barilius torsie (Cyprinidae: Rasborinae) was recorded from river Torsa of Brahmaputra drainage system, and *Rita bakalu* (Siluriformes: Bagridae) from the Godavari river basin.

New records of deep-sea fishes: Three new fish specimens were caught from Kollam, southwest coast of India as by-catch of deep-sea fishing. They were confirmed as *Chlorophthalmus acutifrons* (Hiyama, 1940), *Psenes arafurensis* (Günther, 1889) and *Psenes cyanophrys* (Valenciennes, 1833). The morphometric and meristic characters of these specimens


Chlorophthalmus acutifrons


Psenes arafurensis


P. cyanophrys

Whole mitochondrial genome of important food fishes

Indian featherback, *Chitala chitala* (Osteoglossiformes); hilsa shad, *Tenualosa ilisha* (Clupeiformes) and *Systomus sarana sarana* (Cypriniformes) are important food fishes as well as capture fishery resources of India. Among these *C. chitala*, is endangered and considered important for aquaculture as well. To resolve taxonomic uncertainties, the mitochondrial genomes of these three species were sequenced, assembled and annotated. The sizes of mitochondrial genomes ranged from 16.5-16.7 kb; and structural composition comprised 37 genes including 13 protein coding, 22 tRNA and 2 ribosomal RNAs (12S rRNA and 16S rRNA). The availability of mitochondrial genomes will be useful resource for molecular systematics, biogeography as well as comparative genomics.

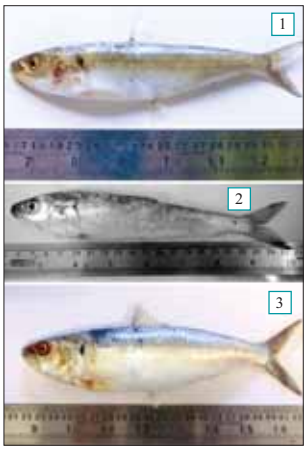

Chitla chitla


Tenuslosa ilisha


Systomus sarna sarna

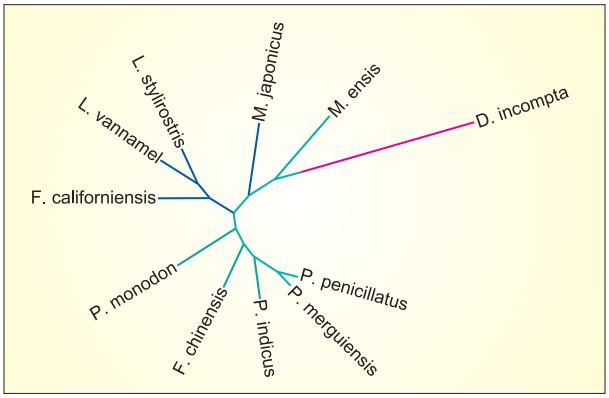
agree with the taxonomic descriptions and COI comparison with BOLD and GenBank databases. The generated COI sequences were submitted to GenBank (KJ020210-KJ020214, KJ020215-KJ020217).

Morphotypes in Indian oil sardine: Indian oil sardine, *Sardinella longiceps* shows divergent morphology while in sympatry and reasons for morphological divergence were investigated using morphometric, genetic and nutritional analysis. Based on visual appearance there are three variants. Variant 1 and 2 were collected from Kozhikode and termed as stout (normal) and slender sardines, respectively. Variant 1 had more fat content compared to variant 2, indicating differences in habitat/niche use and consequent differences in dietary preference. Variant 3, available only from Gulf of Oman was termed as Oman sardine. They were heavier with greater body depth indicating presence of greater energy reserves and a good condition factor. Morphotypes of Indian oil sardine are the result of divergent selection and adaptive variation to maximize fitness to a particular habitat and thus optimize habitat use. Whole mitogenome scans in Indian oil sardine from different locations also ascertained the above conclusions.



Genome size of commercially important and endangered freshwater fish species: Genomic DNA content and ploidy level in blood cells of 52 economically important freshwater fishes were estimated. The average genome size ranged from 0.58±0.03 pg in banded gourami (*Trichogaster fasciata*) to 1.92±0.04 pg in scribbled goby (*Awaous grammepomus*). Among the Order DNA content ranged from 0.64±0.07 to 1.45±0.073 pg in Cypriniformes, 0.70±0.07 to 1.41±0.02 pg in Siluriformes and 0.60±0.05 to 1.92±0.04 pg in Perciformes. The nuclear DNA content exhibited variations within and between the Orders. Further, no relationship was observed between the genome size, chromosome number and organism complexity among the 52 species. New records of nuclear DNA content of 44 species were also generated.

Phylogenetic analysis among penaeid shrimps: Mitochondrial DNA genes were explored to study the phylogenetic relationships among the penaeid shrimps. Phylogenetic relationships expose evolutionary paths and speciation events for a particular species. Full



Dendogram depicting phylogenetic relationship among penaeid shrimps

mitogenome of *Penaeus indicus* has the same 13 protein-coding genes like other penaeid shrimps. The 13 protein-coding nucleotide sequences of 10 penaeid shrimp mitogenomes (*Metapenaeus ensis, M. japonicus, Litopenaeus stylirostris, L. vannamei, Felimare californiensis, Penaeus monodon, Fenneropenaeus chinensis, Penaeus indicus, P. merguiensis, P. penicillatus*) as well as that of *Drosophila incompta* (KM275233.1, outgroup) were extracted. Individual gene sequences of all species were aligned separately and then concatenated to generate a consensus sequence of 11,237 bp. A phylogenetic tree was constructed using maximum likelihood method with 500 bootstrap replicates.

❑

5. Crop Improvement

Cereals

One hundred-and-fifty-five high-yielding varieties/ hybrids of cereals comprising 68 of rice, 18 of wheat, 27 of maize, 17 of pearl millet, 10 of sorghum, 4 each of fingermillet and little millet, 3 of barley, 2 each of oat and kodo millet were released for cultivation in different agro-ecologies of the country during 2016.

DRR Dhan 45 (IET 23832) high zinc rice variety : It is the first zinc-rich rice variety released and notified, and has been recommended for Tamil Nadu, Andhra Pradesh, Telangana and Karnataka under irrigated ecologies. Its zinc content in polished rice is 22 ppm, and its mean yield is 5.2 tonnes/ha.

High zinc rice variety DRR Dhan 45

Released rice varieties/hybrids

Rice Variety	Area of adoption	Salient features
Pusa Basmati 1609	Delhi, Uttarakhand, Punjab and western Uttar Pradesh	Moderately resistant to leaf blast, neck blast
Birsa Vikas Sugandha1	Jharkhand	Moderately resistant to blast, brown spot, stem borer
Pant Dhan 24	Odisha, Bihar	Long slender grains;moderately resistant to gall midge biotype-1, stem borer, brown spot
Kalachampa	Odisha	
KPH460 (IET 22938)	Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Gujarat	Medium slender grains; resistant to leaf blast
Nua Acharamati	Odisha	Short bold grains; resistant to brown plant hopper, leaf folder, moderately resistant to gall midge, sheath blight, whorl maggot, leaf blast, sheath rot, rice tungro virus, bacterial leaf blight, brown spot
Hiranmayee (OR 2329-44)	Odisha	Medium slender grains; resistant to leaf folder,moderately resistant to gall midge, stem borer, whorl maggot, leaf blast, sheath rot, rice tungro virus, bacterial leaf blight, brown spot
Tanmayee (2339-8)	Odisha	Medium bold grains; resistant to leaf blast, moderately resistant to gall midge, stem borer, leaf folder, whorl maggot, sheath blight, rice tungro virus, bacterial leaf blight
DRR Dhan 44 (IET 22081)	Uttarakhand, Haryana, Bihar	Long slender grains; resistant to leaf blast, moderately resistant to bacterial blight, brown plant hopper, white- backed plant hopper
DRR Dhan 43	Tamil Nadu, Puducherry, Kerala, Karnataka	Long bold grains; resistant to leaf blast, moderately resistant to sheath rot, brown spot, neck blast, brown plant hopper
ADV 8301	Gujarat, Maharashtra, Andhra Pradesh, Tamil Nadu	Medium slender grains

Rice Variety	Area of adoption	Salient features
Pant Basmati 2	Punjab, Haryana, Uttarakhand and Uttar Pradesh	Moderately resistant to bacterial leaf blight, brown spot, sheath blight, leaf blast
Pant Basmati 1	Delhi, Uttarakhand and Uttar Pradesh	Moderately resistant to leaf blast
DRR Dhan 45	Tamil Nadu, Karnataka and Andhra Pradesh	High zinc; long slender grains; moderately resistant to leaf blast
CR Dhan 310	Odisha, Madhya Pradesh and Uttar Pradesh	High protein variety with medium slender grains
Ajit	Uttarakhand, Maharashtra and Tamil Nadu	Medium slender grains; moderately resistant to neck blast, leaf blast, rice tungro disease, sheath rot, brown spot
KRH 4 (Hybrid 4 Karnataka Rice)	Karnataka, Gujarat and Maharashtra	Good milling, cooking and puffing
PR 121 (RYT 3240)	Punjab	Long slender and translucent grains; resistant to all 10 pathotypes of bacterial leaf blight prevalent in Punjab
PR 122 (RYT 3129)	Punjab	Long slender and translucent grains; resistant to all 10 pathotypes of bacterial blight prevalent in Punjab
PR 123 (PAU 3842)	Punjab	Long slender and translucent grains; resistant to all 10 pathotypes of bacterial blight prevalent in Punjab
GNR 3	Gujarat	Resistant to bacterial leaf blight, leaf blast, false smut, moderately resistant to stem borer, leaf folder
CR Dhan 101 (Ankit)	Odisha	Moderately resistant to leaf blast, neck blast, sheath blight, brown spot, stem borer, leaf folder, green leaf hopper
CR Dhan 203 (Sachala)	Odisha	Moderately resistant to leaf blast, sheath rot, brown spot, stem borer, leaf folder
CR Dhan 206 (Gopinath)	Odisha	Moderately resistant to leaf blast, sheath rot, brown spot, stem borer, leaf blight
CR Dhan 307 (Maudamani)	Odisha	Moderately resistant to leaf blast, sheath rot, brown spot, stem borer, leaf folder
Pusa 1592	Punjab, Haryana, Delhi and Jammu and Kashmir	Resistant to bacterial leaf blight
Chhattisgarh Zinc rice 1 (CGZR1)	Chhattisgarh	High zinc variety with long grains; moderately resistant to leaf blast, neck blast, stem borer
SHIATS Dhan 4	Uttar Pradesh	Medium slender grains; moderately resistant to blast, stem borer, brown spot, rice tungro disease
SHIATS Dhan 5	Uttar Pradesh	Moderately resistant to leaf blast, brown spot, bacterial leaf blight
Chandra (MTU 1153)	Punjab, Bihar, Madhya Pradesh, Chhattisgarh, Maharashtra, Tamil Nadu, Karnataka and Kerala	Long bold grains ; resistant to false smut, moderately resistant to leaf blast, neck blast, brown spot, sheath rot, rice tungro disease, white- backed plant hopper, green leaf hopper
DRR Dhan 46	Bihar, Madhya Pradesh and Maharashtra	Long slender grains; moderately resistant to leaf blast, neck blast, brown spot, bacterial leaf blight, sheath rot, brown plant hopper, white- backed plant hopper
BNKR 3 (Sampriti)	West Bengal	Moderately resistant to leaf blast, neck blast, brown spot, bacterial leaf blight, stem borer, leaf folder

Rice Variety	Area of adoption	Salient features
Badshabhog Selection 1	Chhattisgarh	Moderately resistant to brown spot, sheath rot
Tarun bhog Selection 1	Chhattisgarh	Moderately resistant to leaf blast
Dubraj Selection 1	Chhattisgarh	Moderately resistant to leaf blast, sheath rot, bacterial leaf blight
PBNR 03-2	Maharashtra	Drought tolerant
JRH 19	Madhya Pradesh	Early maturity; medium slender grains; drought tolerant
Vishnu bhog Selection1	Chhattisgarh	Short grains, aromatic rice
Kunram Sannalu (KNM 118)	Telangana	Long slender grains, less prone to shattering and lodging;tolerant to leaf blast, neck blast
Somnath (WGL 347)	Telangana	Resistant to gall midge biotype-1, 5, leaf blast, neck blast
Telangana Sona(RNR15048)	Telangana	Medium maturity; medium slender grains
JGL 18047 (Bathukamma)	Telangana	Resistant to blast, bacterial leaf blight, brown plant hopper, green leaf hopper
Ratnagiri 5	Maharashtra	Moderately resistant to leaf blast, bacterial leaf blight
Sahayadri 5	Maharashtra	Long bold grains; moderately resistant to leaf blast, bacterial leaf blight
HKR 48 (HKR 99-60)	Haryana	Moderately resistant to bacterial leaf blight, leaf folder
Gujarat Anand Rice 3	Gujarat	Moderately resistant to leaf blast, neck blast, bacterial leaf blight, stem borer, leaf folder, white-backed plant hopper
Chinsurah Nona 1	West Bengal	Resistant to bacterial leaf blight
Punjab Basmati 3	Punjab	Long slender scented rice; tolerant to blast
GNR4	Gujarat	Moderately resistant to leaf blast, neck blast, brown spot, sheath rot, bacterial leaf blight
NK 16520 Hybrid	Uttar Pradesh, Chhattisgarh, Bihar, Jharkhand, Odisha and Telangana	Moderately resistant to leaf blast, neck blast, brown spot, sheath rot, bacterial leaf blight
JKRH 3333 Hybrid	West Bengal, Bihar, Chhattisgarh, Gujarat and Andhra Pradesh	Direct seeded aerobic hybrid; medium slender grains
Swarna Shreya	Chhattisgarh, Madhya Pradesh and Bihar	Tolerant to water scarcity
KPH 272 Hybrid	Telangana, Karnataka and Tamil Nadu	Resistant to leaf blast.
TM 07278	Bihar and Odisha	Moderately resistant to leaf blast, neck blast, rice tungro disease, stem borer, leaf folder
KPH 467 Hybrid	Chhattisgarh, Madhya Pradesh and Maharashtra	Moderately resistant to leaf blast
Pusa Basmati 1637	Punjab, Haryana, Jammu, Uttarakhand and Uttar Pradesh	Long slender grains, strong aroma; resistant to blight
Pusa Basmati 1728	Punjab, Haryana, Delhi, Uttarakhand, Uttar Pradesh	Extra long slender grains, very strong aroma; resistant to bacterial blight

Rice Variety	Area of adoption	Salient features
PAC 8744	Chhattisgarh	Moderately resistant to leaf blast, brown spot, sheath rot
BS 158 (Arize Swift)	Madhya Pradesh	Moderately resistant to leaf folder
Chhattisgarh Madhuraj Dhan 55	Chhattisgarh	High zinc and low glycemic index
BNKR 3 (Sampriti)	West Bengal	Moderately resistant to leaf blast, neck blast, brown spot, bacterial leaf blight, sheath blight, leaf folder
MTU 1121 (Sri Dhruthi)	Andhra Pradesh	Resistant to blast, brown plant hopper
Bauna Kakanamak 101	Uttar Pradesh	Aromatic, semi dwarf; short slender grains
JR 767	Madhya Pradesh	Suitable for rainfed areas
CR 1009 Sub 1	Tamil Nadu	Moderately resistant to brown spot, leaf blast, brown plant hopper, white- backed plant hopper
TKM 13	Tamil Nadu	Moderately resistant to leaf folder, stem borer, leaf blast, green leaf hopper, rice tungro disease, brown spot, sheath rot
VL 7620	Uttarakhand	Cold tolerant, tolerant to leaf blast, brown spot
KPR1 (IET 23077)	Hilly Zone of Karnataka	Moderately resistant to leaf blast

Early-maturing long slender grained rice DRR Dhan 46: This is an early duration (110-115 days), high-yielding (6.5-7.0 tonnes/ha), long slender grained

Long slender grained rice DRR Dhan 46

variety for irrigated/ transplanted areas of Bihar, Madhya Pradesh and Maharashtra. It has good cooking quality and head rice recovery (65%), and showed moderate resistance to leaf blast, neck blast, brown spot, bacterial leaf blight, sheath rot, brown plant hopper and white-backed plant hopper. It can be grown under boro cultivation also.

New *Lr* gene in wheat landrace: A unique leaf-rust resistant gene *LrLWH* in LWH 2 (Local Wheat Hango 2), a bread wheat landrace, was collected from Hango, higher hills of district Kinnaur, Himachal Pradesh. Molecular mapping of 172 F_3 populations using 300 SSR revealed seven markers polymorphic to new gene. Mapping studies placed *LrLWH* in the short arm of chromosome 2D, about 6.7 cM proximal to the SSR marker *gdm35*, and *cau96* and *barc124,* mapped at 1.9 cM and 2.5 cM, respectively, distal to *LrLWH*. Six leaf-rust resistant genes *Lr2a*, *Lr2b*, *Lr2c*, *Lr15*, *Lr22* and *Lr39* are also present on 2DS chromosome at different locations than of *LrLWH*. These 2DS *Lr* genes were also evaluated against an array of leaf -rust pathotypes. *Lr39* was found resistant to all Indian leaf- rust pathotypes while *LrLWH* was susceptible to point 5R9-7 only. Based on the genomic location and phenotypic data, *LrLWH* has been concluded to be a new leaf-rust resistance gene flanked by DNA markers tightly linked to *LrLWH*, and can be utilized for selection of resistance to wheat leaf rust in wheat-lines.

Released wheat varieties/hybrids

Wheat Variety	Area of adoption	Salient features
UAS 347	Maharashtra and Karnataka	Suitable for timely sown, rainfed conditions; resistant to black and brown rusts
PBW 658	Punjab	Suitable for irrigated, late-sown conditions; resistant to stripe and leaf rust, leaf blight
Raj 4238	Madhya Pradesh, Chhattisgarh, Gujarat, Rajasthan and Uttar Pradesh (Jhansi and Chitrakoot division)	Suitable for irrigated, late-sown conditions; good for *chapati*-making

Wheat Variety	Area of adoption	Salient features
Central Wheat HS 562	Western Himalayan regions of Sikkim and hills of West Bengal and North–Eastern States	Suitable for both rainfed and irrigated, timely sown conditions; field resistance to yellow rust
Durum		
Pusa Malwi (HD 4728)	Madhya Pradesh, Chhattisgarh, Gujarat, Rajasthan and Uttar Pradesh	Suitable for irrigated, timely sown conditions; resistant to brown and stem rusts; with large grains
HD 3117	National Capital Region	Suitable for conservation agriculture under late-sown conditions; tolerant to Karnal bunt, moderately resistant to yellow rust
GW 451	Gujarat	Suitable for irrigated, timely sown conditions; resistant to brown and stem rusts
HDSCW 18	National Capital Region	Suitable for conservation agriculture under early sown conditions; resistant to brown rust, moderately resistant to yellow rust
PhuleSamadhan (NIAW 1994)	Maharashtra	Suitable for both timely and late sown irrigated conditions; resistant to brown and black rusts
MP 3382(JW 3382)	Madhya Pradesh	Timely sown, irrigated conditions; tolerant to brown and black rust;with good *chapati*- making
MPO (JW) 1255)	Madhya Pradesh	Suitable for rainfed/ restricted irrigation, timely sown conditions; suitable for pasta- making; resistant to black and brown rust
DH 114 (Him Pratham)	Himachal Pradesh (High altitude areas)	Developed through double haploid technique
PBW 660	Punjab, Haryana, Delhi, Rajasthan, western Uttar Pradesh, Jammu and Kashmir, Himachal Pradesh and Uttarakhand *tarai* region	Suitable for timely sown, rainfed conditions; resistant to yellow and brown rusts; with good *chapati*-making quality
PBW 677	Punjab	High degree of resistance to yellow and brown rusts
PBW 725	Punjab	Resistant to yellow and brown rusts
PDKV Sardar (AKAW 4210-6)	Maharashtra	Suitable for late-sown; and is early maturing
VL 953 (VL Gehun 953)	Uttarakhand (Hills and Plains)	Suitable for irrigated, organic farming conditions
UP 2784	Uttarakhand (Plains)	Resistance to leaf and stripe rust; moderately resistant to leaf blight in fields

Released barley varieties/hybrids

Barley Variety	Area of adoption	Salient features
RD 2849	Punjab, Haryana, Delhi, Rajasthan and western Uttar Pradesh, Jammu and Kashmir and Uttarakhand (*tarai* region)	Two rowed; suitable for malt purpose; resistant to yellow rust
VLB 94	Uttarakhand	Six rowed; suitable for rainfed conditions; resistant to rusts
RD 2794	Salinity conditions of Punjab, Haryana, Delhi, Rajasthan, Uttar Pradesh, Bihar, Madhya Pradesh, West Bengal, Uttarakhand (*tarai* region)	Six rowed; suitable for salinity conditions under timely sown, resistant to yellow and brown rusts

Released maize varieties/hybrids

Maize Variety	Area of adoption	Salient features
BPCH 6	All zones across the country	Early maturity; yellow, flint kernels
Palam Sankar Makka 1 (EHL 162508)	Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	Late maturity; yellow, flint kernels
KMH7 148	Punjab, Haryana, Delhi, western Uttar Pradesh for *rabi*	Late maturity; orange yellow, dent to semi dent with large kernels
Candy (KSCH333)	All maize-growing areas in *kharif*	Early maturity; yellow, juicy, flint, medium-bold kernels; stable sweetness
D 2244 (DAS-MH501)	Jammu and Kashmir, Himachal Pradesh, Uttarakhand, North East Hills, Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Madhya Pradesh, Rajasthan, Gujarat and Chhattisgarh	Early maturity, yellow orange, semi-dent kernels
Shalimar Maize Composite 5 (PS98)	Jammu and Kashmir/2013	Early maturity; white, semi-dent kernels
Shalimar Maize Comp 6 (KDM322)	Jammu and Kashmir/2013	Early maturity; yellow, dent kernels
Shalimar Maize Comp 7 (KDM72)	Jammu and Kashmir/2013	Medium maturity; yellow, semi-flint kernels
LAXMI 3636 (LTH 22)	Andhra Pradesh, Telangana, Karnataka, Maharashtra and Tamil Nadu	Late maturity; orange yellow, semi-dent kernels
BIO 9782 (BIO 237)	Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh for *rabi*	Late maturity; orange yellow, semi-dent kernels
Dragon (NMH 1247)	Punjab, Haryana, Delhi, western Uttar Pradesh for *rabi*	Late maturity; bright yellow, semi-dent, bold kernels with orange tinge
PMH (8JH 31244)	Punjab in spring	Medium maturity; yellow orange, flint kernels
HEMA (NAH 1137)	Karnataka	Late maturity, yellow orange, semi-dent kernels; resistant to *Turcicum* leaf blight (TLB), Polysora rust
Pratap Hybrid Maize 3 (PH 1974)	Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	Medium maturity; yellow, semi-dent kernels; resistant to post flowering stalk rot (FSR), moderately resistant to *Curvularia* leaf spot (CLS) and Rajasthan downy mildew (RDM)
DKC 9126 (MCH 46)	All maize-growing areas	Late maturity, yellow orange, semi-flint kernels
Palam Sankar Makka 2 (EHL161708)	Himachal Pradesh, Jammu and Kashmir, Uttarakhand and North Eastern Hill states	Medium maturity; yellow orange, flint kernels; moderately resistance to Maydis leaf blight (MLB) and TLB
Uday (DMR248)	Maharashtra	Medium maturity; yellow orange, semi-dent kernels
Pratap Makka 9 (EC3161)	Rajasthan	Medium maturity, yellow, bold, semi-dent kernels
Karimnagar Makka1 (KNMH40) 10131	Telangana	Medium maturity, orange, semi-flint kernels; resistant to TLB, CLS, RDM

Maize Variety	Area of adoption	Salient features
Gujarat Anand Yellow Maize Hy 1 (GAYMH1)(1H 0461/ GYH 0461)	Gujarat	Early maturity, orange yellow, flint kernels; resistant to Maydis leaf blight
HTMH 5106 Hybrid	Telangana	Late maturity
RJ 2020	Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh for *rabi*	Late maturity; yellow orange, flint kernels
RMH 4620 (PRO 385)	Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	Late maturity; orange yellow, semi-flint kernels
Central Maize VL Sweet Corn 1 (FSCH18)	Jammu and Kashmir, Uttarakhand, Himachal Pradesh, North Eastern hills, Delhi, Punjab, Haryana, western Uttar Pradesh, Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	Early maturity; plant sturdy, medium in height with good and green husk cover; TSS 16%
PMH 7 (JH 3956)	Punjab in spring	Early maturity; orange, flint kernels
SHIATS Makka 3 (SHIATS MS 3) (IVT DMR 117)	Uttar Pradesh	Late maturity; white, dent kernels
PMH 10 (Hybrid)	Punjab in spring	Medium maturity; orange, flint kernels

Released sorghum varieties/hybrids

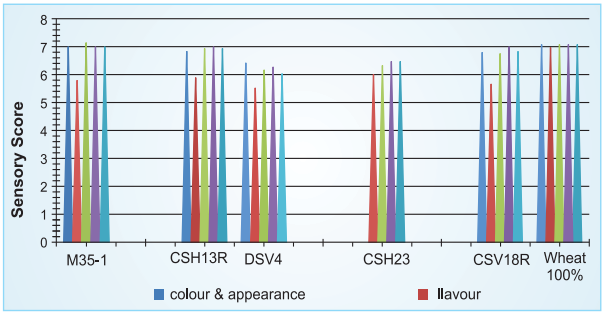
Sorghum Variety	Area of adoption	Salient features
Palamurujonna (SPV2122)	Telangana,Tamil Nadu, Rajasthan and Gujarat	Juicy stem, white-coloured mid-rib, pearly white seeds; tolerant to grain mould ,resistant to anthracnose, leaf blight
CSH 34 (HT-GS 3201) (SPH 1702)	Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Chhattisgarh Gujarat and Rajasthan	Resistant to downy mildew, escapes grain mould due to little more of maturity duration
CSH 35	Maharashtra, Karnataka, Madhya Pradesh, south Gujarat and Telangana	Non-lodging
Phule Rohini (RPASV 3)	Maharashtra	Special purpose variety for processing, especially for *papad*; tolerant to shoot fly, charcoal rot, drought
Phule Vasundhara (RSSH 50)	Maharashtra	Sweet sorghum hybrid with high green cane yield, juice yield, ethanol yield and Brix
Phule Madhur (RSSGV 46)	Maharashtra	Hurda purpose, threshable grain percentage at dough stage; better organolyptic properties; tolerant to shoot fly, charcoal rot, rust, blight
GJ 42 (SR 666-1)	Gujarat	Resistant to shoot fly, stem borer; suitable for heavy rainfall areas of Gujarat
SPH 1641	Maharashtra	Moderately tolerant to grain mould, shoot fly, stem borer
Raj Vijay Jowar 1862 (RVJ 1862)	Madhya Pradesh	Dual purpose; medium maturity with high grain yield and fodder yield
RVICSH 28	Madhya Pradesh	A high fodder-yielding sweet sorghum hybrid with 17% feed-stalk juice Brix

Interspecific crosses of maize and teosinte

Interspecific crosses (*Zea mays* × *Z. maxicana*) between maize and teosinte were made with the objective to obtain maize-plant with tillers. Interspecific crosses segregating for tillering and branching were advanced.

A teosinte-plant with twelve branches was obtained by selection and inbreeding. Efforts would be made to develop a population with this trait to improve total green fodder yield. A stay green line (SGM 14-1) was selected having physiological mature cob and plant with green foliage and stem.

Sorghum for biscuit-making: Dropping biscuits are developed with sorghum and wheat in 7:3 ratio. Formulations of sorghum flour, wheat flour of superior quality with addition of sugar, milk solids, transfree-fat, salt and natural identical flavouring substances are used for preparation of biscuits. Flour from four sorghum cultivars — M35-1, CSH13R, DSV4, CSH23— was used as substitution for wheat flour in 70:30 proportion. The biscuits were evaluated for physico-chemical and textural properties and sensory tests. CSH13R and M35-1 were found best suitable cultivars when compared with 100% wheat, as their overall score was 7.2%. The biscuits prepared with cultivars CSH13R and M35-1 were with desirable qualities; CSH13R being a hybrid offers a better choice to the industry in terms of lower cost of production, to the tune of 15-25%.



Sensory evaluation of sorghum and wheat composite biscuits

Physico-chemical and textural properties of sorghum- based composite biscuits

Cultivar	Moisture (%)	Fat (%)	Water activity	Alcoholic acidity (%)	Hard-ness	Damaged starch (%)
M35-1	10.21	2.76	0.380	0.01	1115	2.47
CSH 13 R	8.42	2.74	0.311	0.01	915	3.39
DSV 4	9.61	3.01	0.420	0.05	981	4.95
CSH 23	10.01	2.99	0.368	0.01	1095	2.41
CSV 18R	8.99	2.74	0.355	0.01	700	3.12

Released small millets varieties/hybrids

Small Millet Variety	Area of adoption	Salient features
Fingermillet		
ARJUNA (OEB 526)	Odisha, Bihar, Chhattissgarh, Karnataka, Tamil Nadu	Medium maturity (106 days), light brown grains; moderately resistant to leaf, neck and finger blast diseases
GNN6	Gujarat	Medium maturity, reddish brown seeds; moderately resistant to leaf blast, finger blast
GN5	Gujarat	Late maturing, white-coloured seeds; moderately resistant to leaf blast, finger blast
VL Mandua 348	Uttarakhand Hills	Suitable for organic cultivation; resistant to neck and finger blast, tolerant to lodging; with light copper grains.
Little Millet		
Chhattisgarh Kutki 2 (BL4)	Chhattisgarh	High iron content; tolerant to major pests
GV2	Gujarat	Medium maturing, clean white-coloured large seeds; resistant to pests and diseases
Phule Ekadashi (KOPLM 83)	Sub-montane and Ghat Zone of Maharashtra	Late maturing with non-lodging characteristics
Jawahar Kutki 4 (JK 4)	Rainfed areas of Madhya Pradesh	Suitable for sole as well as inter/mixed cropping;tolerant to drought
Kodo Millet		
Jawahar Kodo 137	Rainfed areas of Madhya Pradesh	Brown medium large seeds, suitable for sole as well as inter/mixed cropping; tolerant to drought, lodging, moderately resistant to head smut

Released pearl millet varieties/hybrids

Pearl Millet Variety	Area of adoption	Salient features
ProagroTejas	Rajasthan	Early maturing; resistant to downy mildew
PHB 2884	Punjab	Late maturing, grey seeds
86 M 84	Rajasthan, Gujarat, Haryana, Madhya Pradesh, Uttar Pradesh, Punjab and Delhi	Late maturing, grey obovate large grains; resistant to downy mildew, blast
Central Pearl Millet Hybrid MPMH 21 (MH 1777)	Drier parts of Rajasthan, Gujarat and Haryana	Early maturing, grey-brown hexagonal grains; resistant to downy mildew, blast, smut
HHB 272 (MH1837)	Drier parts of Gujarat, Rajasthan and Haryana	Early maturing, grey globular grains; resistant to blast
Pearl Millet CO 10	Tamil Nadu	Medium maturing, grey-brown bold grains;resistant to downy mildew
JKBH 1008 (MH 1828)	Drier parts of Gujarat, Rajasthan and Haryana	Early maturing, grey-coloured globular grains; resistant to downy mildew, blast
MP 535 (Pusa Composite 701)	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Uttar Pradesh and Madhya Pradesh	Medium maturing, globular grey-brown grains;resistant to downy mildew
MH 1928 (XMT 1497)	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Uttar Pradesh and Madhya Pradesh	Medium maturing, grey-coloured hexagonal grains; resistant to downy mildew blast, rust, ergot
KBH 3940 (MH 1984)	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Uttar Pradesh and Madhya Pradesh	Late maturing, grey-coloured obovate grains; resistant to downy mildew, blast, rust, ergot
Nandi 75 (MSH 287) (NMH 82)	Summer growing areas of Gujarat, Rajasthan, Uttar Pradesh, Maharashtra and Tamil Nadu	Late maturing, grey-coloured globular grains; resistant to downy mildew, rust
86 M 82 (MH 1888)	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Uttar Pradesh and Madhya Pradesh	Late maturing, grey-coloured obovate seeds; resistant to downy mildew, ergot, rust, smut
86 M 13 (MSH 276)	Summer growing areas of Gujarat, Rajasthan, Uttar Pradesh, Maharashtra and Tamil Nadu	Late maturing, grey-coloured obovate seeds;resistant to downy mildew
BIO 8145 (MH 1970) Hybrid	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Uttar Pradesh and Madhya Pradesh	Late maturing, grey-coloured globular grains; resistant to downy mildew, blast, rust, ergot
JKBH 1100 (MH 1810) Hybrid	Uttar Pradesh	Late maturing; resistant to downy mildew, rust, smut diseases
JKBH 1105 (MSH 254) Hybrid	Summer areas of Uttar Pradesh	Late maturing, globular, grey-brown grains; resistant to downy mildew, rust, smut diseases
Phule Aadishakti (DHBH 9071)	Maharashtra	Late maturing, grey globular seeds; resistant to downy mildew

Oilseeds

Fifty high-yielding varieties including 16 of rapeseed-mustard, eight of groundnut, seven of linseed, five each of soybean and sunflower, four of sesame, three of castor and two of niger were released for different agro-ecological regions.

Canola Indian mustard: First Canola Indian mustard variety Pusa Double Zero Mustard 31 (PDZ 1) with less than 2% erucic acid in oil and less than 30 ppm glucosinolates in seed-meal has been released for timely sown irrigated areas of National Capital Region, Delhi. This yellow-seeded variety, with average

Released varieties/hybrids of oilseeds

Oilseeds Variety	Area of adoption	Salient features
Rapeseed-mustard		
Pant Rai 20	Plains of Uttarakhand	Suitable for timely sowing in both irrigated and rainfed areas
PBR 357	Jammu, Punjab, Haryana, parts of Rajasthan and Delhi	Suitable for irrigated timely sown conditions
RGN 298	Rajasthan, Punjab, Haryana, Delhi and Jammu	Suitable for rainfed conditions
GM3 (Gujarat Mustard3)	Gujarat	Tolerant to high temperature and salinity
Pusa Double Zero Mustard 31 (PDZ 1)	NCR region of Delhi	Low erucic acid and low glucosinolate
RLC 2 (IC 511615)	Punjab	Low erucic acid
PBR 378	Punjab	Suitable for timely sown rainfed areas
Gujarat Dantiwada Mustard 5 (SKM 518)	Punjab, Haryana, Jammu, Rajasthan and Delhi	Suitable for rainfed conditions
Raj Vijay Mustard 1	Madhya Pradesh	Suitable for early sowing
JK Samriddhi Gold (JKMS 2)	Uttar Pradesh	Suitable for timely sown irrigated conditions
JK Pukhraj (JKYS 2)	Uttar Pradesh	Suitable for timely sown irrigated conditions
Bayer Mustard 5450	Uttar Pradesh	Suitable for timely sown, irrigated conditions
RLC 3	Punjab	Low erucic acid and low glucosinolate
Toria		
Sushree	Odisha	Suitable for late sown condition and non-lodging type
TL 17	Punjab	Short duration; fits in paddy-wheat cropping system
Ethiopian mustard		
BJC 1 (PC 6)	Punjab	Frost tolerant
Groundnut		
G 2-52	Northern Karnataka	Resistant to rust and late leaf spot (LLS)
CO 7	Tamil Nadu	Resistant to rust
GJG 19 (Gujarat Junagarh Groundnut 19)	Odisha, West Bengal, Jharkhand and Manipur	Tolerance to stem rot, dry root rot and rust
Raj Mungfali 3 (RG 559-3)	Odisha, West Bengal, Jharkhand and Manipur	Tolerant to *Spodoptera litura*, leaf hopper and thrips
Phule Warna (KDG 128)	Gujarat, southern Rajasthan, southern Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu	Moderately resistant to rust and LLS
Phule Morna (KDG 123)	Gujarat, southern Rajasthan, West Bengal, Jharkhand, Odisha, Manipur, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu	Moderately resistant to rust and LLS
KCG 6	Southern Karnataka	Tolerant to rust and LLS
GKVK 5	Southern Karnataka	Tolerant to rust and LLS

Oilseeds Variety	Area of adoption	Salient features
Soybean		
SL 958	Punjab	Light yellow oval seeds with black hilum; suitable for timely sown irrigated areas; resistant to yellow mosaic virus (YMV) and soybean mosaic virus (SMV)
MACS 1281	Southern Maharashtra, Karnataka, Telangana, Andhra Pradesh, Tamil Nadu	Round, yellow seeds and black hilum; moderately resistant to bacterial pustules, bacterial leaf blight
JS 20-69	Madhya Pradesh	Medium-sized spherical yellow and shiny seeds with black hilum; resistant to YMV, charcoal rot, bacterial pustules, *Alternaria* leaf spot, pod blight, Indian bud blight, target leaf spot
VL Soya 77 (VLS 77)	Uttarakhand Hills	Large seeds, yellow seeds with black hilum; suitable for rainfed organic conditions; moderately resistant to frog -eye leaf spot, pod blight
VL Bhat 201 (VLB 201)	Uttarakhand Hills	Black and large seeded; resistant to frog-eye leaf spot, girdle beetle
Sunflower		
Sunlight (NSFH 1001)	Karnataka, Maharashtra, Tamil Nadu, Andhra Pradesh	Medium maturity
PSH 996	Punjab	Medium maturity; moderately resistant to downy mildew and charcoal root rot
Phule Bhaskar (SS 0808)	Maharashtra	Early maturing; moderately resistant to necrosis, powdery mildew
PSH 1962 (Hybrid)	Punjab	Medium maturing
RSFH 1887 (Hybrid)	Karnataka	Medium maturing; tolerant to viral necrosis, *Alternaria* leaf spot diseases
Sesame		
DS 5	Karnataka	Medium maturity; large and white-seeded
PKV-NT11 (NT 11-91)	Maharashtra	White-seeded, tolerant to phyllody, bacterial blight diseases; suitable for summer
Gujarat JunagadhTil 5 (GJT 5)	Gujarat	Suitable for rainfed situation
LT 8 (Punjab Til No. 2)	Punjab	Tolerant to *Cercospora* leaf blight and phyllody diseases
Castor		
Kohinoor (NBCH 66)	Gujarat, Andhra Pradesh, Tamil Nadu, Madhya Pradesh, Rajasthan, Karnataka, Maharashtra and Haryana	Late maturing
Pragati (PCS 262)	Telangana	Early maturing; resistant to wilt
HCH 6 (Hybrid)	Karnataka	Late maturing; resistant to *Fusarium* wilt and white fly
Linseed		
Kota Barani Alsi 3	Rajasthan	Resistant to rust, moderately resistant to *Alternaria* blight, powdery mildew, bud fly
Kota Barani Alsi 4 (RL 10193)	Bundelkhand region of Uttar Pradesh, Madhya Pradesh and Rajasthan	Moderately resistant to *Alternaria* blight, powdery mildew; suitable for rainfed situation
PKV-NL 260(NL 260)	Maharashtra	Moderately resistant to powdery mildew and bud fly

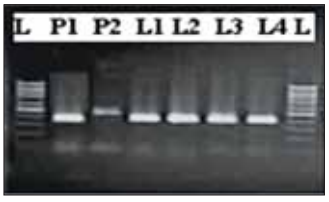
Oilseeds Variety	Area of adoption	Salient features
Chhattisgarh Alsi1 (RLC133)	Chhattisgarh	Moderately resistant to linseed bud fly, *Alternaria* blight, resistant to powdery mildew; suitable for rainfed situation
Divya (BAU 06-03)	Himachal Pradesh, Punjab, Jammu and Kashmir and Haryana	Resistant to rust, moderately resistant to *Alternaria* blight, wilt and bud fly
JLS 79	Madhya Pradesh	Resistant to rust, moderately resistant to wilt, powdery mildew, bud fly
Arpita	Odisha	Resistant to powdery mildew and wilt
Niger		
JNS 30	Madhya Pradesh	Tolerant to *Cercospora* and *Alternaria* leaf blight diseases
IGPN 8004	Maharashtra	Resistant to leaf spot and powdery mildew diseases

yield of 2,370 kg/ha and 41% oil content, matures in 144 days.

Pre-breeding for improvement in soybean: Soybean has very narrow genetic base and use of accessions with unique marker alleles in hybridization would help broadening its genetic base. Genotyping of 90 soybean accessions with 16 SSR markers identified three accessions (IC 15541, IC 18743 and IC 24057) with unique alleles. Use of such type of un-adopted diverse materials often result in introduction of undesirable characters like pod- shattering. CAPS marker analysis of pod-shattering resistance gene (*PDh1*) has identified shattering and pod-shattering resistant loci in 90 accessions, corresponding to shattering phenotype. Eight parent based multi-parent advanced generation inter-cross (MAGIC) population was developed by employing 2-way, 4-way and 8-way inter-cross hybridizations to gain more variability and for capturing diversity from China, USA and Brazil. The nested association mapping population was developed, consisting of twenty cross combinations for achieving drought, waterlogging and rust resistance in soybean. Breeding populations (RILs) for higher 100-seed weight are under development by involving EC 538828 (23 g), T 49 (8 g), JS 335 (12 g) and JS 97-52 (10 g). Five hundred seventy-six F_3/F_4- lines have been phenotyped and 2 SSR markers Satt 555 on LGK and Satt 453 on LGB 1 have showed higher frequency of alleles from EC 538828 in lines possessing higher 100-seed weight (> 13.5 g).

High oleic safflower for diversified uses: Three high oleic varieties — ISF 1 (78.3% oleic acid content), ISF 2 (78.8% oleic acid) and ISF 3 (76.3% oleic acid) have been developed for the first time by introgressing traits from introduced exotic lines.

Lipoxygenase-2 free lines of soybean: High-yielding lipoxygenase-2 free lines in diverse genetic backgrounds, using marker-assisted selection in soybean, have been developed. Further, lipoxygenase- 3 free lines using JS 335 and PI 205085 (*lx3lx3*) have also been developed. P1 and P2 depict amplified products from PI 205085 (*lx3lx3*) and JS 335 (*Lx3Lx3*), respectively. Lanes L1, L2, L3, L4 depict advanced lines Jlx3-1, Jlx3-2, Jlx3-3 and Jlx3-4, respectively, derived from JS 335 × PI 205085 and L denotes 100 bp DNA ladder.



Pulses

Forty-three high-yielding varieties of pulses, including 10 of chickpea, 11 of mungbean, six of pigeonpea, four each of fieldpea and lentil and three each of urdbean and horsegram and two of cowpea were released for different agro-ecological regions.

IPM 205-7 (Virat) mungbean: It is an earliest maturing (52-55 days) summer mungbean variety, released for cultivation in irrigated areas of Punjab, Haryana, Rajasthan, Uttar Pradesh, Bihar, Jharkhand, Madhya Pradesh, Gujarat, Tamil Nadu, Telangana, Andhra Pradesh and Karnataka, in newer niches of rice-wheat system after wheat and in rice-rice cropping after second crop of rice. It has a yield potential of 1.0-1.2 tonnes/ha, and can be safely harvested before

IPM 205-7 (Virat) mungbean

Released varieties of pulses

Pulses Variety	Area of adoption	Salient features
Chickpea		
Pusa 3022	Punjab, Haryana, western Uttar Pradesh, Jammu and Kashmir, Delhi, north Rajasthan, Himachal Pradesh and Uttarakhand	Late maturing; large-seeded, kabuli type; moderately resistant to *Fusarium* wilt, dry root rot, *Ascochyta* blight and *Botrytis* grey mould
PBG7 (GL 26054)	Punjab	Resistant to *Ascochyta* blight ,moderately resistant to *Fusarium* wilt and dry root rot
Aman (CSJ 515)	Punjab, Haryana, western Uttar Pradesh, Jammu and Kashmir, Delhi, north Rajasthan, Himachal Pradesh and Uttarakhand	Moderately resistant to dry root rot, wilt and collar rot, tolerant to *Ascochyta* blight and *Botrytis* grey mould
Nandyal Gram 119	Karnataka, Andhra Pradesh and Tamil Nadu	Kabuli type
Teej (GNG 2144)	Punjab, Haryana, western Uttar Pradesh, Jammu and Kashmir, Delhi, north Rajasthan, Himachal Pradesh and Uttarakhand	Tolerant to *Fusarium* wilt disease
JGK 5	Madhya Pradesh	Matures in 110-115 days; extra-large seeded, kabuli type; resistant to *Fusarium* wilt, moderately resistant to root rot
BDNGK 798	Eastern Uttar Pradesh, West Bengal, Jharkhand, Bihar and North -Eastern Hill states and Maharashtra	Large seeded, kabuli type; tolerant to *Fusarium* wilt
Gujarat Junagadh Gram 6(GJG6)	Gujarat	Matures in 100-112 days, suitable for rainfed areas; resistant to wilt, moderately resistant to stunt
JG 36 (Jawahar Gram 36)	Madhya Pradesh	Matures in 105-112 days; moderately resistant to *Fusarium* wilt, dry root rot and stunt
GBM 2	Karnataka	Matures in 100-120 days; suitable for machine harvesting as pods lie on the upper 1/3rd part
Mungbean		
MH 318	Haryana	Matures in 60 days; suitable for *kharif* and summer; small shiny seeds; moderately resistant to mungbean yellow mosaic virus (MYMV)
Utkarsh (KM 11-584)	Maharashtra	Matures in 65-70 days; suitable for *kharif*; shiny, green, large seeds; moderately resistant to MYMV and CLS
Yadadri (WGG 42)	Telangana	Suitable for *kharif* and summer; shiny, large seeds; resistant to MYMV
Sri Rama (MGG351)	Telangana	Suitable for *rabi* and summer; medium large, dull seeds; resistant to MYMV
GBM 1	Karnataka	Suitable for *kharif* cultivation; shiny, green, small seeds; resistant to powdery mildew
IPM 410-3 (Shikha)	Tripura, Manipur, Himachal Pradesh	Days to maturity: 67-80,suitable for *kharif*; shiny, green seeds; resistant to MYMV and powdery mildew, tolerant to CLS
IPM 205-7 (Virat)	Punjab, Haryana, West Uttar Pradesh, Bihar, Tamil Nadu,Madhya Pradesh and Gujarat	Matures in 50-56 days in summer season; resistant to MYMV, powdery mildew , moderately resistant to CLS

Pulses Variety	Area of adoption	Salient features
SML1115	Tripura, Meghalaya and Manipur	Suitable for summer season; shiny green and medium seeds; resistant to MYMV, moderately tolerant to web blight and CLS
MSJ 118 (Keshwanand Mung 2)	Rajasthan	Suitable for *kharif*; medium large and dull green seeds; moderately resistant to MYMV
ML 2056	Punjab	Suitable for *kharif;* shiny green and medium seeds; resistant to MYMV, CLS, bacterial leaf spot and anthracnose
RMG 975 (Keshwanand Mung 1)	Rajasthan	Suitable for *kharif;* shiny green medium large seeds; moderately resistant to MYMV
Pigeonpea		
Prakash (IPA 203)	Uttar Pradesh, Bihar, Jharkhand, West Bengal	Matures in 250 days; resistant to sterility mosaic disease, tolerant to *Phytophthora* blight and *Fusarium* wilt
Gujarat Junagadh Pigeonpea 1 (GJP 1)	Gujarat	Matures in 170-180 days; moderately resistant to wilt
Ujwala (PRG 176)	Telangana	Matures in 130-135 days; tolerant to wilt
Mannemkonda Kandi (ICPH 2740)	Telangana	Matures in 180-190 days; resistant to wilt and sterility mosaic disease (SMD)
GT 102	Gujarat	Matures in 175-180 days; resistant to SMD , tolerant to wilt
BRG 5	Karnataka	Matures in 160-170 days; resistant to wilt, moderately resistant to sterility mosaic disease
Fieldpea		
Indira Matar 1 (REP 2009-1)	Chhattisgarh and Bihar	Suitable for rice fallows; matures in 105-110 days, tall; moderately resistant to powdery mildew
Central Fieldpea IPFD 11-5	Madhya Pradesh, Gujarat, Chhattisgarh, Maharashtra	Matures in 105-110 days, dwarf; resistant to powdery mildew
IPFD 6-3	Uttar Pradesh	Matures in 120-125 days, dwarf; resistant to powdery mildew
RFP 4 (Keshwanand Matar 1)	Rajasthan	Medium tall, medium large seeds; moderately resistant to powdery mildew
Urdbean		
Indira Urd Pratham (RU 03-14)	Chhattisgarh	Early duration; synchronous maturity; resistant to MYMV and powdery mildew
LBG 787 (Tulasi)	Andhra Pradesh, Tamil Nadu, Karnataka and Odisha	Suitable for *rabi* and summer cultivation; matures in 75-80 days; resistant to MYMV
PDKV Black gold (AKU 10-1)	Maharashtra	Matures in 70-80 days; resistant to stem necrosis, anthracnose and root rot
Lentil		
KLB 2008-4 (Krati)	Uttar Pradesh	Matures in 115-120 days; large seeds; resistant to wilt
KLS09-3 (Krish)	Uttar Pradesh	Matures in 105-110 days; small seeds; resistant to wilt
RLG5 (Keshwanand Masoor1)	Rajasthan	Matures in 115-120 days; small seeds
IPL 526	Uttar Pradesh	Medium large seeds; tolerant to rust and wilt
Cowpea		
Pant Lobia 3 (PGCP 6)	All cowpea- growing regions	Resistant to YMV and bacterial blight; brown seeds

Pulses Variety	Area of adoption	Salient features
Phule Vithai (Phule CP 05040)	Maharashtra	Early maturing; moderately resistant to collar rot and leaf spot
Horsegram		
Pratap Kulthi 2 (AK 53)	Rajasthan	Extra early, lowest tannin content (1.09 mg/g)
Cridavardhan (CRHG22)	South Zone	Moderately resistant to anthracnose, YMV and *Cercospora* leaf blight
Phule Sakas (SHG 0628-4)	Maharashtra	Large brown seeds; early maturity; moderately resistant to YMV

the onset of monsoon. It is highly resistant to mungbean yellow mosaic disease and powdery mildew, and is moderately resistant to *Cercospora* leaf spot.

Commercial crops

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

Co 0212: This sugarcane variety of mid-late maturity was released for cultivation in Tamil Nadu and Puducherry. Overall mean performance of the variety was 150.56 tonnes cane yield/ha, 12.80% of commercial cane sugar and 19.27 tonnes of sugar yield/ha in 12 months across different locations in Tamil Nadu. It is moderately resistant to red rot and is tolerant to drought

Co 0212 - A drought and salinity tolerant sugarcane variety

Released varieties/hybrids of commercial crops

Commmercial crop Variety	Area of adoption	Salient features
Cotton		
CICR NA 1003	Andhra Pradesh, Karnataka and Tamil Nadu	High locule retention capacity (shattering resistance); resistant to major diseases and pests
CCH 2623	Andhra Pradesh, Karnataka and Tamil Nadu	High ginning outturn;field tolerant to jassids and majority of diseases
Sujay (SCS 793)	Andhra Pradesh, Karnataka and Tamil Nadu	Moderately resistant to jassids, aphids and leaf spot
H 1353	Gujarat, Maharashtra and Madhya Pradesh	Tolerant to jassids and thrips
Phule Yamuna (RHC 0717)	Gujarat, Maharashtra and Madhya Pradesh	Tolerant to sucking pests and bollworms, resistant to bacterial blight, moderately resistant to *Alternaria* late blight and free of grey mildew
SVHH 139	Punjab, Haryana and Rajasthan	High yielding non-*Bt* hybrid
F 2164	Punjab, Haryana and Rajasthan	Resistant to bacterial late blight, fungal foliar diseases, tolerant to pests
MR 786	Punjab, Haryana and Rajasthan	Moderately resistant to leaf curl virus disease, bacterial late blight, tolerant to jassids, whitefly, thrips, bollworm
Sri Rama (NDLH 1938)	Gujarat, Maharashtra and Madhya Pradesh	Tolerant to sucking pests (jassids, whitefly, aphids)

Commmercial crop Variety	Area of adoption	Salient features
Phule Tarang (RHH 0707)	Andhra Pradesh, Karnataka and Tamil Nadu	Resistant to bacterial late blight, moderately resistant to *Alternaria* late blight (ALB), resistant to sucking pests, tolerant to bollworms
CO 14	Tamil Nadu	Extra long staple American cotton, spinnable up to 70s count yarn; moderately resistant to jassids, *Alternaria* leaf spot
G.Cot.20 (GSHV 97/59)	Gujarat	Moderately tolerant to sucking pests , resistant to lodging, moderately resistant to bacterial blight
GN.Cot.25	Gujarat	Tolerant to drought as well as pests and diseases
DHB 915	Karnataka	Extra long staple interspecific hybrid, spinnable up to 80s count yarn
GN.Cot 22	Gujarat	Resistant to jassids, *Alterneria*, bacterial blight, moderately resistant to grey mildew, moderately tolerant to aphids, thrips and boll worms
SVPR 5 (TSH0 250)	Andhra Pradesh, Karnataka and Tamil Nadu	Moderately resistant to leafhopper, bacterial leaf blight (BLB), *Alternaria* leaf spot (ALS) and grey mildew
SVPR 1 (TSHH 0629) Hybrid	Andhra Pradesh, Karnataka and Tamil Nadu	Resistant to BLB; suitable for summer
JLA 505	Gujarat, Maharashtra and Madhya Pradesh	Moderately resistant to *Alternaria,* bacterial blight, grey mildew, tolerant to pests in fields
F 2228 (American Cotton)	Punjab	Resistant to bacterial blight, moderately resistant to fungal foliar diseases
F 2383 (American Cotton),	Punjab	Suitable for high density plantation system and amenable for machine picking; moderately resistant to BLB and fungal foliar leaf spot, moderately resistant to jassids
RHB 0711 (Phule Dhara) Hybrid	Gujarat, Maharashtra and Madhya Pradesh	Resistant to *Alternaria*, bacterial blight , tolerant to sucking pests and bollworms
RHCb 011 (Phule Rukmai)	Gujarat, Maharashtra and Madhya Pradesh	Extra long staple barbadense cotton variety
Raichur Shakthi 455 (RAHH 455)	Andhra Pradesh, Karnataka and Tamil Nadu	Moderately resistant to jassids, aphids, leaf spot, tolerant to bollworms
Sugarcane		
Karan 11 (Co 06034)	Punjab, Haryana, Uttar Pradesh (western and central), Uttarakhand and Rajasthan	Suitable for winter harvesting; moderately resistant to red rot and smut ,resistant to wilt
CoBln 02173 (22/94) D0IYANG	Assam, Meghalaya, Manipur, Mizoram, Tripura, Arunachal Pradesh, Sikkim and Nagaland	Suitable for October planting; moderately resistant to red rot and borers
Co 0212	Tamil Nadu and Puducherry	Tolerant to drought, resistant to red rot and smut
Gujarat Sugarcane 4 (CoN 03131)	South Gujarat	Moderately resistant to red rot and wilt
Gujarat Sugarcane 5 (CoN 05071)	South Gujarat and Peninsular zone	Moderately resistant to red rot and wilt
Gujarat Sugarcane 6 (CoN 05072)	South Gujarat	Moderately resistant to red rot and wilt
Gujarat Sugarcane 7 (CoN 04131)	South Gujarat	Moderately resistant to red rot and wilt
Gujarat Sugarcane 8 (CoN 07072)	South Gujarat	Moderately resistant to red rot and wilt,low incidence of pests and diseases

Commmercial crop Variety	Area of adoption	Salient features
CoPb91 (CoPb 09181)	Punjab, Haryana, Uttar Pradesh (western and central), Uttarakhand and Rajasthan (North West Zone)	Tolerant to lodging and non-flowering, moderately resistant to red rot and moderately susceptible to smut
Jute		
Shresthaa (KJC 7)	Odisha, Assam and Uttar Pradesh	Premature flowering; with an average fibre yield 2.81 tonnes/ha
JRO 2402 Samapti	West Bengal, Assam, Bihar and Odisha for early March sowing	Premature flowering resistance; drought tolerant at an early stage of growth, tolerant to waterlogging
Ishani (JRC 9057)	West Bengal, Assam, Bihar and Odisha for March to end of April sowing; as jute is followed by transplanted Aman paddy	Better fibre quality (W4 grade); especially fibre fineness (1.31 tex); highly tolerant to stem rot and jute semi looper
Mesta		
Satyen (JRKM 9-1)	West Bengal, Assam, Bihar and Odisha for mid-April to last week of May sowing under mid and highland rainfed situation	Resistant to foot and stem rot disease; with very fine (2.54 tex) fibre quality and lesser defective fibre
Dharwad Mesta 1	Karnataka	High yielding and fine fibre quality
Kenaf		
Bimal (JBMG 4)	Odisha, Andhra Pradesh, NE states, Maharashtra, Bihar and West Bengal	Tolerant to stem and foot rot disease and pest like mealy bug
Central Kenaf JBMP 2	Andhra Pradesh, Odisha, West Bengal, Bihar and North-Eastern states for April to last week of May sowing	Stronger (22.25 g/tex) fibre; tolerant to major diseases and pests (mesta mealy bug)
Roselle		
Sampurna (CRIJAFR 8)	Andhra Pradesh, Odisha, West Bengal, Bihar	Tolerant to foot and stem rot disease
Central Roselle Ratna (CRIJAF R 5)	Andhra Pradesh, Tamil Nadu, Odisha and West Bengal	Very fine (2.69 tex) fibre quality and less root content. Average fibre yield is 2.55 tonnes/ha; tolerant to major diseases and pests
Ramie		
Hazarika (R 1411)	Suitable for prevalent intercropping systems of horticultural crops in North-Eastern States and Northern part of West Bengal	First-ever released variety of ramie in the country; finer (0.64 tex / 5.73 denier) fibre quality

and salinity, and possesses A1 quality jaggery of golden-brown colour. This is a good ratooner with excellent field stand.

Co 06034 (Karan 11): It is a mid-late maturing clone, released for commercial cultivation in Haryana, Punjab, Uttarakhand, Rajasthan, central and western Uttar Pradesh. Its average cane yield was 75.41 tonnes/ha with average commercial cane sugar yield of 9.59 tonnes/ha and average sucrose was 18.45% in juice. It would be a suitable alternative for replacing old varieties such as CoS 767 and CoS 8436.

Ramie R 1411 (Hazarika): It is suitable for intercropping with arecanut, pineapple, coconut and rubber in the North- Eastern States and northern part of West Bengal. It has an average fibre yield of 1.47 tonnes/ha (4-5 cuttings in a year), and its

potential yield is 1.87 tonnes /ha.

Forage crops

Twenty high-yielding varieties/hybrids of forage crops comprising two of forage *bajra*, one of napier *bajra* hybrid, five of forage oat, two each of forage sorghum and guinea -grass, three each of forage cowpea and rice-bean and one each of lucerne and sewan grass were released for cultivation in different agro-ecologies.

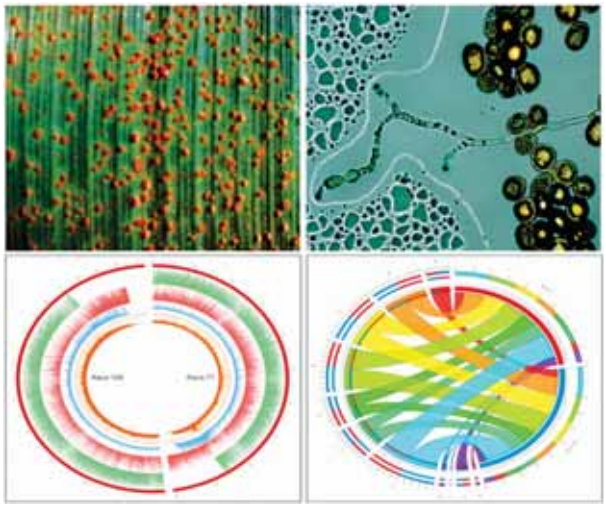
Released varieties/hybrids of forage crops

Forage Variety	Area of adoption	Salient features
Forage *bajra*		
IGPM 5-2	Haryana, Punjab, Rajasthan, Uttar Pradesh, Bihar, Jharkhand, Odisha, Gujarat, Maharashtra, Madhya Pradesh	Late maturity; moderately resistant to major biotic stresses including leaf spot, downy mildew, stem borer and *Pratylenchus zeae*
MotiBajra (APFB 09-1)	Telangana and Andhra Pradesh in rainfed as well as in irrigated areas	Tall, better tillering, dark-green foliage, short duration (56 days to 50% flowering) with multi-cut (3-4 cuts)
Napier *bajra* hybrid		
Napier Bajra Hybrid PBN 346	Punjab	Multi-cut, high *in- vivo* dry matter and also crude protein digestibility. Tall and broad leaves, more leafiness and high tillering ability
Forage oat		
OL 10 (OL 1709)	Punjab	Multi-cut, high *in- vivo* dry matter and also crude protein digestibility. Tall and broad leaves with more leafiness and high tillering ability
Bundel Jai 2010-1 (JHO-2010 1)	Andhra Pradesh, Karnataka and Tamil Nadu	Single cut; moderately resistance to *Sclerotium* rot, leaf blight and powdery mildew
Shalimar Fodder Oats 3 (SKO 96)	Jammu and Kashmir and Himachal Pradesh	Resistant to powdery mildew, *Sclerotium* root rot and leaf blight
JHO 2009-1(Bundel Jai2009-1),	Uttar Pradesh , Maharashtra, Madhya Pradesh and Gujarat	High yielding with good quality and digestibility
UPO 06-1(Pant Forage Oat 3)	Uttarakhand	Good yield and quality
Forage sorghum		
Punjab Sudax Chari 4 (PSC 4)	Punjab	Sweet multi-cut hybrid; moderately resistant to shoot fly and red leaf spots
CSV 21F	All India	Medium maturity; resistant to all leaf spot diseases; tolerant to shoot fly and stem borer
Forage cowpea		
Bundel Lobia 4 (IL1177)	North East Zone	Good fodder quality
Vijaya (APFC 10-1)	Telangana and Andhra Pradesh	Suitable for *kharif* and *rabi* seasons; short duration variety with high leaf stem ratio (0.72) and photo-insensitive
MFC 09-1	Kerala, Tamil Nadu, Karnataka Andhra Pradesh and Telangana	High green forage and dry matter; resistant to yellow mosaic virus and leaf spot
Rice-bean		
Bidhan Rice bean 3 (KRB19)	Jharkhand, West Bengal, Odisha, Assam, Manipur and Kerela	Resistant to stem/collar rot, yellow mosaic virus, anthracnose, bacterial wilt, aphids, caterpillar, stored grain pests, moderately tolerant to acid soils and waterlogging
JRBJ 05-2	Rice-bean-growing areas of Madhya Pradesh and Chhattisgarh	Semi-erect variety
Shyamalima (JCR 720)	Assam	Long vegetative growth when sown in March–April; drought tolerant, sustain growth during winter, suitable for acidic soils and for rice fallows

Forage Variety	Area of adoption	Salient features
Lucerne Krishna (RRB 07-1)	Rajasthan and Punjab	High yielding and of good quality (crude protein: 20.57%); resistant to all insect- pests and diseases
Forage sewan grass Jaisalmeri Sewan (RLSB 11-50)	Rajasthan	Multi-cut, perennial (Four cuttings of good quality can be taken in a year with irrigation)
Guinea-grass Bundel Guinea 4 (JHGG 08-1)	All India	Superior yield and quality; adaptability to rainfed condition; remains green throughout the year under irrigated conditions
Dharwad Guinea Grass1 (DGG 1) (RSDGG 1)	All India	Good adaptability to rainfed conditions, high leaf to stem ratio (1.04), resistant to lodging, non-shattering type; drought tolerance

Biotechnology

Decoding wheat-rust genome: Leaf rust of wheat is the most widespread among all rusts and causes maximum losses in India. Next generation sequencing (NGS) technology was used to decode genomes of 15 strains (~1500 MB data) of wheat leaf- rust fungus. A high quality draft genome (~100Mb) sequence of race 77 with 33X genome coverage and predicted 27,678 protein coding genes, responsible for various functions, has been generated. Genome-wide comparative analysis has revealed that *P. triticina* genome is 37.5% and 40.0% repetitive in case of race77 and race106, respectively;race77 differed substantially from race106 at the segmental duplication (SD), repeat elements and SNP/InDel levels. Certain "host spot regions" in the genome of race 77 are found vulnerable for reshuffling, leading to variability in it.

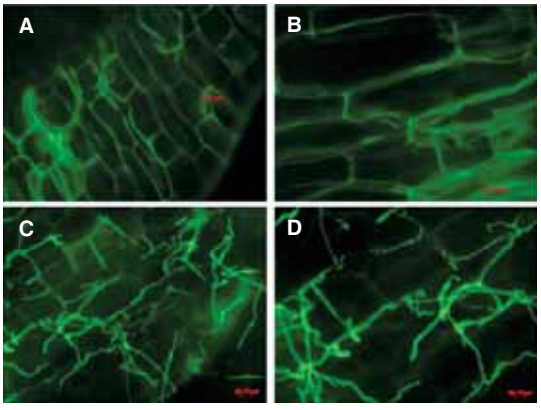


Wheat leaf-rust symptom, fungal spores and comparative analysis of rust genome

Molecular techniques for improving taxonomic identification: A very sensitive, specific and reliable multiplex bio-PCR protocol for simultaneous detection of bacterial pathogens, *Ralstonia solanacearum* and *Erwinia carotovora* sub sp. *carotovora,* causing brown rot and soft rot diseases in potato, has been developed.

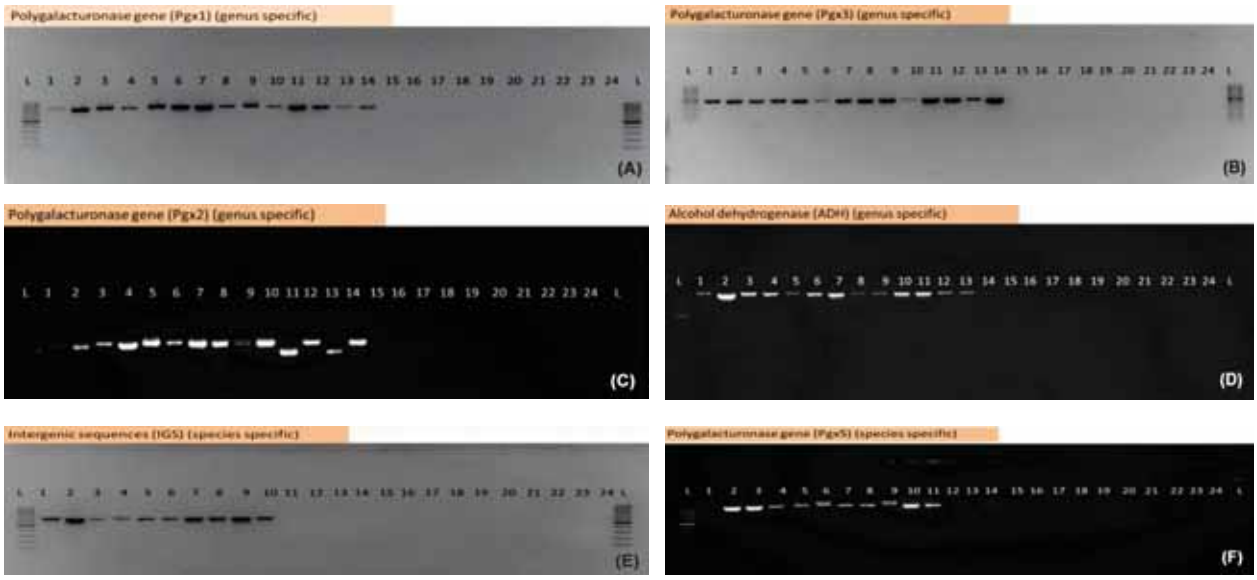
A PCR- based marker (KetoPstRA$_{1500}$) for specific detection of pathogenic fungus, *Puccinia strii formistritici,* causing yellow rust of wheat, has also been developed and validated. The marker could detect as little as 10fg of DNA template, and could diagnose disease before the expression of symptoms.

Induction of biotic stress tolerance in castor : More directed efforts were made towards identifying presence of *Trichoderma* sp. in castor roots *in situ* through specific staining of fungal chitin with wheat-germ agglutinin – Fluorescent isothiocyanate conjugate (WGA-FITC) and visualization of the fungus using fluorescence microscopy. It was observed that fungal multiplication increased with time, and fungal hyphae were generated through interstitial spaces of root epidermal cells. It further established that lateral roots were more colonized compared to tap root. These results were reconfirmed through Transmission Electron Microscopy (TEM).



WGA-FITC staining demonstrated penetration and colonization of castor roots by *Trichoderma.* **A** and **B**: Untreated castor roots (35-days-old); **C** and **D**: Th4d-treated castor roots (35-days-old)

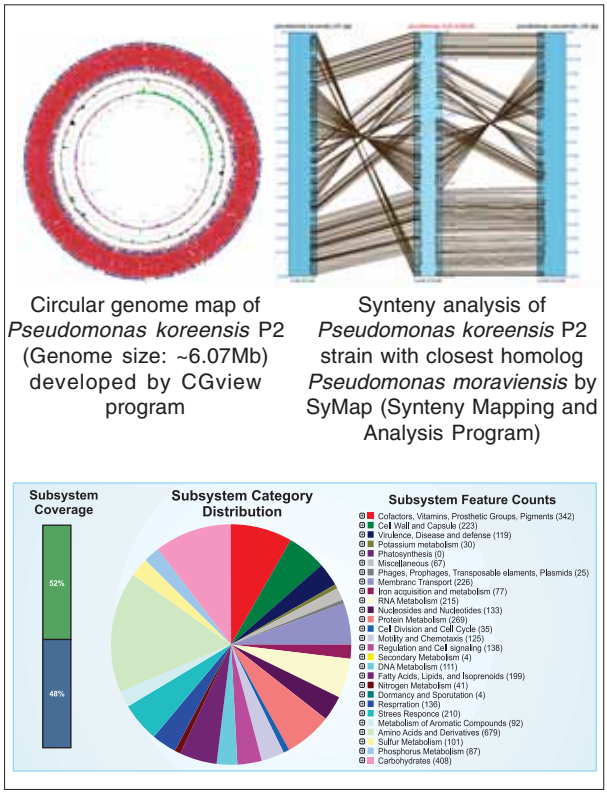
PCR-based diagnostic markers for *Fusarium:* For the development of genus and species-specific diagnostic markers for *Fusarium* species, exo- poly galacturonase (*Pgx*), intergenic spacer (*IGS*) and alcohol dehydrogenase (*ADH*) gene sequences from related species, genera, and other pathogens were applied. The resultant PCR assay was performed for diagnostic markers to identify eleven different isolates of



PCR amplification of (A) *Pgx1* (~781bp), (B) *Pgx3* (~500bp), (C) *Pgx2* (~620 bp), (D) *ADH* (~1100 bp), (E) *IGS* (~633 bp) and (F) *Pgx5* (~1100 bp) genes in *Fusarium* isolates and fungal outgroup representing district geographical lineages. Lanes 1–24 are different *Fusarium* isolates and outgroup fungal isolates. M is a 100-bp DNA marker

F. oxysporum f. sp. *lycopersici* along with different species of *Fusarium* and some other unrelated fungi.

Genome sequencing of *Pseudomonas koreensis* (P2): The complete whole genome sequencing of *Pseudomonas koreensis* P2 was studied in Illumina Hiseq platform in paired end module. Synteny analysis of P2 strain with closest homolog *Pseudomonas moraviensis* was performed by using SyMap tool. Primary genome assembly was done using Velvet (V.1.2.10.). The gene family members associated with phosphorus (P) metabolism, potassium (K) metabolism, zinc (Zn) metabolism, sulphur (S), iron (Fe), heavy metal remediation, antibiotic sensitivity/ resistance and stress were identified in P2 genome, and they would allow this bacterium to be considered as a biological fertilizer in agriculture. It also showed a very high phosphorus-solubilizing potential; and preliminary tests on plants confirmed its plant growth-promoting activity.



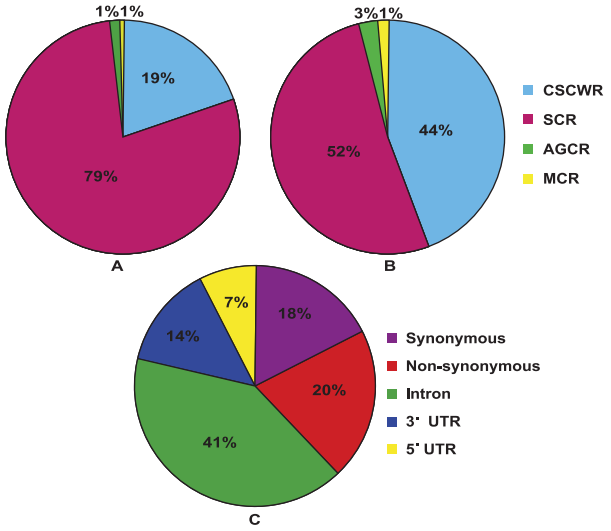
Circular genome map of *Pseudomonas koreensis* P2 (Genome size: ~6.07Mb) developed by CGview program

Synteny analysis of *Pseudomonas koreensis* P2 strain with closest homolog *Pseudomonas moraviensis* by SyMap (Synteny Mapping and Analysis Program)

Annotation and functional characterization of draft genome of *Pseudomonas koreensis* P2

Decoding of karnal bunt genome: This disease caused by the fungus *Tilletia indica* (Syn. *Neovosia indica*) is a serious concern due to strict quarantine affecting international trade of wheat. It is a quarantined pathogen and severe economic losses occur owing to quarantine restrictions. Early detection of the pathogen strains is crucial for managing infestation. The draft sequences of two monosporidial and one dikaryon are a major landmark to understand pathogen diversity, its mating behaviour and to detect pathogens at the earliest. The draft genome size of KB strains PSWKBGH-1, PSWKBGH-2 and PSWKBGH-3 were 37,460,344 bp, 37,216,861 bp and 43,736,665 bp, respectively. The results are published in the international Journal Genome Announcements [Draft Genome Sequence of Two Monosporidial Lines of the Karnal Bunt Fungus *Tilletia indica* Mitra (PSWKBGH-1 and PSWKBGH-2)]. These genomes have been deposited at GenBank under the accession MAPW00000000 (PSWKBGH-1) and MAPX00000000 (PSWKBGH-2).

Validation of 50K SNP chip in rice-based on single copy genes: A unique genic-SNP genotyping chip for genetic and evolutionary studies as well as molecular breeding applications in rice has been designed and validated. The chip designed for Affymetrix platform incorporated 50,051 SNPs from 18,980 different genes spanning 12 rice chromosomes, including 3,710 single-copy (SC) genes conserved between wheat and rice, 14,959 SC genes unique to rice, 194 agronomically



Distribution of different kinds of rice genes and number of SNPs in the affymetrix 50K rice SNP chip (OsSNPnks): (a) number of genes in different categories; (b) number of SNPs in different categories of genes; (c) number of SNPs in different regions of genes

important cloned rice genes and 117 multi-copy rice genes. A total of 320 wild rice accessions were genotyped by 50K SNP chip. Assays with this chip showed high success rate and reproducibility.

Cereals

Cloning of *RuBisCo activase* gene: The gene was cloned from heat-tolerant wheat cultivar HD 2985 for basic studies for improving stress tolerance in wheat to mitigate effects of climate change.

Sucrose synthase locus LOC_Os2g58480 identified: This was identified as polymorphic in two mapping populations, viz. Rasi/ Vibhava and BPT5204/ PTB1.

Mapping of leaf-rust resistant gene in wheat: A novel alien leaf-rust resistance gene (*Lr Sel.G12*) was mapped to chromosome 3BL and linked to two microsatellite markers *Xgwm114* and *Xgwm547* in *Triticum timopheevii* derivative, 'Selection G12'.

Oilseeds

Identification of associated markers for late leaf spot in groundnut: Twenty new polymorphic SSR markers were identified for genotyping of mapping population of GJG 17 × GPBD 4. Three new SSR markers — DGR 308, DGR 508 and DGR 800— were associated with late leaf spot (LLS) disease resistance in groundnut.

Cost-effective SNP genotyping in castor: This assay based on 'Kompetitive Allele Specific PCR genotyping system (KASP)', a fluorescent endpoint genotyping technology of LGC Genomics, was developed for 300 SNP loci in castor. The assays were validated in a panel of 13 inbred lines consisting of parents of mapping population and breeding lines with grey-mould resistance. The genotyping data quality was high with 100% reproducibility among replicates. The alternate alleles of the SNP locus and heterozygotes could be clearly discriminated. This genotyping system in castor is highly robust, rapid and cost-effective (~`10/data point).

Marker-assisted selection in soybean: Genes for yellow mosaic virus resistance from *Glycine max* PI 171443 and *Glycine soja* have been mapped and pyramided in a single line, JS 335, using marker-assisted selection.

Pulses

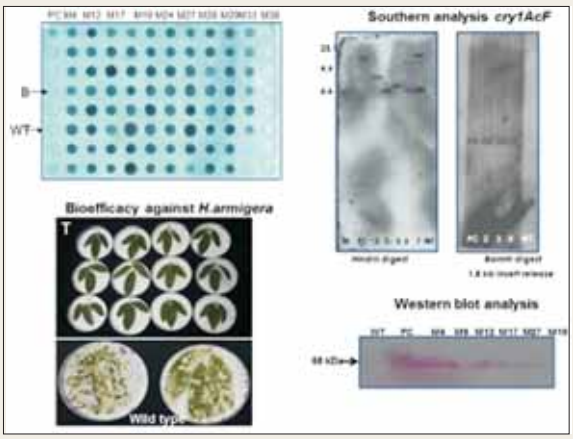
Introgression of insect-resistance in chickpea and pigeonpea: Ten insect resistant (IR) transgenic events, five each in chickpea and pigeonpea, were identified for event selection trial. Three F_1s were developed by crossing transgenic chickpea line BS 6 L (cry2Aa) with *desi* chickpea genotypes *(* JG 11 and DCP 92-3) for insect resistance breeding programme.

DNA fingerprinting

A rice mini-core germplasm set (194 acc.) was designated using data from 50K Single Nucleotide Polymorphism (SNPs) markers chip. Crop-specific GMO matrices of 199 GM events (with 143 GM maize events with 75 genetic elements) and 56 cotton events (with 44 genetic elements) were developed. Imported transgenic lines (207) of different species were tested for absence of embryogenesis deactivator gene-employing primers specific for *cre* recombinase gene.

Transgenic pigeonpea lines developed

The lines were developed with two *Bt* ICP genes, *cry1AcF* and *cry2Aa,* following a non-tissue culture-based *in planta* transformation for pod borer *(Helicoverpa armigera)* resistance. The putative transformants were selected based on kanamycin resistance and presence of T-DNA by PCR analysis. Bioassay against *H. armigera* identified promising transgenic lines with 80-100% mortality. In T_3 generation, eight stably integrated events with 80-100 % insect mortality and high *cry1AcF* expression were identified. Four events had T-DNA integrated as a single copy. Ten stably integrated events with high *cry2Aa* expression demonstrated 80-100% insect mortality.



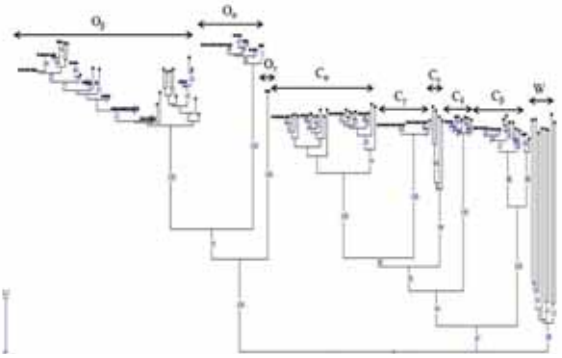
Snapshot of molecular and bioefficacy analysis of the pigeonpea transgenics harbouring *cry1AcF* and *cry2Aa*

Transferability of rice EST-derived microsatellite markers to *Dichanthium annulatum*

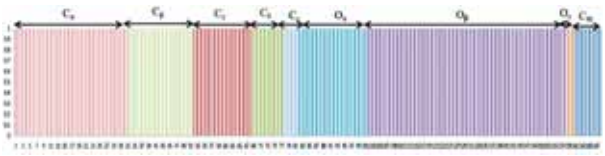
A total of 80 SSR markers developed from stress responsive ESTs of rice were evaluated for transferability in *Dichanthium annulatum*. Upon initial screening of SSR markers in two genotypes of marvel grass, 50 rice SSR primer pairs (62.5%) and 33 (41.25%) primer pairs found transferable, which produced clear and consistent amplified products, were checked for transferability in 25 *D. annulatum* genotypes. This high degree of cross-species amplification showed that flanking regions of SSR sequences were evolutionary conserved among grass species, particularly in *Dichanthium* and rice. A total of 670 bands which gave thick and clear amplification were scored from 33 random primers with an average of 20.3 bands per primer. Out of 670 bands scored, 142 (21.2%) were monomorphic among genotypes and 528 (78.8%) were polymorphic. A majority of rice primer pairs amplified only one or two bands, 4 primer pairs (Osa-2014-322, Osa-2014-350, Osa-2014-399 and Osa-2014-400) amplified three bands each, while primer pair Osa-2014-305 produced six bands. A total of 528 amplified alleles from 16 polymorphic SSR markers were used for genetic diversity analysis, and genetic similarity coefficient ranged from 0.67 to 0.92.

Jute

Organelle genetic diversity traced breeding history: Organelle genetic diversity of 160 jute genotypes (81 *Corchorus capsularis* and 79 *C. olitorius*) from different continents and eight wild *Corchorus* species was studied using 13 mitochondrial and one chloroplast DNA specific markers. A total of four analytical approaches, classificatory analysis by neighbour joining, principal coordinate analysis, Bayesian population structure analysis and non-Bayesian recollection algorithm were used for identification of organelle genome groups. High congruence was observed among different grouping approaches suggesting high accuracy of the grouping based on organelle DNA variability. The study identified more (5) organelle genome groups in *C. capsularis* than in *C. olitorius* (3) with low within-group heterozygosity and a few admixture of groups. *C. olitorius* organelle genome groups exhibited lower diversity compared to *C. capsularis*. Between-species variability accounted for 43% of the total organelle genome variability. The study also revealed high intraspecific differences among cultivated *Corchorus* species at organelle genome level. The organelle genome group of wild *Corchorus* was found distinct from cultivated types.



Genetic diversity of organelle genome groups in *Corchorus olitorius* (O_α, O_β, O_γ) and *C. capsularis* (C_α, C_β, C_γ, C_δ, C_ε). The organelle genetic group of wild *Corchorus* species is indicated by W



Population structure analysis of jute based on non-Bayesian recollection approach

The study also helped trace back breeding history of jute using molecular evidences. The origin of the fibre type cultivars of *C. capsularis* could be traced back to D 154; the first widely cultivated *C. capsularis* variety released in early twentieth century. Similarly, the organelle genome group of new *C. olitorius* cultivars was same with that of Chinsura Green, the first *C. olitorius* variety grown extensively during early and mid-twentieth century. Interestingly same organelle genome group is present in two important African genotypes Tanganyika 1 and Sudan Green, which were introduced after 1950, which is a reliable evidence for African origin of *C. olitorius*.

SSR identification: Genomic SSRs were developed from *C. olitorius* cv. Sudan Green. The Perl script MISA was employed to identify microsatellites from assembled scaffolds. To identify presence of SSRs, only two to four nucleotide motifs were considered, and minimum repeat units were defined as 10, 7 and 5 reiterations for di, tri- and tetra-nucleotides repeats, respectively. A total of 10,341 SSRs were finally identified with 250-bp upstream and downstream flanking sequences. Unique SSRs were selected by utilizing one scaffold corresponding to a single SSR, which resulted in a total of 7,259 SSR sequences. Furthermore, SSRs from scaffolds containing N's were removed, and 956 SSR sequences with flanking regions suitable for primer designing were selected.

InDel identification: For this, high-quality reads were aligned to reference assembled scaffolds using BWA v.0.7.5a, with default parameters for aligning high-quality reads to reference scaffolds. The InDel positions in the aligned reads were compared against reference scaffolds using the 'mpileup' functions from SAMtools v. 0.1.18. A total of 5,471 InDels were identified at various positions. To validate InDels, filtration criteria adopted were: minimum mapping quality = 30 and minimum read depth >= 15. Furthermore, stringent parameters, such as 250-bpflanking sequences, InDel length >10, mapping quality of 60, read-depth of 20, etc. were used to identify only unique InDels, which resulted in a total of 44 InDels. All scaffolds containing SSRs and InDels were functionally annotated using BLASTn and BLASTx.

Validation of SSR and InDel markers: Primers were

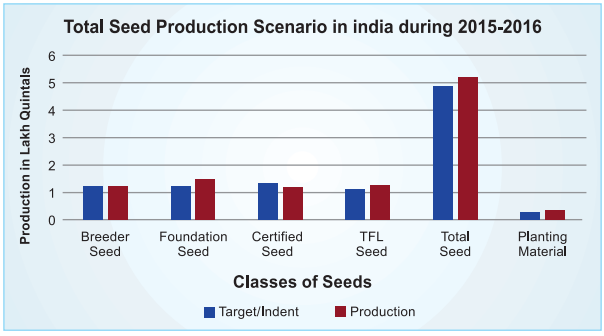
designed for these 1,000 SSR and InDel markers using BatchPrimer3, with optimal parameters such as Tm 57-61 and GC% 40-55, and checked for absence of hairpin structures and self-annealing. All of them were validated in several *C. olitorius* accessions using standard PCR and PAGE.

Mitogenomes of two cultivated jute species revealed: An efficient protocol for high-quality mitochondrial DNA isolation and purification for both the cultivated jute species has been developed. Mitogenomes of *C. capsularis* (white jute) and *C. olitorius* (dark jute) were sequenced by NGS using 2 × 300 bp and 2 × 150 bp chemistry on Illumina MiSeq and NextSeq 500, respectively.

Using Newbler v2.6 and SSPACE v1.1, the filtered reads were assembled de novo to 1,999,602-bp and 1,829,341-bp circular sequences in *C. capsularis* and *C. olitorius*, respectively. Both the mitogenomes were annotated using Mitofy, with an E-value cut-off of 10^{-6}, and the ORFs were identified by specifying start codons as ATG and ACG using CLC genomics workbench V6. *C. capsularis* mitogenome contained 37 protein-coding and 3 rRNA genes, and *C. olitorius* mitochondrial genome contained 35 protein-coding and 3 rRNA genes. As for tRNAs, C. *capsularis* contained 32 tRNAs, while *C. olitorius* contained 34 tRNAs. A total of 620 and 644 ORFs were identified in *C. capsularis* and *C. olitorius*, respectively. Comparative mitogenomics between the two cultivated jute species revealed large-scale genomic rearrangements and their complex evolution.

Seed technology

Quality seed production: During 2015-16, 1.25, 1.49, 1.19, 1.28, and 0.37 lakh q of breeder, foundation, certified, truthfully labelled seeds and planting material, respectively, were produced. Further nearly, 272 lakh of planting material and 13 lakh tissue-cultured plants were produced during the year.



Seed production scenario during 2015-16

Horticulture

Fruit crops

Guava hybrid 'H-1314' (Purple Local × Allahabad Safeda); identified for table purpose, 300-325g fruits weight, firm and 1.6 - 1.8 cm thick white pulp, medium seed hardiness (10.0-10.5 kg/cm^2) and good TSS (10 - 11°Brix). Guava varieties, Arka Kiran and Arka Mridula, as female parents were observed to be cross compatible with wild species *(Psidium guineense)* with~75% fruit set. Advanced inter-generic hybrid progenies between Arka Surya × *Visconcellea cauliflora* attained stability for broad leaf trait and fruit shape with field tolerance to PRSV.

Guava hybrid H-1314

Pomegranate Hybrid -4/2 produces large reddish fruits (400g) with thin rind and soft, dark red, sweet (TSS 17.6°B) arils.

Nagpur Mandarin Seedless-4 is a clonal selection, having attractive seedless fruits, 679 fruits/plant (98 kg/plant), 145 g fruit weight, TSS (10.44°Brix), acidity (0.72%) and juice (46.06%). It contains less than 2.57 seeds/fruit against standard check, 'Nagpur Mandarin' (12.68 seeds/fruit). Acid Lime -7 is high-yielding (195 kg/tree) variety (54 tonnes/ha) with high juice content (50.50%) and attractive fruit. Fruit weight is 48g with 8.45 seeds/fruit, acidity 7.05% and TSS 7.93%. Acid Lime 8 is very high (216 kg/tree) yielding (59 tonnes/ha) and cluster bearing variety. Fruit weight is 50g and juice content 51.5%. The number of fruits/ cluster is 2 - 9. Average seeds/ fruit are 8.61, acidity 7.01% and total soluble solids 7.96%. NRCB-7 is a banana selection from the local culinary landrace, Bangrier (ABB, subgroup Bontha) with 15% higher yield (28-30 kg/bunch) as compared to 22-25 kg in local check, Monthan with 10-12 tightly packed hands/bunch and elongate fruits (20-22 cm) with pointed tip. NRCB-8 banana is an exotic introduction of cv. Saba (ABB) with 30 kg/ bunch. The fruits are dark green and flattened with a blunt tip, suitable for both culinary and dessert

Nagpur Mandarin Seedless 4

purposes. A hybrid progeny, No. 14, of the cross combination of Anaikomban (AA) × Pisang Jajee (AA), 250-270cm long and 80-95cm broad leaves with soft midrib and flexible leaf blade with good keeping quality (one week at room temperature) was observed suitable for leaf production.

CISH-J-42 jamun is a seedless selection. Its fruits are oval and fruit weight is 8g. Thar Kranti jamun (*Syzygium cuminii*) has been developed through selection. Fruits ripen in 75 days from fruit set. Bearing starts in 3rd year, fruit yield 65kg/plant, and suitable for table purpose. Seven hybrids of pomegranate were evaluated during seventh year of planting in *mrig bahar* and compared with Bhagwa. Maximum number of fruits was in NRCP H-6 (125 /plant) and fruit yield in NRCP H-6 (35.64 kg/plant), followed by NRCP H-14 (33.14 kg/plant). NRCP H-6 has been identified for table purpose. Thar Malti ber is a chance seedling selection, late-maturing type and high fruit-yielding (60kg/plant). Fruits are sweet at green maturity stage and suitable for cultivation under arid conditions.

Jamun Thar Kranti

Thar Harit mulberry (*Morus* sp.) has been developed through selection, fruits are green and sweet. Average fruit yield is 20-25 kg/ plant, suitable for cultivation under hot-arid conditions. Thar Pragati phalsa is dwarf, early, precocious -bearer and suitable for high density planting. Fruits ripen in 60 days from fruit set. The fruit yield is 3-4 kg/plant, fruits are suitable for table and processing purpose. Thar Neelkanth bael has been developed through selection**.** The fruit yield is 70-75 kg/ plant (8th year) with 1.5 kg fruit weight, suitable for table purpose and processing. The fruits are less affected by sun scald.

Mulberry Thar Harit

Phalsa Thar Pragati

Plantation crops

Coconut, hybrid Kalpa Samrudhi (Dwarf × Tall) and Kalpatharu (high-yielding, premium ball copra, coconut variety), have been released for cultivation in Kerala, Karnataka and Tamil Nadu. One areca nut selection, VTL146, with dry kernel yield of 3.91 kg/ palm/year and tender nut yield of 3.26 kg/palm/year, was identified for release. One cocoa hybrid, VTCP1, with average dry bean yield of 3.2 kg/tree/year was recommended. In addition, three cocoa clones, VTLC-13, VTLC-20, VTLC-120, with higher yield potential (2.5-2.8 kg/tree/year dry bean yield), optimal canopy both under arecanut and coconut shades, high bean index (1.2) were identified for varietal development.

Vegetable crops

Arka Samrat tomato was recommended as bacterial wilt resistant tomato hybrid for Karnataka, Tamil Nadu, Andhra Pradesh and Kerala. It has ~100 tonnes/ha yield potential. The plants of Arka Avinash brinjal are tall and spreading with dark green foliage and long green fruits, resistant to bacterial wilt, green tender fruits with good keeping and cooking quality. If yields ~ 36 tonnes/ha. The plants of Arka Harshitha brinjal are tall and spreading with dark green foliage and fruits, resistant to bacterial wilt, tender fruits with good keeping and cooking quality. yields ~ 40 tonnes/ha. The plants of Arka Unnathi brinjal are tall and erect with dark green foliage and fruits with green calyx, fruits born in cluster, resistant to bacterial wilt, tender fruits with good keeping quality and good cooking quality. It is suitable for both *kharif* and *rabi*. The yields potential is ~ 34 tonnes/ha. Chilli, Arka Khyati, a CGMS based high-yielding F_1 hybrid having light green, medium pungent and smooth fruits which turn deep red on maturity, yielding 40-45 tonnes/ha (fresh) and 5-5.5 tonnes/ha (dry) in 180 days, has been recommended for cultivation in Karnataka. Pea 'Arka

Tomato Arka Samrat

Arka Khyati (MSH 206): a high-yielding chilli

Priya' was recommended as powdery mildew resistant variety for zone I, IV and VIII. Arka Nirmal, Arka Harini, Arka Mayur, Arka Tapas, Arka Uttam, and Arka Chaitra have been released. Sem or Indian bean, Arka Pradhan, Arka Krishna, Arka Adarsh,. Arka Prasidhi, Arka Bhavani, Arka Vistar have been released.

Arka Mayur (IIHR 5-13)

French bean, Arka Sharath, is round fruited, string less, smooth, crispy, fleshy with no parchment has been recommended for release by SVEC for Karnataka. It is suitable for steamed beans, plants are bushy and photo insensitive and suitable for both *kharif* and *rabi* seasons. It gives maximum number of pods per plant (44.5) compared to checks. It has high pod yield potential of 18.5 tonnes/ha in 70 days. Yard long bean, Arka Mangala, is with tall plants (3-4 m), long (80 cm) light green, stingless, round and tender with crisp textured pods. It comes to first harvest in 60 days. Pod yield is 25 t/ha in 100 days. It is suitable both for *kharif* and *rabi*.

Pumpkin, Thar Kavi, has been developed by hybridization followed by selection from lines CM16 × CM19. Fruits are small (900g) with 7-8 kg yield/ plant. It is moderately resistant to fruit fly, powdery mildew and pumpkin mosaic virus under field conditions. Muskmelon, Sel-3, is a selection, yield of 31.60 tonnes/ha with elongated global fruits, golden yellow smooth rind, creamy-white flesh and crisp and juicy texture. An early and high-yielding variety of long melon is recommended for Bihar, Uttar Pradesh, Jharkhand and Punjab. The average fruit length and fruit weight is 30 cm and 50-60g, respectively. The fruit is crispy, light green with smooth prominent ridges.

Muskmelon selection 3

It has an average yield of 175-200 q/ha. Two antioxidant rich vegetable amaranth varieties, viz. Arka Samraksha and Arka Varna, were developed. Arka Samraksha is uprooting type, high-yielding variety with green leaves and stem, high antioxidant activity of 499 mg (AEAC units) and minimum nitrate (27.3 mg) and oxalates (1.34 g/100 g fresh weight of leaves) content, yields 10.9 t/ha in 30-35 days. Arka Varna is uprooting type, high-yielding amaranth variety with green leaves and pink stem, high antioxidant activity of 417mg (AEAC units), nitrate (37.6 mg/100 g fresh leaf) and oxalates (1.42g/100 g fresh weight of leaves), yields 10.6 t/ha in 30-35 days.

Arka Bheem, a tri-parental synthetic variety of onion has been recommended for cultivation in Karnataka. It has red to pinkish red, elongated globe shaped bulbs, with an average bulb weight of 120 g. It yields 42 tonnes/ha in 130 days.

Spices

Ajmer Coriander-1 (ACr-1) is a high-yielding (11.7 q/ha), dual purpose and stem gall resistant variety and has been released for cultivation in Rajasthan. Ajmer Fennel 2 has been developed and identified for release in AICRPS workshop at all India level for high seed yield (17.9 q/ha) and moderately resistant to *Ramularia* blight disease. Ajmer Dill-2 is a high-yielding (14.6 q/ha) variety and matures in 135 days, released for cultivation in Rajasthan.

Ajmer Dill-2

Drumstick (*Moringa oleifera*), Thar Harsha, is late maturing type (harvesting from April-June, i.e. 160-180 days after sowing). Pods are green and straight (1 m long). It is drought hardy and resistant to leaf eating caterpillar and moderately resistant to fruit fly under field condition. Pod yield is 45-48 kg/ plant. Leaves are suitable for both vegetable and fodder purpose.

Potato

Kufri Mohan has been recommended for release. This variety produces attractive white-cream, ovoid, uniform tubers and is suitable for northern and eastern plains of the country. Medium maturing (90 days) variety, suitable for fresh consumption. With mealy texture, pleasant flavour and free from discolouration after cooking, it produces high tuber yield (35-40 tonnes/ ha). It is resistant to late blight (*Phytophthora infestans*) and recommended for cultivation in Indo-Gangetic plains.

Further, based on consistently good performance over the years, seven advanced breeding lines (hybrids) namely J/8-85, J/8-91, J/8-119, PS/09-16, PS/09-9 (table purposes); MP/9-28 (chips) and HT/07-1329 (heat stress) were identified for multi-location trials.

Tuber crops

Greater yam clone, Dah-9/196, produced highest yield (30.2 tonnes/ha), followed by Da-293 under non-trailing conditions. Among white yam hybrids, Drh-1150, produced highest tuber yield (61.70 tonnes/ha), followed by Drh-1125 (59.70 t/ha). The dwarf white yam hybrids, viz. Drd-1038, Drd-1110, Drd-1835, Drd-920, Drd-1089 and Drd-1078 had excellent cooking quality.

Ornamental crops

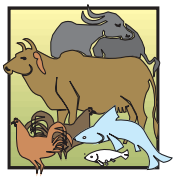
Two hybrids, Arka Manorama and Arka Aayush, of gladiolus were released.

Medicinal and aromatic plants

Isabgol, Vallabh Isabgol-1, is a high-yielding (12 q/ha) medium-duration (120-125 days) variety, recommended for cultivation in semi-arid regions of India.

Vallabh Isabgol 1

❑



6. Livestock Improvement

Cattle

Frieswal Project: The strength of elite cows at various Military Farms was 1,176 which has increased by 6% from previous year (1,111). Out of the 8 bulls inducted for the genetic evaluation in 2006, five exceeded the herd average and the top ranking bull had 3.97% genetic superiority over the population mean.

Indigenous Breeds Project: Under the Indigenous Breeds Project, 26 breeding bulls of Gir, Sahiwal and Kankrej were inducted in the third set for progeny testing. A total of 45,511, 44,521 and 11,890 semen doses were produced from Gir, Kankrej and Sahiwal breeds, respectively. And 2,800, 2,003 and 1,163 inseminations were carried out during the year with overall conception rate of 42.65, 52.57 and 45.33% respectively, and 625, 173 and 212 daughters were produced.

Field Progeny Testing Project (FPT): Under Field Progeny Testing Programme, 30 bulls were introduced for test mating. Frozen semen doses (60,000) were distributed (500 semen doses/bull/centre) to GADVASU, Ludhiana; KVASU, Thrissur; BAIF, Uruli Kanchan; and GBPUA&T, Pantnagar. The overall conception rate was 43.5%.

Buffaloes

Field progeny testing of bulls: Under field progeny testing programme (FPT) at CIRB Hisar, 4,119 AIs were performed using 28 test bulls with 50.41% conception rate in 10 adopted villages.

Genetic improvement: In a Murrah herd, the overall wet average, herd average, 305 days milk yield and average lactation milk yield were 8.45 kg, 5.67 kg, 2,398 kg and 2,598 kg, respectively, which were highest since inception of the project. The service period was 148 days and calving interval 460 days during the period.

In Nili-Ravi buffaloes, the overall wet average, herd average, 305 days milk yield and average lactation milk yield were 8.10 kg, 5.68 kg, 2,473 kg and 2,564 kg, respectively, which were also highest since inception of the project. The service period was 135 days and calving interval 442 days.

Germplasm conservation and dissemination: Murrah young bulls (28) were tentatively selected as future breeding bulls and 6 superior males selected for test mating of 15th and 16th sets. A total of 106,729 and 16,890 semen doses of Murrah and Nili-Ravi bulls were frozen.

Sheep

Introgression of *FecB* gene: A prolific triple breed cross Avishaan developed at CSWRI, Avikanagar, has 12.5% Garole, 37.5% Malpura and 50% Patanwadi inheritance. Avishaan ewe has 99.2% tupping and 98.5% lambing rate on available basis. Multiple births of 57.1% with litter size of 1.6 indicated successful introgression of *FecB* gene in this prolific strain. The average live weights at birth, 3, 6 and 12 months of age of the lambs were 3.1, 16.2, 24.2 and 31.8 kg, respectively. Average adult annual greasy fleece yield is 954 g. The survivability during pre- and post-weaning of lambs and adult stage were 93.0, 96.1 and 98.6%, respectively. In the field flocks, average body weights at birth, 3, 6 and 12 months of age of the lambs born were 2.8, 13.2, 23.0 and 28.1kg, respectively.

Avishaan – A prolific triple breed cross of 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 co-operating centres located in various ICAR Institutes and State Agriculture/Veterinary Universities. Presently, there are 6 ongoing co-operating centres with its co-ordinating unit at ICAR-CSWRI, Avikanagar. Four of these centres are farm based, while two are field based.

Marwari, Muzaffarnagri, Deccani and Nellore sheep are maintained under farm units for improvement through selection and production of superior germplasm. Rams and ewes of Marwari, Muzaffarnagri, Deccani, Nellore and Magra sheep were sold for genetic

Performance of farm flocks

Breed/ Particulars	Average body weights (kg)				
	Birth	3 M	6 M	9 M	12 M
Marwari	3.37	17.90	25.11	29.98	34.55
Muzaffarnagri	3.53	16.21	24.61	28.21	35.45
Deccani	3.29	14.87	20.58	22.20	25.04
Magra	3.28	18.53	26.90	32.80	35.67
Nellore	3.01	15.50	21.00	22.88	25.28

Performance of farm flocks

Breed/ Particulars	Annual GFY (kg)	Tupping (%)	Annual lambing (%)	Overall survivability (%)	Sale	
					Rams	Ewe
Marwari	1.526	97.66	91.42	98.20	67	25
Muzaffarnagri	1.262	100	90.70	97.50	39	10
Deccani	0.951	95.95	93.77	92.11	80	21
Magra	2.308	94.68	87.04	99.01	130	27
Nellore	NA	97.52	85.89	91.73	62	0

Performance of farmers' flocks

Breed/Particulars	Average body weights (kg)				Annual lambing (%)	Distribution of rams
	Birth	3 month	6 month	12 month		
Madras Red	2.55	10.59	15.66	21.13	86.82	126
Magra	2.60	16.15	22.33	30.08	75.75	38

GFY: Greasy Fleece Yield

improvement of farmers' flock during the year. About 126 Madras Red rams and 38 Magra rams were distributed to registered sheep farmers for field flock improvement. Breedable Madras Red ewes (6,176) of 115 sheep farmers and 4,744 breedable Magra ewes of 98 sheep farmers were registered for performance recording and genetic improvement.

Mega Sheep Seed Project: The project has five co-operating units, namely, BAU, Ranchi for Chhotanagpuri breed; KVAFSU, Bidar for Mandya breed; TANUVAS, Chennai for Mecheri breed; RAJUVAS, Bikaner for Sonadi breed; and ICAR-CSWRI, Avikanagar for Malpura breed. The project aims at improvement of indigenous sheep breeds by providing superior germplasm to the farmers through production and distribution of elite rams as well as estrus synchronization of ewes coupled with artificial insemination with freshly diluted liquid semen.

Flocks of sheep, viz. Chottanagpuri (789), Mandya (417), Mecheri (631), Sonadi (428) and Malpura (912) were built up for the production of high performing sheep seed. Superior rams were distributed to registered farmers for improvement of their flock.

Improving goat productivity in Farmers' flock

AICRP on Goat Improvement is operational at 461 villages covering 3,840 farmers. Performance recording was carried out in 25,622 animals during the year. Goat Production Management Information System (GMIS) provided an efficient and effective way of data recording, data analysis, monitoring and evaluation etc. Various sub-modules are regularly modified/ updated as per the feedback received from 18 co-ordinating units of AICRP on Goat Improvement. The website is hosted and currently running with URL "http://pcgoatcirg.icar.gov.in/".

The increase in body weight at 12-month age over the units varied from 0.38 to 32.12%. Similarly, the increase in milk yield at 90 days varied from 3.35 to 48.85% across the units. The average pashmina production of Changthangi goats was 265 g. Preventive health care contributed in increasing the population growth and also improving the farmer's income by 22 to 35%. A higher population growth amongst breeds resulted in increased selection intensity, thus realized genetic gains were higher. Animals with improved productivity were produced at Farm units and distributed to different agencies for breed improvement as well as for up-gradation of local germplasm. The field units also distributed improved bucks to adopted farmers. AICRP units also conducted 101 training programmes for skill development in goat husbandry.

Goat

Genetic Improvement Programme: Selective breeding is being carried out to improve the production performance and to fulfil the need of the genetically superior bucks in their breeding tract. Selective breeding of Jamunapari, Barbari and Jakhrana goats resulted in significant improvement in body weights and milk yields. A positive genetic trend was recorded for milk yield in Jamunapari goat population showing significant improvement in milk yield over the years for both 90 and 140 days of lactation.

Eight multiplier flocks were established in Agra and Mathura district to increase the availability of Barbari bucks for genetic improvement of the breed in the field.

Pig

Crossbred pig varieties: Rani and Asha, new and improved crossbred varieties of pigs, were released by ICAR-NRC on Pig, Rani. The crossbred pig variety Rani was developed by crossing Hampshire (exotic breed) with Ghungroo (indigenous breed) to have 50% inheritance of both the breeds. The breed characters of Rani crossbred have been stabilized through consistent interse-mating of six generations. The breed can attain 75 kg body weight at slaughter age of 8 months with 1.98 cm of back fat thickness. Rani cross has also been validated in farmers' field.

Two new and improved crossbred varieties of pigs namely Rani (*left*) and Asha (*right*) were released

Duroc, another exotic germplasm, was crossed with Rani to develop Asha variety having 25% Ghungroo, 25% Hampshire and 50% Duroc inheritance. Asha can attain 80 kg body weight at slaughter age of 8 months with 1.75 cm back fat thickness.

Poultry

Broilers: The overall average of body weight at 5 weeks in Synthetic Dam Line (SDL) was 1,152.84±2.44g. The average hen housed egg production up to 40 and 52 weeks of age were 65.4 and 108.2 eggs. Egg weight at 40 and 52 weeks were 65.24±1.50 and 62.36±0.77 g, respectively. The age at first egg in Coloured Synthetic Female Line (CSFL) was 179.30 days. Average hen housed egg production up to 40 weeks and 52 weeks were 65.8 and 109.9 eggs/bird.

Layer: The reproductive performance (measured as fertility percentage) of selected strain of Rhode Island Red (RIRs) and the control population (RIRc) for 32nd generation was in the range of 83.6 to 86.9% and 86.0 to 87.8%, respectively. The RIRs females recorded a significantly higher 40th week egg production (51.3 eggs) and egg weight (1.90 g), accompanied with lower age at the first egg (by 39.0 day) as compared to RIRc.

Immuno-competence and microsatellite profiling in RIR: Results revealed significant effect of ADL0328 microsatellite-genotypes on chick weight and body weight at 2 and 28 weeks of age; LEI0068 genotypes on body weight at 28 week of age; LEI0071 genotypes on chick weight and body weight at 28 weeks of age; MCW0010 genotypes on body weight at 16, 32, 36 and 40 weeks of age; and MCW0058 on body weights at 24 and 28 weeks of age.

Ankleshwar (AN) Nicobari (NC)

CARI RED (CR) NC×CR

Improvement of poultry germplasm: At DPR, Hyderabad, PD-1 (Vanaraja male line), GML (Gramapriya male line), PD-2 (Vanaraja female line) and PD-3 (Brown egg layer line) were maintained for use in developing rural chicken varieties. In PD-2 line, age at sexual maturity was 161.5 days, which was lower than that of the last generation. The phenotypic and genetic response for part period egg mass up to 40 weeks of age was 210 g and 65.8 g/generation, respectively, over last five generations. Native chickens (Aseel, Ghagus and Nicobari) were conserved and PD-4 (Improved Aseel) is being improved for body weight and egg production. In PD-4 line, body weight improved by 12 g and shank length 1.33 mm at 8 weeks of age in S-6 generation.

Nicobari female bird Nicobari male bird

Under the conservation programme, Aseel birds were characterized phenotypically as multi colour plumage type (predominantly dark brown, black, golden etc.) with solid feather pattern and normal distribution, pea comb (98%) with dark red colour (82%). In native pure Aseel, the body weight at 6, 12 and 16 weeks was 313.7, 857.3 and 1,312.2 g, respectively, with corresponding shank lengths of 72.3, 97.8 and 110.8 mm. The annual egg production up to 72 weeks of age was 64.4 eggs during the G2 generation.

All India Coordinated Research Project on Poultry Breeding: Under AICRP on poultry breeding, all the centres are working for the development of location specific rural poultry variety utilizing the local native chicken germplasm in addition to the conservation of elite layer and broiler lines.

The KVASU, Mannuthy centre evaluated S-0 generation of native chicken germplasm. The egg production of native chicken germplasm up to 40 weeks of age was 69.8 eggs with an average egg weight of 43.6 g. At AAU, Anand, chicks of S-0 generation of native birds and RIR were produced by pedigreed mating. Three-way cross was produced with F_1 (IWN × Native) × RIR and evaluated. Egg production up to 64 weeks of age was higher in IWN (253 eggs) than IWP (244 eggs) strain.

At Bengaluru centre, body weight of indigenous birds at day-old, 8, 12 and 20 weeks of age was 32.2, 470, 987 and 1,311g, respectively. At GADVASU, Ludhiana centre, the body weight at 5 weeks of age

Caribro-Dhanraj

At 44th RSPPT (Gurgaon) CARIBRO-Dhanraja secured III rank with 6-week body weight of 1.59 kg, FCR (0-6 weeks) 2.3%, mortality 4.6% and dressing 71.56%. Margin of receipt over feed cost at 6-weeks was ₹ 1.94/bird. Fertile eggs were procured from village areas, chicks were hatched and performance was evaluated.

Variety development

Narmadanidhi, a dual purpose colour bird, for rural poultry farming was developed and released under AICRP on Poultry Breeding at NDPCVVV, Jabalpur, Madhya Pradesh. Male birds attained 1 kg body weight in 9-10 weeks of age, while body weight at 20 weeks ranged from 1.6 to 2.2 kg in males and 1.3 to 1.7 kg in females. The annual egg production is about 180 eggs under backyard system.

Narmadanidhi

Jharsim

Jharsim, a multi-coloured bird, suitable for rural poultry production was developed and released under AICRP on Poultry Breeding at BAU, Ranchi, Jharkhand. The body weight at sexual maturity is 1.6-1.8 kg and annual egg production is 120-130 eggs.

increased in PB-1, PB-2 and Control lines over previous generation. The FCR showed marginal improvement in all lines as compared to the previous year. The average phenotypic and genetic response of body weight at fifth week over 10 generations in PB-2 was 14.07 and 8.21 g, respectively. The average body weight of local chicks at day one, four and eight week was 36.6, 235.8 and 746 g, respectively. The phenotypic and genetic response at 5-week body weight over last 10 generations was 9.03 and 39.6 g in PB-2 population.

At the CARI, Izatnagar centre, native chicken collected from farmers were regenerated. The day-old and 5-week body weights of native birds were 32.2 and 216.4 g, respectively. Bhubaneshwar centre completed regeneration of new population of native chicken germplasm.

Egg production up to 72 weeks in Tripura black was 89.3 eggs and in Dahlem Red birds 139.5 eggs at the Agartala centre. The Guwahati centre evaluated the native, Dahlem Red, PB-2 and Kamrupa variety of chicken. The hen housed egg production in Kamrupa variety up to 40 and 52 weeks of age was 46.9 and 87.3 eggs in the farm and 41.9 and 71.5 eggs in the field, respectively.

G-4 generation of native population and two Crosses namely, DNB [(Dahlem Red × Native chicken) × PB-2] and BND [(PB-2×Native chicken) × Dahlem Red] were evaluated up to 72 weeks of age, at the Ranchi centre. The annual hen housed egg production of native population was 73.4 eggs. The egg production up to 72 weeks of age was more in DNB cross (111.1 eggs) than BND cross (96.2 eggs) under field condition.

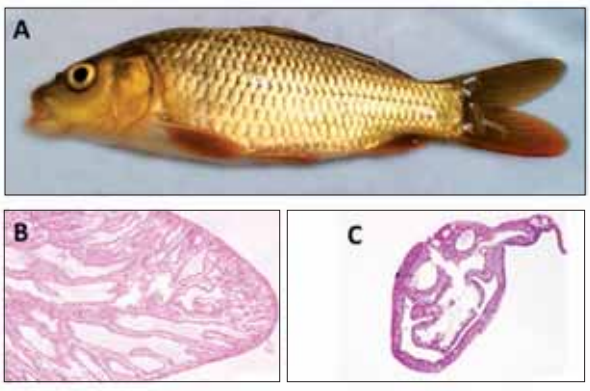
CSKHPKV, Palampur centre evaluated Native chicken, Dahlem Red and crosses namely, DR×N (Dahlem Red×Native chicken) and DN×D [(Dahlem Red×Native) ×Dahlem Red] up to 52 weeks of age. The hen housed egg production up to 52 weeks of age was 83.3, 72.4 and 120.1 eggs in Dahlem Red, native chicken and DR×N populations, respectively. The 20-week body weight was 1,602.8 g in farm and 1,447.7 g under field condition in DN×D cross. The hen housed egg production up to 40 weeks in DN×D cross was 52.7 eggs in farm and 42.3 eggs in field conditions.

MPUAT, Udaipur centre evaluated Mewari breed where the juvenile body weight at 8 weeks was 651.75 g during G-5 generation. The 20-week body weight improved by 245.9 g and 40 weeks body weight by 178.5 g in the present generation. The pullets matured by 4.4 days late as compared to previous generation. The hen day egg production up to 52 weeks was 70.6 eggs.

Fish

Transplantation worthiness of cryopreserved germ cells of Indian major carp: Cryopreservation is an essential tool for germplasm conservation and improvement of productivity in aquaculture. The transplantation worthiness of isolated cryopreserved germ cells (GCs) of Indian major carp, rohu (*Labeo rohita*) was tested by their viability and colonization ability in the allogenic host (*Catla catla*). Rohu GCs were successfully cryopreserved with significantly higher viability using slow cooling rate of –1°C/min and a medium containing dimethyl sulfoxide (DMSO). The frozen/thawed GCs colonized and proliferated in the recipients' gonad. This technique of transplantation of GC into adult gonads paves way for further applications in surrogate animal development.

Surrogate broodstock development: Production



Adult common carp *Cyprinus carpio* (A), testis (B) and ovary (C) showing absence of germ cell after heat-chemical treatment [Scale bar = A (2-cm), B & C (50-µm)]

of surrogate broodstock will help propagate commercially important fishes that are difficult to breed in confinement and also aid in recovery of endangered fish populations. Sterile gonads of common carp, *Cyprinus carpio* were produced using heat-chemical method. These common carp with sterile gonads can be used as recipient for transplantation of donor germ cells, for development of surrogate broodstock. On injection of cytotoxic drug, busulfan, severe gonadal degeneration was observed after 10 weeks at 38ºC water temperature. Hundred per cent sterile (devoid of endogenous germ cells) male and female were obtained. Quantitative analysis of *vasa* gene transcription and change in colouration of gonads were found to be additional tools to measure the degree of gonad sterility.

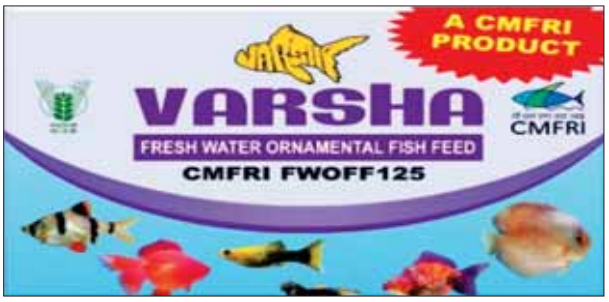
Broodstock diet for pearlspot: EtroBrood^{Plus}, a functional feed for sustaining higher fry yield was developed by ICAR-CIBA. With EtroBrood^{Plus} fry yield per spawning ranged between 1,380 and 4,115 corresponding to 4.6 and 15.4 fry/g of female body weight. In one of the spawnings a record of 5,244 eggs was obtained.

Mass production of hybrid clownfish: Mass production of hybrid percula clownfish was achieved for the first time by ICAR-CMFRI. Successful crossbreeding between Picasso and Platinum clownfish was done. Larviculture protocols were standardized to get year round production of fingerlings by feeding rotifers, *Artemia* nauplii and larval inert diets. An average 65% survival was obtained from larvae to fingerling stage.

Spawning of Picasso × Platinum clownfish

Juveniles of hybrid percula clownfish

Freshwater ornamental fish feed- *Varsha:* ICAR-CMFRI developed and evaluated freshwater ornamental fish feed, *Varsha.* The feed is available in two sizes (1 and 2 mm) at protein levels of 25, 30, 35, 40 and 45%. Varsha contains a high quality marine protein mixture (fish, shrimp, squid and clam), soy, wheat, fish oil, vitamins, minerals, spirulina, assorted carotenoids, anti-oxidants and anti-fungal agents.



Adoption of sea cage farming

Low cost cage farming technology developed by ICAR-CMFRI is well accepted by fishermen groups and entrepreneurs. The State Fisheries Department of Tamil Nadu under the World Bank funded project 'Fisheries Management for Sustainable Livelihoods' (FIMSUL-II) is supporting 10 fisher groups for undertaking sea cage farming in Tamil Nadu. Initiative of ICAR-CMFRI, Mandapam Research Centre in popularizing sea cage farming of cobia led to about 25 fisher groups to adopt sea cage farming and cobia culture in 60 cages in Gulf of Mannar and Palk Bay Region.

Marine shrimp farming in inland saline areas: ICAR-CIFE successfully field-demonstrated the technology for marine shrimp culture in inland saline affected areas. Technology development and demonstration of tiger shrimp (*Penaeus monodon*) and white leg shrimp (*Penaeus vannamei*) farming paved way for large-scale adoption of shrimp farming by the farmers of Haryana, Punjab and Rajasthan. The total area covered in shrimp farming by these states has reached to about 90 ha with an average productivity of about 7 to 10 tonnes/ha and a survival rate of 70-80%.

❑

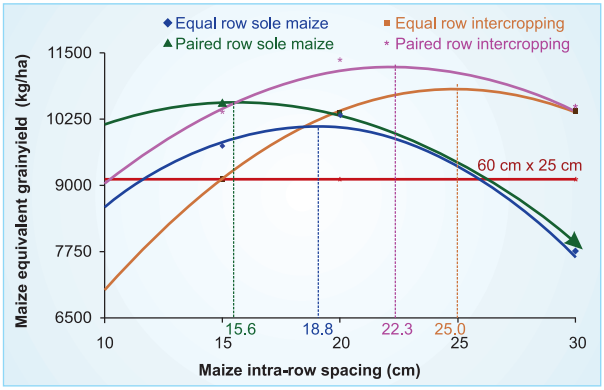
7. Crop Management

PRODUCTION

Production and productivity potential of crops depend mainly on the genetic make-up of the varieties, however, under field conditions, biotic and abiotic stresses during the cropping season, exert significantly on the resultant yields. Biotic stresses including fungal, bacterial, virus and nematode diseases, besides insect-pests and weeds, play an interactive role with host and prevailing environment in deciding productivity. It is a well-known fact that native and alien invasive pests harm crops and reduce vegetative growth as a result of killing the plant or affecting the yield per plant depending on the extent of damage. To meet the national and global challenges of food security and to ensure increase in production, minimization of crop losses through effective crop-health management strategies play an imperative role.

Cereals

Plant geometry, density and intercropping interactive effect on maize productivity: Vivek QPM 9 maize variety was evaluated at different plant geometries (equal row at 60 cm and paired row of 75 cm: 45 cm), plant densities (intra-row spacing of 30, 25, 20 and 15 cm) and intercropping (sole crop and intercropping with soybean). The optimum intra-row spacing for equal row sole crop, equal row intercropping, paired row sole crop and paired row intercropping was 18.8, 25.0, 15.6 and 22.3 cm, respectively. And estimated potential yield at different spacings were 11, 19, 16 and 23% higher than the recommended 60 cm × 25 cm (9,116 kg/ha). Hence, paired row planting of maize intercropped with soybean and having intra-row spacing of 22.3 cm has been recommended to harvest potential yield.



Response of maize equivalent grain yield to different planting geometries and intra-row spacings of maize

Agroforestry in different agro-climatic zones: The methodology has been developed and standardized for mapping and estimating agroforestry area at the district level using medium-resolution remote sensing data (LISS III, 23.5 m). Total area under agroforestry in nine agro-climatic zones is 13.623 M ha, which is 8.09% of the geographical area. In terms of the area, maximum was in agro-climatic zone 5 — Upper Gangetic Plains region (15.47%); followed by agro-climatic zone 12 — West Coast Plains and Hill Region (14.18%).

Agro-climatic zone-wise estimated area under agroforestry

ACZ no.	Agro-climatic zone	Geographical area (M ha)	AF area (M ha)	AF area (%)
3	Lower Gangetic Plains Region	6.733	0.802	11.91
4	Middle Gangetic Plains Region	16.570	1.304	7.87
5	Upper Gangetic Plains Region	14.441	2.234	15.47
6	Trans Gangetic Plains Region	11.603	1.143	9.85
8	Central Plateau and Hill Region	37.843	1.926	5.09
9	Western Plateau and Hill Region	32.740	1.556	4.75
12	West Coast Plains and Hill Region	11.682	1.657	14.18
13	Gujarat Plains and Hill Region	18.977	2.570	13.56
14	Western Dry Region	17.871	0.431	2.41
	Total/Average	168.460	13.623	8.09

ACZ- Agroclimatic Zone

Pulses

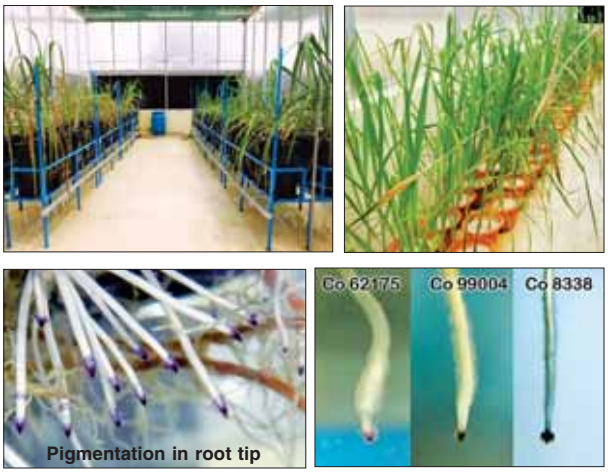
In chickpea, optimum irrigation scheduling with sprinkler irrigation at branching and pod development resulted in significantly higher grain yield (16.1%), net returns (22.4%), BCR (22.8%) and productivity per day (16.4%) over to only at branching stage. In mungbean, sprinkler irrigation resulted in 27% reduction in water consumption, 67.1% higher water-use efficiency, and incremental net returns of ₹ 9,083 and elevated benefit: cost ratio of 0.13 over flood irrigation.

Maximum grain yield was recorded in *kharif* mungbean in plots applied with pendimethalinimaze-thapyr (864 kg/ha) and pendimethalin *fb* clodinafop-propargyl at 150 g/ha (780 kg/ha), and there was no effect on soil microbial parameters even 30 days after their application. Topramezone and clodinafoppropargyl + Na-acifluorfen were found effective in controlling

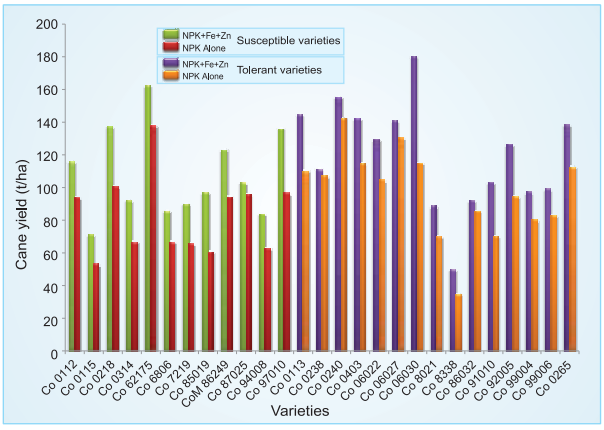
variety of weed flora in chickpea, particularly, broad-leaved weeds.

Commercial crops

Sugarcane: *Rhizosphere characterization of selected sugarcane genotypes:* The rhizosphere characters of 25 sugarcane varieties were studied in hydroponics and data were collected on root branching, purple colouration, binding of dirt and colloidal particles, strong violet / blue pigmentation in root- tip, varying peroxidase and superoxide dismutase activities and total phenolics. Qualitative HPLC analysis indicated presence of galic, caffeic, vanilic, syringic and ferulic acids in the rhizosphere.

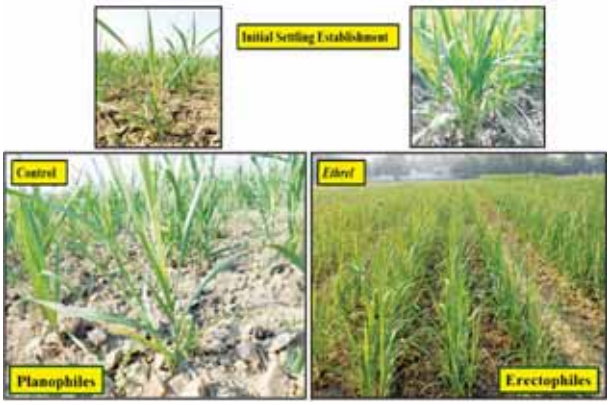


Micronutrient fertilization responses on first ratoon sugarcane: Application of 100 kg $FeSO_4$ + 40 kg $ZnSO_4$ along with the recommended doses of 280:62.5:120 kg $N:P_2O_5:K_2O$ to ratoon sugarcane resulted in 28% higher mean cane yield than NPK alone in 27 sugarcane varieties. Varieties susceptible to micronutrients' deficiency gave 32% higher mean cane yield while tolerant gave 25% higher mean cane yield.



Response of first ratoon sugarcane varieties to micronutrient fertilization

Architectural alterations in sugarcane: Plant growth hormones (Ethrel and GA_3) potentially improved sett vigour, enhanced its ability to sprout and established uniform and robust settlings in spring-planted sugarcane



Uniform and robust settling establishment through Ethrel application in spring-planted sugarcane

Leaf arrangement alterations through Ethrel and GA_3 applications in spring-planted sugarcane

Root architectural alterations through Ethrel and GA_3 applications in spring-planted sugarcane

Crop stand at maturity with more number of millable canes and long internodal length impacted by Ethrel and GA_3 in spring-planted sugarcane

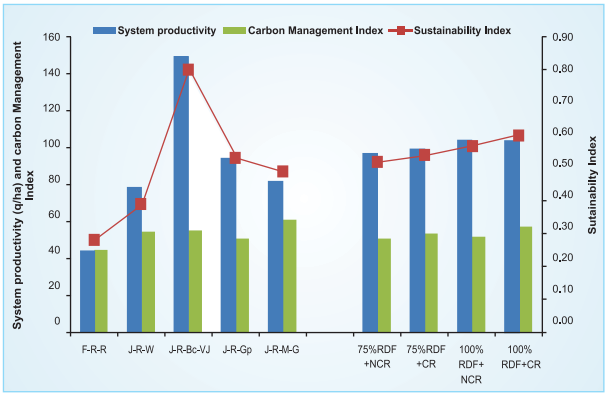
crop. Their use significantly altered leaf orientation, cane length and root architecture. Architectural alterations caused faster heterotrophic to autotrophic transition at the planting stage (February). This induced high initial plant population (45 days after planting, DAP), which was followed by induction of smart canopy with increased source activity above and below the ground sink development at 60 DAP. The formation of smart canopy was due to erectophiles (leaf angle 73°) against planophiles (leaf angle 45°) in control. Changes in leaf angle enabled added advantage of enhanced CO_2 utilization and radiation-use efficiency. GA_3-induced leaf orientation formed a smart canopy and improved dry matter partitioning. Further, leaf erectness also reduced shading effect on the following leaves of the stalk, rendering increased radiation use by lower leaf-lamina. GA_3-induced branched roots with steep angles (30°), threefold increase in root weight and root-hair development, sustained nutrient requirement of increased shoot population. As a result, net assimilation rate [0.65 (cm^2 /d)^2], leaf area ratio (16 cm^2 / g) and leaf area duration [55 (cm^2 d)10^4] enhanced noticeably, leading to increased internode number, length and weight. At grand growth and harvest stage, 5.37 lakh shoots /ha with number of millable canes (NMC) of 3.01 lakh/ ha with Ethrel and GA_3 were obtained against 2.13 lakh shoots /ha in control with NMC of 1.32 lakh shoots/ ha. The application led to significant increase in cane yield of 255 tonnes /ha (per cane weight 847 g) against a cane yield of 84.69 tonnes/ha in control (per cane weight 640 g).The large accommodation of stalks in limited ground area with Ethrel and GA_3 can be explained with the development of smart canopies, supported by robust root system, where each plant occupied merely 331 cm^2 area against 800 cm^2 in the control. The architectural alteration through hormones in the crop increased cane yield from 70–85 tonnes/ha to 255 tonnes/ha in spring-planted crop.

Jute: *Intercropping with greengram:* This intercropping enhanced system productivity, smothered dicot and sedge weeds, ensured protein security, improved soil health and strengthened economically poverty stricken jute-farmers. The system recorded jute equivalent yield of 4.5–5.3 tonnes/ha, where sole jute production was around 3.4–3.5 tonnes/ha along with 0.6–1.0 tonne/ha pulse grains. Its benefit: cost ratio was 2.2–2.46 over 1.80 only from sole jute. Intercropping system recorded 2.8–3.4 tonnes jute fibre/ ha. Weed control efficiency of the system was higher (69-82%) than conventional manual weeding twice (63.62%). Greengram produced 2 tonnes of wastes / ha (average nitrogen 2.35%); which is equivalent to 10 tonnes of farmyard manure.

Jute (cv. JRO 204) and greengram (cv. TMB 37) intercropping (1:1) in North 24 Paraganas

Jute-based sustainable cropping systems: Incorporation of non-traditional crops (baby- corn and greengram) with respect to time and place in the conventional jute-rice-rice, jute-rice-potato and jute-rice-mustard cropping systems has been found sustainable.

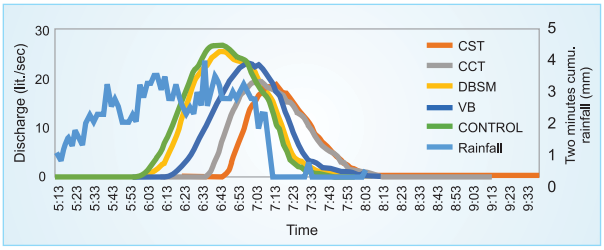
Jute-rice-baby- corn, leafy- vegetable jute and jute-rice-mustard-greengram (where leafy- vegetable jute, mustard and greengram were grown on zero tillage) recorded system productivity to the tune of 14.9 tonnes/ ha and 8.13 tonnes with sustainability of 090 and 0.49, respectively. Carbon management index (CMI) was calculated after four years of crop cycle, and jute-rice-mustard-greengram cropping system recorded highest CMI (60.8), followed by jute-rice-baby-corn-leafy-jute vegetable (55.1). Productivity, sustainability and carbon management index were also higher when 100% recommended dose of fertilizers was applied for all crops along with crop-residue incorporation in the soil.



System productivity, sustainability index and carbon management index of different jute-based cropping systems and fertilizer and crop-residue management practices.
(J–Jute, R–Rice, W–Wheat, Bc–Baby corn; Vj–Leafy jute vegetable; M–Mustard, G–Greengram; CR–Crop-residue incorporation into soil; NCR–Without crop-residue incorporation into the soil)

Forage crops

***Aonla*-based hortipastoral systems:** During the fourth year of the productive phase, plant height, collar diameter and diameter at breast height (DBH) of *aonla* were maximum in contour-staggered trenches (5.0 m, 15.4 cm and 10.9 cm, respectively). Fruit yield was also significantly higher (13.3 tonnes/ha) with contour-staggered trenches, followed by continuous contour trenches (10.7 tonnes/ha) and vegetative barriers (10.1 tonnes/ha). The dry fodder yield was also maximum



Hydrographs recorded from various treatments against 142.8- mm rainfall

in staggered trenches (6.1 tonnes/ha), which was 96.8% higher over control. Microflora population and root biomass were more in contour-staggered trenches {bacteria (6.6×10^6 cfu/g), fungi (114.7×10^4cfu/g) and total root biomass (0.59 g/100g soil)}.

Peak discharge from contour-staggered trenches was 30% lower than control; and it was about 27 and 13% lower in contour-staggered trenches and vegetative barriers, respectively. Peak discharge was delayed by 32, 24 and 18 minutes over control in the contour-staggered trenches, continuous-contour trenches and vegetative barriers, respectively. Lower runoff and delayed peak flow are attributed to higher canopy coverage of trees and growth of pasture under various treatments.

Fruit crops

Pre-harvest spray of GA_3 (100ppm) + potassium sulphate (1%) significantly reduced litchi fruit cracking (14%) and increased fruit weight by 15% in cv. Shahi. The optimum fruit maturity standard of litchi cv. Shahi was recorded at 75-78 days after fruiting when pulp had 18 °Brix TSS and 0.5% acidity. A schedule of 100:50:100 g NPK/plant/year was optimum for litchi var. Shahi with fruit yield of 55 kg/tree at nine-year tree age, while a dose of 75:50:75 g NPK/plant/year was optimum for litchi var. China with 32.21 kg/tree fruit yield in seven-year old trees. A rapid technique (temporary immersion bioreactor) has been developed for mass production of quality planting material of banana cv. Namwa Khom and Udhayam. This bioreactor produces ~56 shoots/explant in cv. Namwa Khom and ~14 shoots/explant in cv. Udhayam within 21 days, which is four- and three-fold increase, respectively, compared to the standard protocol.

Covering of banana bunches shortly after bunch emergence using non-woven, polypropylene bunch sleeves (both blue and white) advanced fruit maturity by 4.4 - 9.3 days, increased bunch weight by 1.6 - 2.8 kg over open (control) bunches with a benefit: cost ratio of 2 : 3.5 and improved the fruit quality compared to the control. Banana bunches were green, free from blemishes and insect damage, fetching 10-15% higher price. Foliar priming of Grand Nain banana plants at flowering stage with acetyl salicylic acid (0.1mM) combined with butylated hydroxy toluene (100 ppm) before imposition of soil moisture stress recorded bunch weight (18.78 kg), comparable to irrigated control (19.72 kg) and other chemicals such as glycine betaine (20mM), beta aminobutyric acid (100 ppm) and 2% urea individually.

Multilocational evaluation of four potential grape varieties revealed a bunch load of 40 bunches/vine with an estimated yield of 11.76 t/acre and 30 bunches/vine with an estimated yield of 15.11 t/acre at Pune (10' × 6' spacing) and Nasik (8' × 5' spacing), respectively, for var. Manjri Naveen, whereas for A18/3, a bunch load of 60 bunches/vine giving a yield of 15 t/acre at Pune (10' × 6' spacing) and 30 bunches/vine giving a yield of 12.5 t/acre at Nasik (8' × 5' spacing) was optimum. For grape var. Medika (juice purpose), a bunch load of 100/vine (yield 15.2 t/acre) and 70 bunches/vine (yield 16.65 t/acre) under Pune and Nasik condition respectively were found suitable for obtaining fruits suitable for juice preparation. In Kishmish Rozavis White (raisin variety), a bunch load of 80/vine (yield 17.42 t/acre at Pune and 16.36 t/acre at Nashik) at both the locations was optimum.

Maximum number of fruits was recorded (76 fruits/plant) in pomegranate var. Bhagwa due to application of sugarcane bagasse mulch, followed by black and pervious (85 fruits/plant), wheat straw or safflower straw mulches. High-density planting (4m ×1 m) in acid lime budded on Rangpur lime rootstock gave 25 t/ha in second crop as compared to 2.8 t/ha inconventional planting (6m × 6m).

Vegetable crops

In tomato, drip fertigation with 80 kg K_2O/ha in nine splits registered maximum fruit yield (2.38 kg/plant; 58.17 t/ha), 70% moreover conventional fertilization. However, maximum potassium use efficiency (98.5 kg yield/ kg K_2O) was with K fertigation @ 60 kg/ha. The maximum dry matter production (215.53 g/ plant) was recorded with K fertigation at 100 kg/ha.

Ornamental crops

In gladiolus, Chandani, Punjab Dawn, Rosiebee Red and Purple Flora, were identified as early flowering cultivars for Pune region. In chrysanthemum, spray type cultivars White Queen, Basanti, Ramlal Dada and Sunny were found to be suitable, whereas among pot mums cultivar Liliput is found to be suitable with respect to dwarfness, compactness and good number of flowers per plant. Among standard type, cultivars Thai-Chen-Queen, Pusa Centenary, White Star and Yellow Star were found to be suitable for Pune region.

Orchids

The scent volatiles emissions of *Zygopetalum intermedium* flowers was studied using gas chromatography-mass spectrometry and a total of 21 scent volatile compounds were identified.

Tuber crops

Compost (24.66 t/ha) prepared from cassava starch factory solid waste was an alternative to farmyard manure (26.64t/ha), green manuring *in situ* with cowpea

(27.18t/ha), crop residue incorporation (25.03t/ha), vermincompost (22.15t/ha) and coir pith compost (21.78t/ha), NPK up to75%(26.55t/ha), $MgSO_4$@ 20kg/ha (27.94 t/ha) and ZnSO@ 12.5 kg/ha (24.44 t/ha). Methodology for cassava acreage estimation by remote sensing and GIS was developed using Landsat 8 OLI satellite imagery along with inverse multiquadratic based Possibilisticc-Meansclassifier. At optimized weighted constant for inverse multiquadratic based Possibilistic c-Means for 4 date combination, the total estimated area was found to be 4234.1 and 2175.63 ha for white Thailand and Mulluvadi, respectively. The total estimated area under cassava in Salem district in 2014 was 8324.2 ha.

Medicinal and aromatic plants

Twenty-eight genotypes of *Andrographis peniculata* were evaluated for their responses to foliar hormone application of 200 ppm GA_3 (as a growth promoter) 30 and 45 days after transplanting, followed by 100 ppm ethrel (as a stress elicitor) 60 and 75 DAT. Hormonal application had increased the leaf area per plant (692 cm^2) from 630 cm^2 in the control. Planting of *Coleus forskohlii* during September and harvesting at 180 DAP produced maximum dry tuberous root yield of 16.34q/ha with total forskolin yield of 22.37 kg/ha and benefit : cost ratio of 2.63.

Spices

Application of FYM + NPK + PGPR + micronutrients resulted in highest yield (3.19 kg/standard), followed by application of FYM + NPK + micronutrients (2.91 kg/standard) in black pepper. Nursery raised in pro trays followed by transplanting exhibited maximum mean seed yield of fennel, dill, celery and ajwain (1966 kg/ha), followed by soil-less media (1890 kg/ha), nursery raised in soil (1712 kg/ha) and minimum in direct seed sown crop (1502 kg/ha).

Application of botanical adjuvants (*Sapindus mucorasai*) seed extract (2%) and *Dalbergia sissoo* leaf gel (2%) with insecticide actamiprid (0.0025%) and botanical neem oil (2%) enhanced the efficacy by 61% and 45%, respectively for the control of aphids in coriander and cumin compared with sole application.

CROP HEALTH MANAGEMENT

Plant protection sciences and biosecurity awareness in India has advanced appreciably over the years. During crop season of 2016-17, the impending crop losses owing to whitefly in cotton and armyworm in rice were significantly reduced through timely interventions. Efforts have been intensified to manage invasive insect-pest *Tuta absoluta,* introduced into India, through IPM and fast-track regulations of effective insecticide molecules as nascent control measures. Proactive actions have been taken to meet challenges of alien pests and diseases such as wheat blast, Ug99 etc. prevalent in other parts of the globe. There is a need to strengthen global networking for ensuring availability of diagnostic tools/ kits/ techniques to monitor or quarantine, especially for the pests of economic importance in other countries, which are not reported from India. Similarly strict enforcement of domestic quarantine measures are necessary to restrict spread of the regional pests and pathogens within confined areas.

Plant quarantine

A total of 111,685 imported samples including transgenic (1070) and trial materials were processed for quarantine clearance. Of 1,676 samples infested/ infected with different pests, 1,467 samples were salvaged. Eighty-nine Phytosanitary Certificates were issued for export of 12,615 samples. Important interceptions included- **fungi**, *Diplodia maydis* in maize from the USA, *Diaporthe phaseolorum* on jatropha from Germany; *Tilletia barclayana* on paddy from China, *Lasiodiplodia* sp. and *Rhizoctonia bataticola* on maize from Thailand,

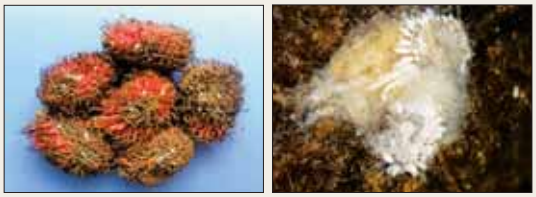
Invasive pests- A threat to agricultural biosecurity

International trade has long been recognized as a major pathway by which non-indigenous insect- pests arrive in new areas. Rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus*– a destructive invasive pest has been found infesting coconut-palm in parts of Tamil Nadu and Kerala. RSW has the potential to spread to coastal regions of Kerala, Karnataka, Andhra Pradesh and Goa.

Infestation of *Aleurodicus rugioperculatus* on coconut

Biosecurity alert protected invasive pest from entering into the country

Proactive efforts have resulted in preventing entry of two invasive mealy bug species — *Exallomochlus philippinensis* Williams and *Exallomochlus hispidus* (Morrison) (Hemiptera: Pseudococcidae), through the



Exallomochlus species infesting rambutan and mangosteen

consignments of rambutan and mangosteen; imported from Thailand. These are potential biosecurity threats to sapota, custard-apple, guava and citrus in India.

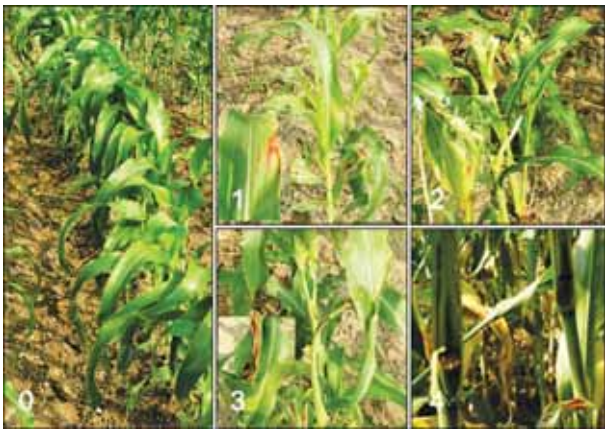
Stenocarpella maydis from Thailand and the USA, *Stenocarpella* sp. from the USA and Mexico, *Colletotrichum lindemuthianum*, *R. bataticola* and *Drechslera australiensis* on sorghum from Argentina, *R. bataticola* on cotton from the USA, *Alternaria porri* from Kenya and *Drechslera sacchari* and *D. halodes* on pearl millet from Canada, *Stemphylium* sp. on garlic from Israel, *Botrytis* sp. and *Verticillium* sp. on chilli from the Netherlands, *Peronospora manshurica* on soybean from Taiwan; **viruses**, *Bean pod mottle virus* and *Tomato ringspot virus* on cowpea from Nigeria and Italy and *Peanut stunt virus* and *Pea enation mosaic virus* from Italy, *High plains virus* on transgenic maize, and *Bean mild mosaic virus*, *Cherry leaf roll virus* and *Cowpea severe mosaic virus* on transgenic soybean from the USA; **nematodes**, *Aphelenchoides besseyi* on paddy from Bangladesh, China, Philippines and the USA, *Meloidogyne* spp. and *Pratylenchus* sp. from rooted saplings of black locust from Hungary; **insects**, *Cryptolestes ferrugineus* on wheat from Mexico and on cabbage from the Netherlands, *Tribolium castaneum* on barley from Morocco and on paddy from China, *Sitophilus granarius* on paddy from China, *S. zeamais* on maize from Egypt and Philippines, *S. granarius* from Thailand, *Chalcid* seed wasp on tomato from the USA and mites on garlic from Israel; and among **weeds**, *Avena barbata, Buglossoides arvensis*, *Centaurea melitensis, Echium plantagineum, Fallopia convolvulus* on barley from Morocco.

Cereals

Management of armyworm on rice: Sali rice in several villages of Jorhat and Manjuli Districts of Assam was affected with severe outbreak and infestation of armyworm/ cutworm, *Spodoptera mauritia* and *S. latura* during September 2016, causing crop damage to the extent of 50-90%. Prolonged duration of stagnant flood water resulted in spurt of worms. Timely intervention and issue of advisories for application of malathion dust (5%) at 20-25 kg /ha or chlorpyriphos 20EC or quinalphos 25EC at 2 ml/litre resulted in effective management of losses. Farmers were also advised to manage the pest using neem formulations, and biocontrol agents, viz *Nomuraea rileyi*, *Beauveria bassiana* and NPV.

Weed control in barley: Application of pinoxaden at 40 g/ha + carfentrazone at 20 g/ha or pinoxaden at 40 g/ha, followed by metsulfuron at 4 g/ha has been recommended for effective control of complex weed flora in barley for North West Plain Zone. In the North Hill Zone, pinoxaden at 40 g/ha + metsulfuron at 4 g/ha or isoproturon at 750 g + metsulfuron at 4 g/ha effectively controlled barley weed flora.

Sorghum: Pokkah boeng or twisted top (c.o. *Fusarium subglutinans*) is an emerging disease causing considerable economic losses to sorghum. Since sources of resistance to the pathogen are not known, artificial inoculation of the test genotypes is necessary for screening. A robust protocol for artificial inoculation was developed for screening sorghum for resistance against *F. subglutinans* . This technique could be utilized for screening genotypes for pokkah-boeng resistance.



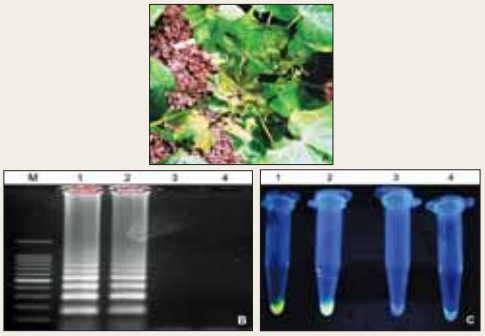
Pokkah boeng disease of sorghum—Grades on a scale of 0-4

Commercial crops

Effective fungicidal treatment to sugarcane setts: A mechanized sett treatment device has been developed for effective delivery of nutrients, fungicides and insecticides for pest and disease management in sugarcane nursery. Fungicidal treatment of sugarcane setts reduced red rots and smut infection effectively in sugarcane. The technology has been commercialized and recommended for use in nurseries and sugar industry.

Rapid detection of Tobacco Streak Virus (TSV) on cotton and soybean

Thrips transmitted Tobacco Streak Virus is an emerging challenge to cotton in south and central India. The viruses are reported to infect more than 200 plant species. Molecular diagnostic method, using Confirmatory testing by nucleic acid-based diagnostic using Single tube, reverse transcription loop-mediated isothermal amplification (RT-LAMP) assay, has been developed for the detection of Tobacco Streak Virus in infected plants of cotton (*Gossypium hirsutum*) and soybean (*Glycine max*).



(**A**) Symptoms of TSV on cotton-plant; (**B**) Detection of single tube isothermal amplification by 1.5% gel electrophoresis (1–Soybean sample, 2–Cotton sample, 3–No template control, 4–Blank (H_2O) control, M–Marker); (**C**) Colorimetric detection of LAMP by using Syber safe DNA gel stain (1–Positive soybean sample, 2–Positive cotton sample, 3–No template control, 4–Blank (H_2O) control)

Plantation crops

Managing spread of coconut whitefly: An invasive species of spiralling whitefly, *Aleurodicus rugioperculatus,* was recorded in coconut plantation

in Coimbatore. To manage the attack of coconut whitefly, an advisory was popularized among the farmers of Coimbatore district (Tamil Nadu) and Palakkad district (Kerala). Village- level workers were trained to spray predator, *Chrysoperla zastrowii*, on coconut trees. Yellow polythene sheet smeared with grease or castor oil wrapped around the trunk at the height of 5-6 feet from the ground level helped trap adult-insects.

Nematode management

Bacterium *Lysinibacillus sphaericus,* isolated as endosymbiont from females of *Rotylenchulus reniformis,* was identified and characterized based on rRNA. Cell-free culture filterate of *L. sphaericus* (suspension 10^8 per µl) caused 75 -87% mortality of *R.reniformis*

Mechanized Sett Treatment Device

preadults. Application of *L. sphaericus* was evaluated as seed treatment on *R.renifomis* under pot conditions. In split-root experiments, *L. sphaericus* on roots protected plants from reniform nematode through induction of systemic acquired resistance (SAR).

Rice root-knot (*Meloidogyne graminicola*) in rice, guava and pomegranate has recently emerged as a major problem in the country. The disease is spreading through nurseries in rice and through infected planting materials in guava and pomegranate to newer areas. A simple technology for management of rice root-knot in nurseries, based on soil solarization of the nursery beds covered with 25 µm polythene sheet for 15 days during May/June (transplanted rice) + carbofuran (soil application) at 1kg a.i./ha at 45 days after transplanting, has been developed. Application of *Trichoderma* at 20 kg/ha or *Paecilomyces lilacinus* at 20 kg/ha + castor-cake at 2.0 tonnes / ha reduced nematode population (44%), root galling (38%) and increased yield by 29.7% in pomegranate infected with root-knot nematode.

Root-knot nematodes are also causing tremendous yield losses in tomato and cucumber crops grown in polyhouses in several states. Integrated management of nematodes by fumigation with Metam sodium at 30 ml/m^2 under polythene mulch for 15 days + neem-cake 200 g/m^2 + *Pseudomonas fluorescens* at 50 g/m^2 (mixed 15 days prior to transplanting tomato/cucumber) reduced nematodes by 80%, root galling by 51%, and increased yield by 49% in tomato. Newer chemicals like Nimitz and Fluopyram have given good results for nematode management.

Integrated pest management

Validation of IPM on rice fields: A protocol of IPM was validated on rice-crop cv. Pusa Basmati 1121 in 350 hectares in farmers' participatory mode in cluster

New molecules to control *Rhizoctonia solani* and *Sclerotium rolfsii*

New chemical molecules of halogenated Schiff bases were synthesized and screened for anti-fungal bioassay against *Rhizoctonia solani* and *Sclerotium rolfsii.* Among the screened compounds, N-propyl-3, 5-dicholoro-2- hydroxyl acetophenonimine was found most active against both the fungi. Whereas two naturally occurring isoflavones viz. genistein and biochanin A, and their dihydro derivates (isoflavanones) as well as nine perhydrogenated isoflavones (isoflavans) showed high antifungal activity. Genistein isoflavan and isoflavans with two hydroxyl groups and one methoxy group proved highly fungitoxic.

Bioformulations for biocontrol

A number of bioformulations of biocontrol agents *Pseudomonas fluorescens, Trichoderma harzianum* and *T. viride* namely **Eco-Pesticide** (Talc-based bioformulation of *P.fluorescens*); **Green Fungicide** (Talc-based bioformulation of *T.harzianum*) and **Bio Pulse** (fly-ash based bioformulation of *Trichoderma harzianum* and *Bacillus amyloliquefaciens*) were developed and validated for their efficacy against a number of soil and seed- borne pathogens. These formulations effectively controlled diseases caused by *Rhizoctonia, Sclerotium, Sclerotinia, Fusarium, Pythium, Ralstonia, Macrophomina, Bipolaris, Phoma*, etc.

(A) (B) (C) (D) (E)

Microbe-based biocontrol agents; A-C= bioformulations, D= control field and E= field treated with Bio Pulse

Biosecurity alert and preparation against wheat blast

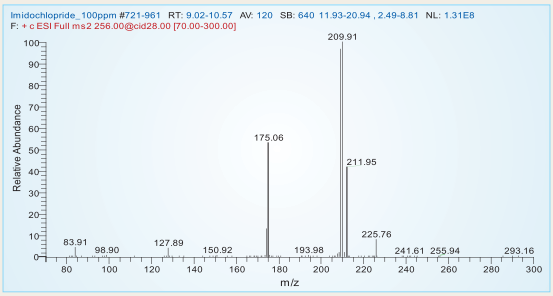
Extensive surveys were conducted in West Bengal along the international border following outbreak of wheat blast in Bangladesh in March 2016. In India, in the 1st week of April, absence of the disease was confirmed. Based on the survey report, 40 released varieties / advanced wheat lines were sent to CIMMYT, Mexico, for evaluation against wheat blast disease in the hot spot for this disease (Bolivia, Brazil, Paraguay and Argentina). On the basis of the disease-screening results, resistant varieties would be developed for farmers.

Seed-borne endophytic *Penicillium* – a growth promoter and biocontrol agent

An endophytic *Penicillium* sp. isolated from seeds of rice possessed plant growth promotor as well as effective biocontrol potential against key rice pathogens viz. *Rhizoctonia solani, R. oryzae sativae, Bipolaris oryzae and Fusarium* in *in-vitro*. Treatment of seeds with the endophyte significantly enhanced shoot length, root length, and fresh and dry seedling weight with concomitant increase of chlorophyll, proteins, amino acids and lignans in rice-plants. Exogenous application of *Penicillium* sp. improved plant growth and enhanced plant survival against salt stress and *Fusarium* infection.

Insect-gut microflora degraded pesticide

Experimental analysis proved that gut microflora of insect-pests degraded pesticides. LC-MS analysis confirmed the ability of *Bacillus pumilus* degrading insecticide Imidacloprid, isolated from the gut of *Amrasca biguttula biguttula*. Imidacloprid (209.91) was degraded into Imidacloprid guanidine (175.06), chemical molecule comparatively less toxic to Indian cotton jassid.



Decreased area of the spectrum indicates degradation of the compound

of villages in Budh Nagar, Uttar Pradesh, and also in 650 ha at Chhajpur (Panipat), Haryana. In the fields only one application of chemical pesticide i.e., carbendazim as seed treatment was given whereas in farmers' practice, 2-5 applications of chemical pesticides (chlorantraniliprole 0.4% GR, carbofuran 3G, chlorpyriphos 20 EC) were applied.

In the IPM trials on the direct-seeded rice (DSR), high yield (5.5 tonnes/ha) and benefit: cost ratio (3.39) were observed as against the transplanted paddy.

Biological control

Bentonite-based formulations of *Bacillus thuringiensis* against rice leaf folder (*Cnaphalocrocis medinalis*): Water-soluble granular formulation of *Bacillus thuringiensis* was developed for management of rice leaf folder. The Bt formulation validated at different agroclimates indicated that the strain was also effective against the seedling blight of rice caused by *Sclerotium* sp. Effective management of the disease in nursery beds was validated by the application of bio-control agent.

Pesticide monitoring

Eighty-one multilocation supervised field trials were conducted to evaluate persistence and dissipation of new and existing pesticides on various crops in different agroclimates. The data were employed to fix maximum residue limit (MRL) for eight pesticide-crop combinations by the Food Safety Standards Authority of India (FSSAI), while their safe waiting period and label claim on respective crops were approved by the Central Insecticide Board and Registration Committee. Monitoring of pesticide residues at the national level was done in 22,103 samples of food commodities and water. Pesticide residues were detected in 4,640 samples (21.0%), while samples exceeding MRL were only 522 (2.4%). For the residues of non-approved pesticides detected in the monitoring study, 183 GAP trials were conducted for approval and harmonization of label claim.

Vertebrate pest management

Bioacoustics technology uses only natural sounds of predators, distress and alarm calls of target and closely related species of target animals. The equipment produces fixed volume of 110db of noise to keep them off fields at source covering 10-15 acres when ambient noise level is around 42 db. At 37 db of ambient noise, the equipment can cover up to 19 acres. Bioacoustics was 92% effective in dispersing wild boar from cropped area.

The bioacoustics equipment was demonstrated in crop fields at 42 locations in Telangana. The crop damage due to wild boar attack which was up to 58% before equipment installation, reduced to nil. In all the locations, the equipment was effective depending on the crop stage.

Pollinators

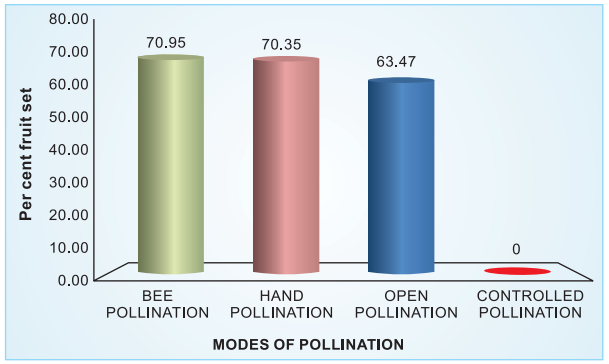
Bumble- bees (*Bombus haemorrhoidalis*) for tomato pollination in polyhouses: The laboratory-reared bumble bee, *B. haemorrhoidalis* colonies, introduced in polyhouse for buzz pollination of tomato-crop, proved superior over self pollination (crop without pollinator) of tomato (Solan Lalima) with respect to quantitative (number of fruits per cluster, number of fruits per plant, fruit weight, yield, seed number, 1000 seed weight) as well as qualitative (fruit size, healthy

Bumble- bee life cycle

fruit, seed germination, seedling length, seedling dry weight, SVI-I, SVI-II) traits for seeds and fruits.

The colonies of *B. haemorrhoidalis* having 10-25 worker-bees when shifted from incubator to field, survived one complete cycle. These colonies produced more queens and survived till December like natural ones. This is for the first time, *B. haemorrhoidalis* colonies were reared around the year in India. The daughter queens, which were mated during October and then maintained under controlled conditions of temperature and humidity, reared brood successfully during winter (January-February) without undergoing hibernation.

Productivity enhancement in cherry: Exclusive bee polination with Apis mellifera in cherry-orchards at solan at one colony per hectare resulted in fruit-set of 70.95% compared to 70.35 and 63.47% in hand pollination and open pollination, respectively. Cherry did not set fruits when visit of pollinators was excluded by nylon-nets.



Per cent fruit set by different modes of pollinations in cherry orchard

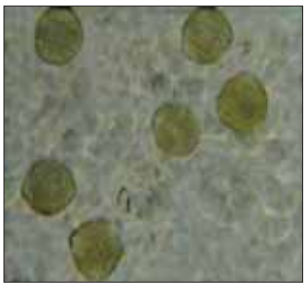
Selective breeding of *Apis mellifera* through artificial insemination of the queen

Artificial Insemination of queens was carried out during February- March'2016. Comparative performance of Artificially Inseminated (AI) Queens was found superior compared to Naturally Inseminated (NI) ones. The colony performance index in terms of brood area, pollen and nectar area was maximum in artificially infested queens during the fourth week of March(3880.82±0.08, 3100.64±1.59, 2450.17±1.78 and 2305.56±3.16sq cm) against NI (2810.52±2.12, 2400.20±0.51, 2250.07±0.79 and 2200.21±2.17sq cm).

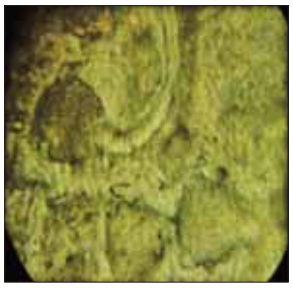
Enhancing productivity of pigeonpea: Experiment on the efficiency of pollinators in enhancing productivity of pigeonpea at Nagaland on the basis of number of pollens deposited per visit, viability of pollen-grains and their visitation rate indicated that five species of insects — *Megachile lanata*, *M. relata*, *M. monticola, M. conjuncta* and *Xylocopa tenuiscapa* —were true insect pollinators of pigeonpea. *M. lanata* was the most efficient pollinator. There was 13.4% yield increase in open pollination over pollinator exclusion, showing significant role of pollinators in increasing pigeonpea yield.

Megachile relata pollinating pigeonpea flower

Megachile lanata pollinating pigeonpea flower



Pollen-grains deposited on the stigma of the pigeonpea under microscope



Germ tube formation of pollen-grains of the pigeonpea under microscope

Management of biotic stresses in *Apis cerana*: Two microorganisms (*Psuedomonas* sp. and *Bacillus cereus*) were isolated from the Indian bee, *Apis cerana*, colonies in Kerala, which exhibited symptoms of a new disease. Samples of the infected brood combs were identified using blood agar and DNA sequencing. Feeding infected colonies with garlic at 10 g per 10 litre of sugar syrup (at 250 ml/col/week) for three consecutive weeks showed cent per cent recovery. The uncapped cells of the infected brood were found capped after three weeks.

Fruit crops

Four sprays of *Metarhizium anisopliae* oil formulation @ 0.5ml/l resulted in > 80 % reduction in mango hopper (*Idioscopus* spp.) population and 71 % reduction in thrips population. Parasitoids of banana skipper fly (*Erionota* spp.), namely *Agiommatus* sp. (Pteromalidae), *Ooencyrtus* spp. (Encyrtidae), *Tetrastichus* spp. (Eulophidae), *Telenomus* (Platygastridae), *Brachymeria* spp. (Chalcididae) and two tachinids were identified from different parts of India. *Stethorus pauperculus* was found effective predator of banana mite, *Oligonychus indicus*. The DNA barcodes were generated for three insect pests of banana, namely lacewing bug, whitefly and flower thrips. The accession numbers were obtained from Gen Bank. Pruning of twigs in June after harvesting followed by manuring with four kg castor cake and one kg neem cake in July and spraying of Novaluron 10 EC (0.015%) were found effective against litchi looper and leaf folder. First spray of neem oil (3ml/l) before flower opening, second and third spray of diflubenzuron 25 WP (0.03%) at clove stage and 21 days after second spray managed fruit- and seed-borer infestation in litchi. A methyl ester based pheromone compound was identified for pomegranate fruit borer.

In vivo evaluation of the compound PC1 extracted from botanical zimmu (*Allium cepa* × *Allium sativum* L.) at 0.1% w/v. Observations revealed complete control of *Fusarium* wilt in cv. Grand Nain. Further, soil application of 100 ppm of silver nanoparticles synthesized from strain of *Trichoderma asperellum* and zimmu leaf extract recorded complete control of *Fusarium* wilt.

New reports

Occurrence of Banana Bract Mosaic Virus (BBrMV) along with Banana Streak Mysore Virus (BSMYV) in cv. Poovan in Assam and Banana Streak Gold Finger Virus (BSGFV) in hill banana at Lower Pulney Hills was recorded and their presence confirmed by cloning and sequencing of partial genome of the respective viruses. Occurrence of Banana Mild Mosaic Virus (BMMV) in India was recorded. The sequence of Indian isolate of BMMV shared 74.4–91.7% nucleotides and 87.3–95.7% deduced amino acid similarities with other BMMV isolates.

Plantation crops

Prophylactic treatment of coconut utilizing talc-coated cake with botanical extracts of *Clerodendrum infortunatum* and *Chromolaena odorata* was observed to reduce rhinoceros beetle induced leaf damage by 54%. Spraying young bunches with combination of coconut oil (200 ml) and sulphur (5 g/l) emulsion or spiromesifen (1 ml/l) or neem oil (2%) or common salt (2%) plus APSA (0.2%) were found effective in the suppression of coconut eriophyid mite. The palms treated with chlorantraniliprole (0.018%) and neem oil (0.5%) recorded 73-75% reduction of coreid bug incidence in coconut.

The IPM module was developed for the management of root grubs in arecanut garden by timely collection of beetles, application of insecticide (bifenthrin 2 kg ai/ha), imidacloprid @ 0.045%) and entomopathogenic nematode (*Steinernema carpocapsae*) @ 1.5 billion IJ/ha. Further, packaging with 60-80 micron polyethylene (LDPE) resulted in sustained higher survival (69.9%) of EPN, *Steinernema carpocapsae* up to 30 days in temperature regime of 25-27ºC.

Vegetable crops

In cabbage, a module comprising foliar application of azadhiractin 0.03% @ 5ml/l, rynaxpyr 18.5 SC @ 0.15 ml/l, novaluron 10 EC @ 1.5ml/l, emamectin benzoate 5 SG @ 0.35g/l at 10-15 days interval was highly effective with 88.43% reduction in DBM larvae and 69.64 % increase in marketable yield with cost : benefit ratio 1:8.68. Carbofuran@1kg, a.i./ha + copper oxychloride@0.25% + TRB4+CRB2 @1% was highly effective reducing galls by 64.5%, soil population 28.0% as well as disease severity scale to 1, gall index 3 and reproductive factor 0.2 over inoculated control where corresponding values were as 0.0, 0.0, and 3.5 and 7 and 1.3, respectively. This treatments also increased the plant height (41.3%), root length (47.7cm) and yield (77.5%) compared to inoculated control. Flonicamid 50 WG @ 0.4g/l was effective with 93.26 and 85.91% reduction in leafhoppers (*Amrasca biguttula biguttula*) and whitefly (*Bemisia tabaci*), respectively. Its residue dissipation followed first order kinetics with half-lives 3 - 3.5 days. The pre-harvest interval (PHI) was 16 and 20 days for recommended and double the recommended doses, respectively. The residues dissipated below MRL of 0.01 mg/kg on the same day. The dietary exposure of measured residues was lower than the MPI of 0.576 mg/person/day on all the sampling days for a single and double dose.

A strain of *Trichoderma asperellum* inhibited the mycelial growth of *Pythium aphanidermatum*, *P. debaryanum* (causing damping off disease), *Sclerotium rolfsii* Sr1 and *S.rolfsii* Sr3 (causing collar rot disease) by 43.57, 38.16, 42.56 and 54.87% respectively after 6 days of its inoculation. It also inhibited the mycelia growth of *Fusarium oxysporum* f.sp.*lycopersici* (causing wilt disease) and *Alernaria solani* (early blight disease) by 26.27 and 24.17%. Its identity was worked out and the sequence deposited in GenBank (NCBI) with an Accession No. KT824429. It showed 100% compatibility with mancozeb, azoxystrobin, cymoxanil + mancozeb, metalxyl + mancozeb at 100, 200 or 300 ppm.

A new pest *Lema pectoralis* Baly (Coleoptera: Chrysomelidae) has been identified which attacks the indigenous *Eulophia andamanensis* orchid. ❑

8. Livestock Management

Nutrition

Feed informatics: Real time information of animal population and feed resources is vital for the development of livestock sector. Information technology based tools are being developed to improve data collection and compilation, and estimate feed and fodder resources availability in terms of concentrates, green and dry fodder in all the mandals/taluks of India. The database would be useful in forecasting the surplus/deficit at micro level in real time to assist the planners/administrators. A website was designed based on open source software platform for real time collection and compilation of livestock data.

Probiotic from gut of Asom native chicken: Isolates found positive for *Lactobacillus* genus specific primers were evaluated for probiotic properties. Finally, top three isolates AJ3, ACE5 and GJ1 were evaluated through feeding trial in commercial broilers. The best performance was exhibited in diets supplemented with isolate AJ3 as probiotic. The culture typing of these isolates at IMTECH, Chandigarh revealed that isolate AJ3 and ACE5 had high similarity with *Lactobacillus reuteri*. The isolate AJ3 may therefore be recommended to be used as probiotic in poultry diet for commercial poultry production.

Nutrient bioavailability and productivity

Sheep: Boron supplementation improved calcium utilisation, immunity and growth performance, but did not affect tissue architecture of visceral organs.

Goat: Supplementation of trace mineral,viz. Cu and Zn was found associated with rapid testicular growth, changes in LH secretory pattern, a gradual increase in blood testosterone, initiation of spermatogenesis and improvement of semen quality and fertility in goats.

Poultry: The amino acids supplementation into 18d embryonated eggs resulted in significant improvement in body weight gain. In contrast, *in ovo* injection of nano Zn did not alter the growth performance, gut development and immunity.

Feed supplements

Boostermin supplementation @ 2.0% in concentrate mixture improved daily milk production and the reproductive performance of cows in the field conditions.

Multi-nutrient liquid supplement can economize the ration by safely reducing 20% of the concentrate mixture with substantial improvement in growth rate (~11%), antioxidant status, immunity and reproductive parameters in Murrah buffalo heifers.

A mixture of tree leaves (jackfruit, papaya and *bahera*) supplementation @ 8 and 16% of DMI reduced methane production by 13% in goats without affecting nutrient utilization. Feed additive containing nitrate, garlic and clove inhibited methane production by 25% at high roughage and 19% at low roughage diet. Supplementation of both tea seed saponin (0.4% of DMI) and tea seed @ 5.2% (dose equivalent to 0.4% saponin) significantly improved growth rate, FCR and N balance in experimental Gaddi goats. Tea seed saponin supplementation was more effective in modifying the lipid profile as compared to tea seed in Gaddi goats.

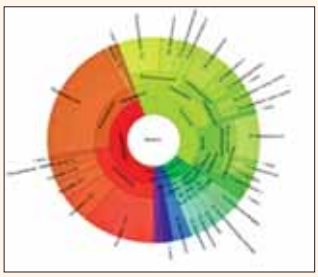
Out of the eight commonly cultivated grasses of North Western Himalayan Region, based on nutrient composition, *in vitro* digestibility and metabolisable energy value, *Avena sativa* JHO 822 ranked the highest and *Chrysopogon fulvus* the lowest.

Supplementation of a symbiotic containing *Lactobacillus johnsonii* CPN23 and Jerusalem artichoke

Biogeography of gut microbes

A cattle rumen microbial clone library was generated to study the bacterial diversity. The most abundant in cattle rumen was genus *Prevotella* (33%) followed by *Bacteroides* (28%), *Streptococcus* (11%) and *Clostridium* (10%).

Firmicutes was the major phylum with Prevotella, *Lachnospiracea incertae sedis*, *Butyrivibrio, Clostridium, Ruminococcus,* and *Fibrobacter* the predominant genera in buffalo. Rarefaction analysis of abundant operational taxonomic units (OTUs) having at least three members indicated 99.8% coverage in cattle and 78.9% coverage in buffalo at putative species level. Eight mimosine degrading and three sulphate reducing bacteria from rumen were isolated from buffaloes. These findings may open new directions for further characterization of rumen bacterial communities. Whole metagenomic profile, generated to study the microbial population and carbohydrate active enzymes in crossbred steers, revealed that glycoside hydrolases were the most abundant followed by glycosyl transferases, carbohydrate binding modules and carbohydrate esterases in cattle rumen metagenome. Microbes with ability to degrade plant fiber, tannins, oxalates and eupotox were isolated from the rumen of migratory goats and sheep.



Phylogenetic classification of bacterial community in cattle rumen using SILVA database

Success Stories

Flourishing goat husbandry

The family of Mrs Dipty Deka— her husband and two children— were leading a difficult life only with the wage of her husband at Batabari, Darrang district. She enrolled herself as one of the beneficiaries of the "All India Coordinated Research Project on Goat Improvement" in the year 2009 with only two breeding does. She has increased these to 27 healthy goats in spite of selling her goats at regular interval. She sold 9 goats during this period with an income of around ₹ 35,000. Under the project, goats received necessary veterinary care besides elite breeding buck for healthier future progeny. The AICRP on Goat Improvement played an important role in improving their financial condition.

The AICRP on Goat Improvement has played a very important role to support her in all possible ways and helped her a lot to improve the financial condition.

indicated positive impact on the fibre utilization in dogs.

Cattle

Adult Frieswal bulls fed increased concentration of Zn from 40.0 to 80 ppm showed significantly increased sperm concentration (million/ml) from 837.88 in diet 1 to 913.65 in diet 2 and 965.08 in good bulls. Post thaw motility (PTM%) also increased significantly from 46.04 to 49.93.

Distillers' grains (DG) are considered good sources of protein for dairy cattle because fiber, protein and fat are concentrated approximately 3-fold in distillers grains (DG) when starch is fermented to produce ethanol. Replacement of concentrate mixture by rice based condensed distillery syrup (RCDS) @ 15% (on DM basis) reduced the feed cost without affecting the milk production.

Buffalo

Supplementation of garlic oil (1µl/30 ml buffered rumen fluid) has positive effects on rumen fermentation with 38.35% reduction in methane production without reducing *in vitro* dry matter digestibility.

Goat

Methane emission and mitigation strategies: Estimation of methane using SF_6 technique in goat was standardized. Adult, male, grazing Barbari goats were used for *in vivo* methane emission using SF6 technique. In animals grazing for 6-7 hr on the pasture of Anjana grass (*Cenchrus ciliaris*), *Cucumber* spp. and *Ziziphus* spp, supplementation of subabool (*Leucenea leucocephala*) showed *in vivo* methane emission (g/day) as 18.30.

***Moringa oleifera* based complete feed**: *Moringa* plant was found to be a protein rich goat feed. Total yield of 163.5, 155.10 and 164.02 q/acre was obtained in two cuttings from the plant density of 30 cm × 30 cm, 30 cm × 15 cm and 15 cm × 15 cm, respectively. The plant population in the sown field was lesser than the actual plant population potential of land, hence the actual potential of biomass production in two cuttings could be much higher.

The chemical composition of biomass from leaves, leaves + stem and stem portion of second cut indicated: proteins 22.32, 19.32 and 17.42%; ether extract 6.71, 4.78 and 1.88%; and energy content (Kcal/g) 3.60, 3.48 and 3.48 Kcal/g respectively. Complete feed containing 80% moringa biomass and 20% concentrate was fed to the Barbari, Jakhrana and Jamunapari goats (average age of 86 days) for 91 days. Barbari goats fed with moringa based complete feed showed higher body weight gain (55.88 g/day) than that in control animals (49.76 g/day). Significantly lower values of total serum cholesterol and LDL and higher triglyceride in moringa fed animals indicated their better immunity status and lipid profile compared to control animals. The antioxidant property and HDL content were higher in moringa fed goats than control goats. Higher HSP 70 in control animals than the moringa fed animals indicated that moringa fed animals were comparatively less stressed than the control animals.

Camel

High protein and energy diet: The diets 20% rich in protein and energy effectively reduced the weight loss in breeding males. Higher growth rate in female calves was observed in the complete feeds having 20% higher protein and energy prepared out of local agro-industrial by-products and concentrates as a pelleted feed.

Mithun

Feed block: Paddy straw was mixed with either wet cake or dried distillery grains and soluble (DDGS) to determine its effect on quality of feed block in terms of density and changes in dimension with the passage of time. Optimum level of moisture content was determined during the mixing of wet-cake with paddy straw for successful feed block preparation. Microbial load in the wet cake (i.e., by-product from distillery factory) stored in airtight container for 1 month did not differ significantly with that of freshly collected wet cake.

Isolation of tannin degrading/tolerant bacteria: Pure cultures (n=7) of tannin degrading / tolerant bacteria from mithun faecal samples were collected from Nagaland and Manipur and deposited to NIANP under VTCC Network project.

Equine

Total mixed ration: In order to fulfil the need of farmers regarding requirement of area specific concentrate mixture in horse populated region in India, NRCE has initiated a programme for developing the concentrate mixture. The combination barley + wheat bran+groundnut cake showed highest digestibility among the concentrate mixture combinations.

Pig

Chelated mineral supplementation: Indigenous production of trace mineral products namely Zn-Met, Cu-Met, Co-Met and Fe-Met were standardized. Supplementation of indigenously developed chelated trace minerals in grower crossbred pigs resulted in improvement of growth by 8.22 and 22.6%; improvement in FCR by 20.9 and 25.9% and reduction in feed cost per kg weight gain by ₹ 20.84 and 25.96 at medium level and high level of supplementation.

Poultry

Utilization of alternate feed resources: Rice based distiller's dried grains with soluble (DDGS) are available from distillery industries. It is a very good source of protein (45%), available energy (2,880 kcal ME/kg) and phosphorus (0.77%) and also contains yeast cells and nucleotides. DDGS is available at a lower price than other protein sources. The study indicated that it can be incorporated at 10% level replacing soybean meal for economical egg production, and better egg quality traits and immuno- competence in laying hens.

Management of mycotoxicosis: Inclusion of *Saccharomyces cerevisiae* (0.1%) in ochratoxin (200 ppb) contaminated diet ameliorated the ill effects of ochratoxin and improved the welfare aspects of stressed birds. Ochratoxin A was found more toxic than aflatoxin B1. Synergistic relation existed between ochratoxin A and aflatoxin B1 in broiler chickens.

Evaluation of nutrients: Oreganol, a plant derivative from *Oregano vulgaris* at 200g/tonne improved the body weight (742 vs 707g) and feed intake at 6 weeks (1,675 vs 1,588g) significantly as compared to control in Vanaraja birds. The body weight gain, feed efficiency and breast weight were significantly higher in DL methionine group followed by L methionine and MHA (methionine hydroxyl analogue) in broilers. Anti-body titre against ND (New Castle disease) vaccine was significantly higher in DL methionine group followed by MHA and L methionine. In PD-3, the egg production and number of eggs were higher in birds fed with diet containing 3.25% calcium and 0.35% P as compared to other groups during the 37-40 weeks of age. The selenium (Se) concentration in biomass increased gradually from 0 to 200 ppm and it was observed that best performance was at 30 ppm, where the biomass and Se uptake was optimum compared to the other concentrations. Supplementation of *Mentha aquatica* (0.50 ml) and *Zinger officinale* (1.5 ml) extracts resulted in higher *Saccharomyces cerevisiae* growth in terms of CFU/ml compared to other herbal extracts. The higher body weight gain was recorded among the group fed with diet supplemented with selenized-yeast compared to control diet.

Nutritional and physiological interventions for enhancing reproductive performance in animals

A survey on Nutritional and Reproductive Status of Buffaloes was conducted from 1,000 farmers of 40 villages in 10 districts of Haryana- majority respondents with medium (5-10 acre) land holding category and major purpose of buffalo rearing dairying. Important findings were:

- The average breedable buffalo herd size was 2.09 heads.
- Majority (98.8%) of the farmers used intensive system of buffalo housing.
- Wheat straw (63%) was the sole roughage used during all seasons along with available green fodders.
- Cottonseed cake (75.1%) and broken wheat (46.3) made the major part of concentrate in buffalo ration.
- Majority of the buffalo owners (52.8%) did not feed mineral mixture to their buffaloes and had no tendency (67.3%) to maintain proper record of nutritional and reproductive aspects of their buffalo.
- The mean daily milk yield of lactating buffaloes was 10.63 kg.
- Majority (62.2%) of the surveyed respondents were adopting AI in the study area.
- Reproductive parameters were: mean age at first conception, 31.98 months; mean age at first calving, 42.03 months (mean service period 110.81 ± 2.89 days); buffaloes (63.03%) conceived within 90 days postpartum; mean calving interval, 420.80 days (46.18% buffaloes had calving interval of less than 400 days).
- Calving related disorders were—retained placenta (2.41%), followed by prolapse (1.93%), dystocia (1.59%) and abortion (0.69%).
- 9.47% of buffaloes were anestrus followed by repeat breeder (6.34%), whereas 9.69% of heifers were reported to be delayed pubertal followed by repeat breeder (6.79%) in the surveyed area.

Animal physiology and reproduction

Cattle

Preputial cleaning device: This is a pressurized device useful for complete internal cleaning of the preputial cavity of bulls used for semen collection. This device has provision of pressure gauge, which avoids chance of causing injury to the preputial membrane. It offers cleaning of preputial cavity of 4–5 bulls in one go. It will be helpful in reducing the bacterial load in the semen ejaculate, hence, useful in clean frozen semen production.

Buffalo

Cloning: Cloned blastocysts (328) were produced with overall blastocyst rate of 37.5%. All these cloned embryos were produced from superior buffalo males or females. From these 46 cloned embryos were

transferred in 46 recipients resulting in 3 pregnancies which were confirmed with ultrasonography; however two pregnancies aborted at 1.5 and 3.5 months and one live birth was recorded. This cloned calf named 'Hisar-Gaurav' was obtained from donor somatic cell isolated from tail of a superior Murrah bull.

Stem cell technology: Stem cell technology in buffalo was mainly focussed for optimization conditions for gene transfer (GFP) into somatic cells and buffalo fetal fibroblasts. The buffalo fibroblasts were electroporated with GFP construct at 300 volt for 10 ms with 1 pulse. In five trials, ~30-40% cells were integrated with GFP construct.

Research work for the generation of induced pluripotent stem (iPS) cells from buffalo fetal fibroblasts through non-viral approaches was also initiated. The primary buffalo fetal fibroblasts (BFFs) were cultured from a 2 to 3 month-old fetus obtained from a slaughterhouse. Presumptive buffalo iPS cells were maintained on gelatinized plates and enzymatically sub-passaged after confluency. BFFs and buffalo iPS cells were cultured in a humidified atmosphere consisting of 5% CO_2 in air at 37°C.

Estrus synchronization for AI: A new method of synchronization of estrus/ovulation was developed based on kisspeptin in bovine species. The synchronization method based on kisspeptin (kisspeptin: day 0; PGF2á: day 7 and kisspeptin: day 9), resulted in inducing better growth of follicles than ovsynch protocol. The newly developed method was better than the conventional ovsynch method in terms of per cent ovulation in the treated animals.

Scientific validation of '*Doka*': Efforts were made to scientifically validate the traditional method of '*Doka*'. Background information on the practice was collected through personal interviews and questionnaires conducted on over 200 buffalo farmers of different villages of Haryana. Regular watching of animal is essential for identification of *Doka*. Biochemical analysis in serum and milk of '*Doka'* samples suggested presence of lower serum albumin and phosphorus concentrations. In milk, total protein (g/dl) was significantly lower in '*Doka'* samples. Ovarian ultrasonography indicated that number of large follicles (>10.0 mm) was higher in '*Doka'* animals as compared to the other groups. Buffaloes exhibiting '*Doka'* were in majority (approx. 80%) and showed estrus behaviour after 2.22±0.60 days of its occurrence.

Goat

Chemically defined extender: Chemically defined semen extender for Black Bengal buck semen preservation was developed. Egg yolk present in the semen extender protects sperm cells from cold shock damage during storage at low temperature. As egg yolk coagulating enzyme and phospholipase present in the goat seminal plasma damages sperm cells besides increasing microbial contamination, it was replaced by soybean lecithin, which is rich in phosphatidylcholine in preservation of Black Bengal buck semen. Tris based semen extender for preservation of Black Bengal Buck semen with soybean lecithin at 1.5% (w/v) showed optimal post thaw recovery for insemination purposes.

Mithun

Biostimulation of bulls: Mithun bulls are known for their shy nature and they do not readily mount over the estrus female in a confined condition. Hence, for improving collection of semen using artificial vagina the bulls were biostimulated by exposing them to estrus females as well as urine, dung and sweat of estrus females. A significantly higher level of testosterone, FSH and LH was recorded in the mithun bulls post biostimulation.

Reproductive performance of bulls: The testicular morphometry and endocrinological profiles of mithun males varied significantly with the age and seasons. In comparison to summer, a significantly higher scrotal circumference was observed in winter and spring with significantly higher level of FSH, LH, testosterone, thyroxine and IGF-1 and lower cortisol. The association between hormone profile, testicular and scrotal parameters and age groups in mithun bulls was significant.

Age of puberty: Exogenous administration of Kisspeptin in mithun revealed an early onset of estrus, an increased expression of kiss1 and GPR54 mRNA, peripheral estradiol and FSH concentration and an increased follicular growth with early onset of estrus in the animals.

Timed AI: Post-partum mithun cows were synchronised using either progesterone releasing intra-vaginal device (PRID) followed by PGF2α or Ovsynch protocol (GnRH + PGF2α). Estrus detection was confirmed through rectal palpation as well as through ultrasound scanning of ovaries. The estrous synchronised mithun cows were artificially inseminated with frozen-thawed semen and pregnancy was confirmed after 50

Green energy (biogas) production exclusively from poultry excreta

In-vitro standardization for efficient bio-gas production from poultry excreta was done through dilution (D), carbonization (C) and acidification (A) techniques. Best combination of D and C experiments was used for substrate formulation and *in-vivo* bio-gas production using 0.2 M^3 anaerobic digester and designated as DC. In DCA, substrate was formulated using combinations of D, C and A. Diluted (D) poultry excreta without any other combinations acted as control (T_0). The hydraulic retention time (HRT), bio-gas production, blue flame proportion etc., was significantly better in DCA followed by DC and was lowest in D. The ratio of bio-gas production in D:DC:DCA was 1:2:4. The content of methane (%, V/V), carbon-dioxide (%, V/V), oxygen (%, V/V), hydrogen sulphide (ppmv) and balance gases in DC was 58.3, 33.23, 1.33, 22.33 and 7.03, respectively. The respective values in DCA were 55.47, 35.5, 0.83, 57.00 and 8.17. It was concluded that conditioning of poultry excreta has better potential for all-weather bio-gas production.

days of insemination. The animals treated with Ovsynch protocol showed a higher rate of synchronisation (83.33 vs. 66.66%). However, there was no significant difference in pregnancy rate between Ovsynch and PRID protocol.

Poultry

Housing systems: The behavioural inventory of young layers of White Leghorn (CARI-Priya) and their welfare status under different housing conditions were studied during winter. At 18th week of age, 450 layer birds from a single hatch were randomly assigned into three treatment groups, viz. floor housing, colony cage and individual cage. Results revealed that, during winter, the floor reared layers spent significantly more time in sitting (46.4%), walking (7.2%) and investigating behaviour (4.0%) than those reared on colony (38.2, 4.8 and 1.4%) or individual cage (30.9, 1.4 and 1.0%). Individual cage layers spent more time in feeding (40.7%) than the colony (26.6%) or floor birds (22.9%). However, time spent for drinking and preening activity was similar in all housing systems.

In the colony cages, feather pecking was more frequent, while in cage layers pecking appeared stereotyped in many hens, but at a low frequency. There were significant differences in the welfare status regarding feather conditions, claw length, gait scores and tonic immobility of the birds between the management conditions, while no significant difference was found in keel bone condition and foot lesions. Significantly higher fearful response and time for first peck (response to novel object test) was observed in individual cage layers than the floor and colony birds.

Evaluation of semen diluents and its use in improving fertility in chicken: Semen diluents namely, BPSE (Beltsville poultry semen extender) and TES (N-Tris hydroxymethyl-methyl-2-amino ethane sulphonic acid)-NaCl were evaluated for determination of a good semen diluent for dilution of chicken semen. Based on semen parameters, BPSE semen diluent showed better results as compared to TES. The fertility rate was 72.4% in BPSE group and 65.1% in TES-NaCl group at 0 hr storage of semen. The hatchability was 60.23% in BPSE group and 56.08% in TES-NaCl group. Vitamin C (10 mg) supplemented with BPSE showed better results in terms of per cent motility (59.1%), MTT (thiazolyl blue tetrazolium bromide) (25.7%), which were significantly higher than TES-NaCl, and per cent sperm abnormality (21.9%) was also significantly low. Dietary energy and protein level combinations influenced the per cent abnormal sperm, fertility and hatchability in layer breeder males.

Augmenting reproductive efficiency in ducks: The growth of reproductive tract and sperm storage tubules in Khaki Campbell ducks during 13th to 24th week was studied and the sperm storage tubules were observed to be fully developed and functional by 23rd weeks. The finding is significant for standardizing reproductive interventions for augmenting reproductive efficiency in ducks.

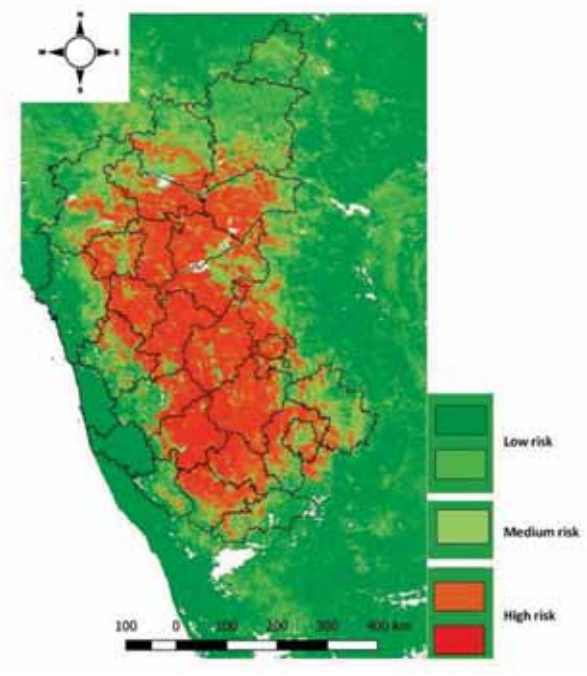
LIVESTOCK PROTECTION

Epidemiology and disease informatics

Epidemiological study was carried out for different viral, bacterial and parasitic diseases. Fasciolosis was reported with highest outbreaks followed by FMD, trypanosomosis, HS, babesiosis, PPR, black quarter, sheep- and goat-pox, rabies and BT during this year. Disease events (977) were predicted for 13 livestock diseases in 33 states/UTs of India, in which HS tops the list followed by FMD and BQ. Livestock serum samples (4,319) from the country were aliquoted, catalogued and stored in the serum bank. An economic analysis revealed that total visible loss projected due to FMD in the country during 2015-16 was ₹ 721.41 crore.

The HS outbreak in Asom was mapped with preparation of heat map. The Risk MAP (Risk mapping, assessment and planning) generated for HS potential predictors for disease using remote sensed variables in Karnataka showed good correlation with past outbreaks. Therefore, risk MAPs were developed using remotely sensed variables by planning vaccination, allocation of resources in high risk areas and also future surveillance of the disease in the region. Whole genome sequencing of multi drug resistant *Escherichia coli* and *Pasteurella multocida* type A was submitted in Genbank with accession number LUYD00000000 and MEDF01000000, respectively.

During anthrax outbreaks investigation, samples were collected from bovines, elephants, sheep and goats from Odisha and Karnataka. Risk MAP for anthrax in Karnataka region was developed based on RS parameters (NDVI, LST, NDWI, NDMI) using 337 anthrax outbreak data from 2000-14 in Karnataka.



Risk MAP for haemorrhagic septicaemia using remote sense variables

***Trichinella* spp. infection in wildboar and wild felids**

Trichinella sp. infection is reported sporadically from India in domestic and wild animals including civet cats, bandicoots, shrews, Indian mole rat and domestic pigs. Recently, *Trichinella* sp. infection was detected in the carcasses of a wild pig (Pilibhit, Uttar Pradesh), two leopards (Bahraich and Shahjahanpur, Uttar Pradesh) and a tigress (Kheri, Uttar Pradesh). Molecular biology techniques were used for species level identification of *Trichinella* recovered from the carcasses of the wild animals by adopting the protocols of multiplex PCR and by sequence analysis of Mt-lsr, 5S rRNA and ITS-2 regions of genomic DNA. Based on multiplex PCR results as well as the nucleotide sequence analysis of the mitochondrial large sub unit ribosomal DNA (Mt-lsr) and 5S intergenic spacer region DNA fragment (5S ISR), mixed infection of *T. britovi* and *T. nelsoni* was confirmed in all the four cases. In one leopard, besides *T. britovi* and *T. nelson*, T6 genotype of *Trichinella* sp. was also identified by multiplex PCR.

A duplex PCR was standardized targeting genus specific primes and methicillin resistant determinate (MecA) primes for rapid identification and detection of methicillin resistant *Staphylococci* (MRSA, MR-CoNS). In livestock antibiotic resistance in Meghalaya and Asom revealed that 41% *E.coli* ESBL/AmpC/MβL producer with CTXM-IV was detected as most common determinant among cattle, pig and poultry. Whole genome sequencing using Illumina platform was performed for one representative multidrug resistant *E. coli* of poultry origin designated NIVEDI NEP44. WGS data analyses revealed the complete repertoire of virulence, bacteriocin and multidrug resistant efflux pumps in the emerging prevalent clone of MDR *E. coli* detected in the livestock, providing deeper insights of the pathogen biology. This Whole Genome Shotgun was deposited at DDBJ/ENA/GenBank under the accession LUYD00000000.

The fluorescent polarization assay (FPA) for brucellosis was developed and used for differentiation of infected and vaccinated animals (DIVA). It can be used from 21 days post vaccinated animals for DIVA whereas commercially available cELISA can be used only beyond 60 days post vaccination as a DIVA test. Random samples (5,997) were screened for brucellosis, recording highest sero prevalence of 11.32% in sheep followed by 2.77% buffalos, 2.14% goats, 1.94% pigs and 0.85% in cattle. Recombinant synthetic gene construct of multi-epitope antigen using immune-dominant epitopes of *Brucella abortus* was expressed and characterized.

Bluetongue virus was isolated from sheep/goat samples received from 5 North Eastern states, 24.46% sero prevalence for BT virus were recorded. Sheep pox and goatpox virus were also isolated during field outbreaks.

Data analysis of 20 PPR outbreaks in sheep and goat, occurred in Madhya Pradesh and Karnataka, revealed mild to severe form of the disease. The phylogenetic analysis of the N & F gene sequences of PPRV from NE region of India revealed circulation of lineage IV virus. Further 48.86% PPRV antibodies were recorded among goats in NE region. BVDV 1 and BVDV 2 were prevalent with 1.5% seroprevalence for bovine viral diarrhea virus (BVDV) among ruminants in Nagaland and Manipur. Samples from Nagaland, Manipur and Meghalaya also revealed CSF virus in 62.96%.

Lymnaea auricularia snails, collected from 11 districts of Karnataka, were screened for the presence of *Fasciola* infection and 5.1% prevalence was recorded. Prevalence was more in Deccan plateau (4.65%) followed by Western Ghats (4.57%) and coastal region (3.43%). Screening of bovine surra samples from eight states/UTs revealed 79% prevalence of *Trypanosoma evansi* antibodies with highest prevalence in Puducherry.

Japanese encephalitis virus and other flaviruses: Japanese encephalitis virus (JEV/SW/IVRI/395A/2014), isolated from stillborn piglets with hydrocephalus and hydranencephaly were sequenced (GenBank Accession no. KP164498). Phylogenetic analysis indicated that the virus belonged to genotype III and shared closest homology with some old Japanese isolates of JEV. The virus also shared close homology with viruses involved in JE outbreaks among humans in Uttar Pradesh

Three different species of bats (*Pteropus, Rousettus* and *Pipistrelle*) were captured from their roosting sites in and around Bareilly. The fruit bats roosted on big trees and old abandoned buildings. Tissue specimens from *Pipistrelle* species were found positive for West Nile and Kyasanur Forest Disease viruses and an unknown influenza virus by RT-PCR and sequencing.

West Nile virus and JEV infection in ducks: The extent of WNV infection in domestic ducks in Kuttanad region, was investigated. In Kerala, 95 (45%) of 209 ducks were found positive in WNV Ab ELISA. End point neutralizing antibody titre revealed WNV specific antibodies in 11.5% ducks in 3 districts, JEV specific antibodies in 21 (10%) ducks in 2 districts, and flavivirus specific antibodies in 9% ducks. Persistence of WNV and JEV activity was in wider areas in Kerala than previously reported; it may help the public health authorities in formulating surveillance programmes in the region and domestic ducks may be useful captive sentinels in monitoring WNV/JEV activity.

Genetic and antigenic analysis of border disease virus: Pestiviruses isolated from sheep and goats in India thus far have been bovine viral diarrhoea virus 1 (BVDV-1) or BVDV-2. The virus isolated in years 2009-10 was characterized at genetic and antigenic level. Phylogenetic analysis typed the Indian border disease virus (BDV) isolate as BDV-3. A more detailed analysis showed that the N^{pro} (168), C (100 aa), E^{rns} (227 aa), E1 (195aa) and E2 (373 aa) proteins were of size characteristic for BDV reference strain X818. Antigenic differences were evident between the BDV-3 isolate and previously reported BDV-1, BDV-5 and BDV-7 strains. This is the first identification of BDV

Diagnostic preparedness against avian influenza H7N9 virus

The H7N9 influenza virus is considered as a major threat to poultry industry as well as public health in India. The first incidence of H7N9 avian influenza virus in China in 2013 caused mortality in human population. Since H7 avian influenza virus has not been reported from India, H7N9 virus was generated for its diagnostic preparedness through reverse genetics using synthetically prepared genes from genetic sequences available in public database. In an effort to develop diagnostic tool for H7 subtype AIV, the haemagglutinin (HA) of H7N9 virus was cloned, expressed and purified from *Escherichia coli*. Western blot analysis using anti-H7 serum confirmed the expression of rHA. The recombinant HA was used to develop an indirect ELISA test for detection of antibodies against H7 avian influenza that would provide a rapid and economical approach for early response to impending influenza virus pandemic. Monoclonal antibodies against H7N9 virus were also developed and were found useful in detecting H7N9 virus in the virus infected MDCK cells.

in sheep in India, which highlights the need for continued pestivirus surveillance and assessing its impact on sheep and goat production.

Global proteome analysis of H5N1 infected lungs: In order to understand the difference in the molecular pathogenesis of H5N1 virus in chicken and ducks, comparative proteomics approach was used. LC MS/MS was carried out and the global proteome of HPAIV H5N1 infected lungs at 3 time points post infection was profiled. The chicken mass spectra data sets comprised 147,451 MS scans and 19,917 MS/MS scans. Total 120,000 MS spectra and 30,000 MS/MS spectra were identified in duck proteome dataset. At local FDR 5% level, 3,313 and 2,095 proteins were identified in chicken and duck lungs, respectively. This was studied in conjunction with the meta-analysis of transcriptome data of AIV infected lungs of these species. The activation of critical pathways namely, TLR, RLR, NLR, ILIR, and JAK-STAT signaling pathways in response to HPAI H5N1 infection in chicken and duck lungs with variation in the numbers of proteins involved in each species, was seen. The high level upregulation of cytokines, chemokines and interferon stimulated genes with 1 to 6 fold change were observed in chicken lung tissues. However, the expression of critical antiviral genes was upregulated in duck lung tissues. The overabundance of cytokines, chemokines and interferon stimulated genes (ISGs) results in cytokine storm and widespread tissue damage leading to susceptibility of chicken to HPAI H5N1 infection. Activation of critical proteins in RIG-I/MAVS/IFNAR1- dependent antiviral pathways, leads to regulation of virus replication with minimal tissue damage thus resulting in tolerance to HPAI H5N1 infection in ducks.

Development and improvement of diagnostics

FMD: Diagnostic performance of serum neutralization test (SNT) and liquid phase blocking ELISA (LPBE) in FMD vaccinated animals was assessed. Replacing the use of animals for quality assessment with *in vitro* tests like serum neutralization test (SNT) or liquid phase blocking ELISA (LPBE) requires establishment of logistic regression model from series of challenge experiments. Before establishing logistic regression model, relationship between SNT and LPBE titer was assessed for classifying cattle as protected and unprotected. SNT and LPBE were carried out on known negative (n=306) and positive samples against FMDV O/IND/R2/1975 (n=92), A/IND/40/2000 (n=16) and Asia1/IND/63/1972 (n=11) to evaluate the diagnostic and performance characteristics by receiver operating characteristics (ROC) curves. Using 471 bovine trivalent FMD vaccinated serum, the relationship between SN_{50} and $LPBE_{50}$ titers was analysed following linear regression modeling.

Establishment of DNA Bank of Indian wildlife

A DNA Bank of different wildlife species was established at the Wildlife Centre of ICAR-IVRI, Izatnagar. Genomic DNA from 52 wildlife samples (14 blood/38 tissue) from 17 different species were isolated and stored at —20°C. These will be useful for species identification, which is required in forensic investigations.

PPR: Peptide-activated AuNPs was successfully applied for visual sensing of peste-des-petits-ruminants virus (PPRV). Conjugation of PPRV ligand peptides was accomplished on Au nanoparticles and visual detection of PPRV was observed based on plasmon color change from red to blue.

Listeriosis: Three in-house developed ELISAs (wLLO-, rLLO- and rPI-PLC-based ELISAs) for diagnosis of listeriosis were evaluated on clinical samples (136 caprine, 106 bovine, 92 porcine) in comparison to isolation of pathogenic *Listeria monocytogenes*. rLLO-based ELISA showed higher specificity than the widely used wLLO-based ELISA and rPI-PLC-based ELISA, which showed high cross-reactivity.

Tuberculosis recombinant proteins: Tuberculosis recombinant proteins (ESAT-6, CFP-10, and MPB86) can be used as diagnostic antigen for differentiation of *Mycobacterium bovis* and non-tuberculous mycobacteria (NTM) in cattle.

Canine babesiosis: Immuno chromatic test (ICT) for diagnosis of babesiosis was developed for rapid and sensitive detection of *Babesia gibsoni* infection in canines. The test was standardized with 20 nm gold particles coated with recombinant *B. gibsoni* secreted antigen 1 (*Bg*SA1). A comparison of various immuno-assays like microscopy, nested-PCR and indirect ELISA with r*Bg*SA1 for detection of antibodies to *B. gibsoni* showed 12/134 (8.9%), 46/134 (34.3%) and 38/134 (28.3%) dogs positive, respectively.

Relaxin based pregnancy diagnosis: To develop a relaxin based methodology for pregnancy diagnosis

in bitches, the ProRlx was expressed in recombinant form both in prokaryotes and yeast. However, the hyper immune sera raised against the recombinant Rlx could not differentiate the pregnant and non-pregnant bitch serum in ELISA format, probably due to sharing of the epitopes among the Rlx precursor proteins. Therefore, seven peptides were synthesized in linear and MAP format for canine rlx targeting different epitopes. The seven peptides were purified and characterized with available rabbit anti-relaxin antibodies. Polyclonal hyper immune sera were raised against the seven synthetic peptides in guinea pig and chicken. Sandwich-ELISA was standardized using chicken anti-rlx peptide Ab as capture Ab and rabbit anti-prorlx Ab as detection Ab. The standardized protocol was used to evaluate the serum response of pregnant and non-pregnant. The sandwich-ELISA showed 90% specificity and 66% sensitivity.

Diagnostics for brucellosis: A visual loop mediated isothermal amplification (LAMP) was standardized for the detection of *Brucella* in vaginal swabs, preputial swabs and milk. This technique was highly sensitive and can detect *Brucella* DNA as low as 10 femtogram. The diagnostic capability of detection of brucellosis in terms of limit of detection (LOD) assay is 3 × 10 cfu/ml. This test has a specificity of 98% compared to iELISA and SAT.

Standardization of OMP31-TAQMAN® PROBE based real-time PCR assay: An assay was devised by spiking known culture of *Brucella melitensis* in vaginal washings and milk samples, with CFU/ml starting from 10^{11} to 10 dilution. For vaginal washings, the Y intercept is 54.310 and the efficiency was calculated as 93.6% based on the slope (S) value of -3.485, while the regression coefficient of the test is 0.996. On the other side, the *B. melitensis* spiked milk showed a regression coefficient of 0.980, slope of -1.52 and y-intercept of 35.60.

Specificity tests for the Omp31 gene Taqman® probe based real-time assay: The Omp31 gene Taqman® probe based real-time assay was standardized for detection of *B. melitensis* in clinical samples. The test was devised by incorporating the DNA of several related and unrelated pathogens. The samples were given a positive call by the machine based on the magnitude of relative fluorescence units (RFU) with higher than the cut-off value. Among various suspected clinical samples tested, many were positive owing to the higher sensitivity of the test. The other unrelated bacteria were clearly ruled out with a very low RFU call below the cut-off. The related genus, viz. *Brucella abortus* showed slightly higher RFU magnitude, but still it was well below the machine calculated RFU cut-off.

Echocardiography of calves affected with FMD

Echocardiography was conducted in calves showing signs of foot and mouth disease. There was no significant difference in important echocardiographic parameters such as LVId, LVIs, IVSd, IVSs, LVWd and LVWs between the healthy and the affected animals. However, the EF, SF and EPSS were altered in a few cases. The most significant change in the affected animals was cardiac fibrillation and calves showing cardiac fibrillation could not be saved even after institution of prescribed therapy.

Vaccine development and delivery

Newcastle disease: A novel reverse genetics system involving modified strain F of Newcastle disease virus (NDV) and incorporating VP2 gene of a very virulent strain of infectious bursal disease virus (IBDV) was developed. The rescued recombinant virus, generated from a lentogenic vaccine strain, is being used as a vaccine in young chicks. The recombinant virus was safe in chicks.

Caecal coccidiosis: Immunization of chickens with recombinant EtAMA1, EtMIC3-MAR1b and EtMIC3-MAR1c along with TiterMax gold adjuvant given intramuscularly followed by homologous challenge with 10,000 sporulated oocysts of *Eimeria tenella* resulted in oocyst reduction of 57.22%, 24.93% and 53.0%, respectively. The anticoccidial index of rMAR1c, rAMA1 and rMAR1b immunized groups were 161, 153 and 141, respectively. Both CMI as well as humoral immune response were induced in immunized chickens. Overall, the Th1 immune response (INFγ, NO) was highest in rMIC3-MAR1c followed by rMAR1b and rAMA, while the Th2 response (IL-4, IL-10) was highest in oocyst immunized birds followed by rAMA1, rMAR1c and rMAR1b immunized birds. The highest IgG response was observed in rMIC3-MAR1c immunized birds followed by rAMA1, while it was lowest in rMIC3-MAR1b immunized birds.

Characterization of pathogens

H gene of PPR was identified as the most diverse gene with highest evolutionary relationship with the full genome sequences and, hence considered to be the most preferred candidate phylogenetic marker. The most recent common ancestor of the 27 PPRV isolates analyzed were placed in the late 19th or in the early 20th century with high posterior probability values. Growth kinetics study of thermoadapted PPR vaccine strains (Revati and PPR-Jhanshi) showed that the virus multiplied at 40°C to a titre of 10^6 $TCID_{50}$/ml.

Screening of 197 enteroaggregative *Escherichia coli* (EAEC) isolates recovered from diarrhoeic infants (n=95) and young animals (n=102) from different regions of the country revealed highly diverse PFGE profiles in most cases. Analysis of *E. coli* isolates (n=87) recovered from street vended foods and associated environment for extended spectrum beta lactamase (ESBL) marker genes (*blaTEM, blaCTXM* and *blaAMPC*), revealed that 4 isolates were positive for *blaTEM* and 1 for *blaAMPC* gene.

Screening of biofilm-associated genes (*fla*AB, *peb*1A, *peb*4, *lux*S and *cj*0511) by PCR in *Campylobacter* spp. isolates (n=121), revealed highest detection rate

for *peb*1A (85.12%), followed by *peb*4 (67.77%), *lux*S (66.94%), *cj*0511 (44.63%) and *fla*AB (23.14%).

CTX-M-15 type extended spectrum β-lactamase producing *Klebsiella oxytoca* isolated from clinical and subclinical bovine mastitis and repetitive extragenic palindromic-PCR based phylogenetic analysis revealed genetic diversity of the isolates. A New Delhi beta-lactamase producing *Klebsiella pneumoniae* strain SK5 was isolated from a case of bovine mastitis.

Phylogenetic analysis of the *BgTRAP* gene revealed that Indian and Bangladesh isolates of *Babesia gibsoni* formed a distinct cluster away from other Asian isolates.

Repository of veterinary, dairy and rumen microorganisms

A total of 2,939 cultures/clones are deposited in the VTCC (Veterinary Type Culture Centre) after authentication using conventional and molecular characterization methods such as sequence analysis of 16S rRNA and important virulence genes. During the period under report, 270 veterinary microbes, 74 rumen microbes and 39 dairy microbes were isolated, accessioned and preserved.

Viral isolates: Viral isolates (170), viz. buffalopox virus, camelpox virus, sheeppox virus, peste des petits ruminants virus, goatpox virus, rabies virus, equine influenza virus, equine rotavirus, Japanese encephalitis virus, bovine and human rotavirus, bovine herpes virus-1, and equine herpes virus-1 and 4, infectious bursal disease virus, infectious bronchitis virus and Newcastle disease virus of different livestock species were accessioned and preserved in freeze dried form in the repository.

Bacterial isolates: Economically/scientifically important bacterial isolates (1,037) were accessioned and stored in the repository. To increase the microbial genomic resource diversity of culture collection, the rare strains of bacteria were isolated, identified and characterized from diverse animal background. Phenotypic/genotypic information including microscopic cell morphology photographs, 16S rRNA and other specific gene sequences and clones of isolates were generated/stored.

Recombinant clones and bacteriophages: Recombinant clones (511) with specific genes of viral and bacterial isolates and 76 bacteriophages were presently accessioned and preserved in the repository.

Rumen microbes: Anaerobic bacteria, yeast/fungi and archae (total 331) were accessioned and preserved in the repository. These include important bubaline rumen fungi such as *Anaeromyces* sp., *Orpinomyces intercalaris* and *Orpinomyces joyonii;* caprine isolates: *Piromyces* sp. and *Neocallimastix* spp.; and rumen bacteria such as *Bacillus licheniformis, Butyrivibrio* sp., *Eubacterium limosum, Megasphaera elsdenii, Prevotella* sp., *Streptococcus bovis, Streptococcus equines, Streptococcus gallolyticus, Streptococcus lutetiensis, Streptococcus sanguinis* and *Veillonella parvula* from cattle, goat and buffalo. These isolates were characterized by sequence analysis of ITS and LSU regions of the genome and analyzed for useful biological activities such as fibre and protein degradation (*Prevotella* spp, *Butyrivibrio* spp); urea hydrolysis (*Megasphaera* spp); tannin degradation *(Streptococcus* spp*);* bacteriocin production *(Bacillus)* etc.

Three anaerobic cultures, viz. *Pediococcus acidilactici* NRCC 1, *Pediococcus acidilactici* NRCC 2 and *Lactobacillus plantarum* NRCC 1 isolated from C1 compartment (rumen) fluid of adult dromedary camel (*Camelus dromedarius*) were submitted to VTCC-RM. Their whole genome shotgun sequence and 16s rDNA sequences were submitted to NCBI Gene Bank.

Dairy microbes: Bacterial cultures/isolates (507) including *Lactococcus* spp, *Leuconostoc* spp, *Streptococcus thermophilus* and *Lactobacillus* spp, *Lactococcus lactis* ssp.*lactis, Leuconostoc lactis, Lactobacillus fermentum, Bifidobacterium dentium, Bifidobacterium longum, Leuconostoc mesenteroids* spp *mesentroids, Leuconostoc mesenteroids* ssp. *cremoris, Leuconostoc* sp., *Leuconostoc mesenteroids* ssp *para mesentroids, Lactococcus lactis* ssp. *diacetylactis, Micrococcus* sp., *Lactis, Lactococcus lactis* ssp. *Cremoris, Lactococcus lactis* ssp. *lactis bv. Diacetylactis, Streptococcus thermophilus, Kluyveromyces lactis, Saccharomyces bisporus* etc. are available in the dairy microbes repository.

Clinical and surgical interventions

Composite scaffolds for bone and tendon repair: Achilles tendon from buffalo (aged about 1.5-2 years) was harvested aseptically from a slaughter house within 3 hr of slaughter. The samples were subjected to treatment either with 2% SDS or freeze and thaw (F&T) cycle. Morphological characteristics and surface structure of the implants were studied by histological examination and scanning electron microscopy. The grafts were also applied in the clinical cases of tendon gap defects and showed the potential to support healing of damaged tendon.

Bubaline decellularized cancellous composite bone xenograft: Wedge and complex fractures in dogs were treated with lockning compression plate (LCP) and the role of bubaline decellularized cancellous composite bone xenograft was evaluated for biological osteosynthesis of such fractures. It was found that the composite (allogenic canine MSCs seeded) bubaline decellularized cancellous bone xenograft may be beneficial for treating the non-reconstructible wedge and complex fractures of long bones in dogs.

Therapeutics

Fruit extract of *Embelia ribes* (Baibirang) @ 30mg/kg body weight could reduce EPG by 86.18% in sheep infected with GI nematodes. Chymotrypsin galactose (630 mg) was effective as intra-uterine therapy for completely neutralizing the antisperm antibodies in repeat breeding cows. Polyherbal extract of *Eclipta alba, Solanum nigrum, Macrotyloma uniflorum, Murraya koenigii* and *Phyllanthus niruri* @ 30 mg/kg b wt po daily for 2 weeks revealed potent antioxidant, diuretic and hepato-protectant effect in dogs with

compromised liver condition.

Pyrilamine (1 µM) and cyproheptadine (1 µM) evoked a rightwards displacement of histaminergic curve, but cimetidine (1 µM) had no effect on isolated reticular groove preparation of adult male goats. Essential oil of *Callistemon viminali* (bottle brush) leaves produced concentration-dependent relaxation on isolated reticular groove preparation. Sumatriptan (10^{-6} M), ketanserin (10^{-5} M) and ondansetron (10^{-6} M) markedly reduced tryptaminergic effect on isolated reticular groove preparation.

Betulinic acid (BA) and ursolic acid (UA) treatment in CKD rats improved the oxidative stress parameters and kidney function parameters. Anti-inflammatory bowel disease (IBD) effects of BA may be attributed to its anti-inflammatory and antioxidant potential. BA showed good antinociceptive activity in animal models of visceral pain.

Therapeutic potential of caprine bone marrow derived mesenchymal stem cell conditioned media: Present study was conducted to assess the secretary potential of caprine mesenchymal stem cell (MSCs). Mononuclear cells were seeded @ 1-2 × 10^5/ well in 24 well plates in DMEM supplemented with 20% FBS and antibiotics. Third passage MSCs were cultured up to 80% confluence and media was changed with KO DMEM+KO SR media and conditioned media was harvested at different time intervals i.e. 24 hr, 48 hr, 72 hr, and 96 hr. Immunocytochemical localization and Western blot analysis confirmed the presence of biomolecules,viz. VEGF, IGF-1, LIF, TGF-β1, bFGF, SCF, iNOS, IL-6 in CM. Further, ELISA analysis revealed that concentration of VEGF and IL-6 increased successively till 96 hr, and at 96 hr the values were 536.3 pg/ml and 40.5 pg/ml, respectively. It can be concluded that caprine MSCs conditioned media contains important biomolecules, thus it may be used for regenerative therapy.

Foot and mouth disease

During the reported period, 252 FMD incidences were recorded in India. Maximum incidences were reported from the Southern region followed by Eastern and North eastern region. Karnataka witnessed maximum FMD incidences during the period. There was no incidence of the disease in Punjab, Andhra Pradesh, Mizoram and Delhi, and a few sporadic cases were recorded in Haryana and Himachal Pradesh.

Serotype O caused maximum (97%) outbreaks and serotype Asia1 was isolated in two incidences recorded in West Bengal and Nagaland. During last three years, the number of incidences owing to serotype Asia1 were very less; mostly observed in the eastern and north eastern region, which shares international border. Serotype A, which was absent during last year was isolated in six incidences during this year. Maximum incidences of FMD were recorded during January and February. Only few incidences were observed between March and June.

Success story

3A based DIVA ELISA to detect antibodies induced by FMDV

Detection of antibodies to the non-structural proteins (NSPs) of FMD virus (FMDV) is the preferred differential diagnostic method for identification of FMD-infected animals in the vaccinated population. Nevertheless, due to the observed variability in the antibody response to NSPs, the likelihood of screening or confirming the FMD infection status in animals is increased if an antibody profile to multiple NSPs is considered for diagnosis. To develop and evaluate an additional NSP-based diagnostic assay, the recombinant 3A protein of FMDV was expressed in *Escherichia coli* and used as an antigen for detection of FMD infection specific antibodies. At the fixed cut-off value of 45% of positivity, the diagnostic sensitivity and specificity of 3A indirect-ELISA (I-ELISA) were 95.7 and 96.3%, respectively. In FMD naturally infected cattle, about 85% of clinically infected and 75% of asymptomatic in-contact populations were positive at 13 months post-outbreak. The 3A I-ELISA was further evaluated with the bovine serum samples collected randomly from different parts of the country. The performance of newly developed 3A I-ELISA was compared with the extensively used in-house r3AB3 I-ELISA with findings of 93.62% overall concordance in test results. The r3A I-ELISA could be useful as a screening or confirmatory assay in the sero-surveillance of FMD in India irrespective of extensive bi-annual vaccination.

Phylogenetic analysis based on VP1 (1D) coding region was carried out to assess genetic variations, inter-strain relationships and track movement of the virus. During the year, phylogenetic analysis of serotype O virus revealed extended and exclusive dominance of Ind2001 strains. In case of serotype Asia1, the isolates from Nagaland clustered within the lineage C indicating its exclusive prevalence since 2005. All the six isolates of serotype A characterized during the period, clustered within the clade18c of VP3^{59}-deletion group of genotype 18. Vaccine matching exercise was carried out to evaluate antigenic relationship of field isolates with currently used vaccine strains to monitor antigenic variation, if any, occurring in the field, and to assess appropriateness of in-use vaccine strains. Selected virus isolates of all three serotypes were subjected to one-way antigenic relationship analysis (r-value) using Bovine Vaccinate Serum (BVS) against respective vaccine strains. In case of serotype O, the vaccine strain INDR2/1975 covered 88% of the field isolates. This vaccine strain is able to provide optimal antigenic coverage over the field isolates.

National FMD Virus Repository was upgraded with new virus isolates. The virus repository has served the cause of the country by providing isolates for molecular epidemiological studies, evaluation of antigenic relatedness between the field and vaccine strains and

Commercialized drug formulations

The drug formulations, viz. Diarrionex-HS, Herbal anti-bacterial anti-diarrhoeal powder for management of diarrhoea in animals; HEALEX-FR, an ointment/ gel for external injuries, septic and maggot wounds management in animals; G Min Forte, Areamix– area specific mineral mixture for Uttar Pradesh for management of mineral deficiency and optimizing production in animals, were commercialized.

selection of new candidate vaccine strains whenever required. Virus isolates (55 serotype O, 11 serotype A and 2 serotype Asia1) were added to the repository during the reported period. At present the National FMD virus Repository holds a total of 2,008 isolates (O-1308, A-319, C-15 and Asia 1-366).

Under National FMD Serosurveillance, 68,948 bovine serum samples collected at random from various parts of the country were tested in r3AB3 NSP-ELISA for assessing the prevalence of NSP-antibody (NSP-Ab) positive animals, which is an indicator of FMD virus exposure regardless of vaccination status. The test revealed overall seropositivity in ~ 23.41% samples/ animals, which is comparatively lesser than the previous year's average (29.2%). The percentage protective antibody titre (SP antibody) in the serum samples collected at random from FMD-CP states were higher when compared to the other states.

During the reported period, 191,402 pre- and post-vaccinated serum samples were tested under FMD Control Programme (FMDCP). Of these 90,244 serum samples were from first phase (2003-04) FMDCP districts representing XVI, XVII and XVIII phases of vaccinations, and remaining 101,158 serum samples were from expanded FMDCP districts of 2010 representing Phases VI and VII. Currently, 89, 78.6 and 87.1% of animals tested were having protective ($\log_{10}$ 1.8 and above) antibody level against serotypes O, A and Asia 1, respectively, in post-vaccination serum samples in the initial FMDCP (2003-04) districts. Similarly in the expanded FMDCP districts (2010), 93.2, 89.5 and 89.7% of animals tested had protective antibody level against serotypes O, A and Asia1, respectively in post-vaccination serum samples.

Avian influenza

Highly pathogenic avian influenza H5N8 viruses: Avian influenza H5N8 viruses were isolated from water fowls for the first time in Delhi, Madhya Pradesh, Punjab, and Kerala in October 2016. One representative isolate each from National Zoological Park, New Delhi and Gandhi Zoological Park, Gwalior, Madhya Pradesh were processed for genome sequencing and analysis. Based on the presence of multibasic cleavage site (PLREKRRKR/GLF) in the haemagglutinin (HA) gene, the virus can be categorized as highly pathogenic to poultry. These viruses belong to the new phylogenetic clade 2.3.4.4, and are closely related to the H5N8 viruses isolated from wild birds in Russian Federation suggesting dispersal of virus during southward winter migration of birds.

Antigenic analysis of highly pathogenic avian influenza (HPAI) H5N1 viruses: Antigenic analysis of HPAI H5N1 viruses isolated from poultry during 2006 to 2015 in India comprising 25 isolates from four phylogenetic clades, 2.2 (01 isolate), 2.2.2.1 (01 isolate), 2.3.2.1a (17 isolates) and 2.3.2.1c (06 isolates) was carried out. Seven H5N1 isolates from all four clades were selected for production of chicken antiserum, and antigenic analysis was carried out. The data indicated antigenic divergence (6-21 fold reduction in cross-reactivity) between the two recently emerged clades 2.3.2.1a and 2.3.2.1c. A systematic analysis of antigenic drift of the contemporary strains will help to determine the strain(s) suitable for vaccine candidate.

Genetic characterization of H6N2 avian influenza virus: An H6N2 avian influenza virus isolated from healthy ducks in live bird markets of Asom in 2015, was characterized by complete genome sequencing. Haemagglutinin (HA) gene analysis revealed it to be a low pathogenic avian influenza virus and closely grouped with H6N2 virus isolated from a wild bird in China, whereas the Kerala H6N2 virus isolated in 2014 displayed close relationship with H6N6 virus isolated from duck in Japan in 2014 and formed a separate lineage within Eurasian region. As H6 virus has contributed genome segments for the emergence of avian influenza viruses with public health significance, surveillance and complete genome sequencing of emerging strains will help in the control of avian influenza.

Pathology of reassortant highly pathogenic avian influenza H5N1 virus: The pathogenicity of H9N2-PB2 reassortant H5N1 virus was studied in BALB/ c mice and compared with non-reassortant H5N1 virus at third, seventh and eighth dpi. Both viruses caused severe congestion, oedema, haemorrhage and consolidation in lungs of mice as time elapsed, the lesions being more pronounced in non-reassortant group. Microscopically, lungs showed severe congestion, haemorrhage, thrombus, fibrinous exudate in perivascular area, interstitial septal thickening, bronchiolitis and alveolitis leading to severe pneumonic changes, lesions being more severe in non-reassortant virus infected group. Viral antigen and RNA were detected by immunohistochemistry and RT-qPCR, respectively, in the nasal mucosa, lungs, trachea and brain at all the three intervals in both the groups. In reassortant virus infected mice, proinflammatory cytokines IL-1, IL-6 and KC were upregulated in the brain and lungs and more innate sensors, viz. TLR-3 and TLR-7 mRNA were also expressed during infection. In non-reassortant H5N1 virus infected mice, cytokine responses were less pronounced than reassortant H5N1 virus infected mice. In conclusion, the H9N2-PB2 reassortant H5N1 virus caused milder lesions in mice and the innate immunity might have played a major role in its low pathogenicity.

SUCCESS STORY

Japanese encephalitis - ELISA kit (IgG) for swine

An indirect ELISA kit using rNS1 antigen to detect the IgG antibodies in swine against Japanese encephalitis (JE) virus was developed at the ICAR-IVRI, Izatnagar. This is the first indigenous kit developed for serodiagnosis of JE in pigs. Swine, being an amplifier host, plays an important role in epidemiology of JEV and therefore early detection of either JEV or antibodies against JEV in swine is a pre-requisite for initiating necessary measures to prevent the spread of infection to humans. However, a brief period of viraemia hinders detection of JEV and hence detection of antibodies using ELISA is the best alternative. The kit has been developed under the ICAR-funded Outreach Programme on Zoonotic Diseases. The kit has excellent repeatability as revealed in intra- and inter-institutional laboratory validation studies. It possesses an appreciable diagnostic sensitivity (91%) and specificity (98%).

Cattle

A fast and economical genotyping method for detection of BLAD and CVM was developed and the same was applied for patent. An in-house built lamp assay was developed for rapid detection of cow components adulterated in buffalo milk/meat and an Indian patent was filed.

Goat

First 'Indigenous Vaccine' against Johne's disease: Vaccine (therapeutic as well as prophylactic) against Johne's disease was successfully developed, commercialized and was launched after getting license from Drug Controller of India, Karnataka. 'Indigenous Vaccine' treats JD in all 4 domestic livestock species. Vaccine was both 'Preventive and Therapeutic'. Inked MoU with M/S Biovet (P) ltd., Bengaluru, CIRG (ICAR) and CSIR, New Delhi; and transferred vaccine strain 'S 5' of *Mycobacterium avium* subsp. *paratuberculosis* 'Indian Bison Type' for commercial production of vaccine (Bio JD oil & Bio JD gel) by M/S Biovet (p) ltd., Karnataka.

SUCCESS STORY

Wildlife healthcare and management

The National Referral Centre on Wildlife Healthcare at ICAR-IVRI, Izatnagar, was approached for diagnostic investigations in different zoos, national parks and forest departments. Specialists from the institute were dispatched at short notice to conduct investigations and advise appropriate therapeutic and control measures for wildlife health management. Important disease outbreaks or cases diagnosed were typanosomosis in blackbucks at Nandanvan Zoo, Raipur; generalized tuberculosis in spotted deer at Sakkarbaug Zoological Park, Junagadh; and babesiosis in lion at Lion Safari, Etawah. Emergency treatment services were provided by the specialist team whenever required. Most notable among these were surgical intervention to treat idiopathic megacolon in a Bengal tiger (T-24) at Sajjangarh Biological Park, Udaipur and treatment of massive suppurative wound in an elephant in the Dudhwa National Park, Uttar Pradesh.

Pig

Methicillin resistant *Staphylococcus aureus (MRSA)*: Livestock-associated MRSA (LA-MRSA) can be transmitted to humans in close contact with MRSA infected / colonized animals. Characterization of MRSA isolates from pigs through Staphylococcal cassette chromosome *mec* (SCC *mec*) typing revealed the presence of types III with 41.66% isolates and type V with 58.33% isolates. The study will help to elucidate the epidemiology of LA-MRSA.

Detection of PPV, PCV and CSFV: Classical swine fever, porcine circo virus and porcine parvo viruses are commonly associated with reproductive problems in pigs. A multiplex PCR was developed for simultaneous detection of these three viruses.

Equines

Surveillance, monitoring and control of existing and emerging disease of equines: NRCE screened 5,360 samples for equine infectious anaemia (EIA), 2,660 serum samples for equine influenza, 1,735 samples for EHV1 (equine herpes virus 1), 1,546 samples for JEV and 13,980 samples for glanders and 1,531 samples for trypanosomosis. All serum samples were negative for EIA. EHV1 and JEV had seropositivity in 14.04% and 2.87% cases, respectively. Major concern during the year was the occurrence of glanders, which spread to newer areas with detection of positivity on 60 animals from the states of Jammu & Kashmir, Uttar Pradesh, Punjab, Gujarat and Uttarakhand. *Burkholderia mallei* could be isolated from five biosamples.

Recombinant equine influenza virus (EIV): All the eight gene segments of H3N8 (Indian EIV strain) were cloned in pHW2000. The recombinant virus containing HA and NA gene segments of H3N8 and other six segments of H1N1 (wsn) was generated. To generate bacterial artificial chromosomes (BACs) for EHV1 for mutagenesis studies and development of recombinant vaccine, mini F plasmid construct was co-transfected along with EHV1 viral DNA in RK13 cells, and through homologous recombination, recombinant-virus-with-GFP was generated in the RK-13 cells. The construct was electroporated into *E. coli* cells to generate BACs.

Genetic diversity of equine herpesvirus 1 (EHV1): Characterization of EHV1 isolates from different outbreaks revealed that they differ due to single nucleotide polymorphisms (SNPs) in a few ORFs, significant being the ORF30 and ORF68. The ORF30 sequence analysis of 24 EHV1 revealed that two of

the Indian samples from abortion cases (Delhi/2008 and Tohana/2007) had nucleotide substitution 'G' at position 2254 in ORF30 while the remaining 22 had 'A'2254 genotype, indicating that isolates with neuropathogenic potential are prevalent in India.

Camel

Detection of *Trypanosoma evansi*: A nano gold based immunochromatographic test, lateral flow assay (LFA) for detection of *T. evansi* infection in animals, was successfully developed to provide a field level test. The test compared well with ELISA developed earlier by NRCE using whole cell lysate (WCL) antigen in preliminary analysis. Similarly, a recombinant flagellar protein based indirect ELISA was also developed for diagnosis of *T. evansi* infection in equines with diagnostic sensitivity and specificity comparable to WCL - ELISA. The assay was also validated at NRCE through inter-lab comparison with highly encouraging results of testing over 3,000 field serum samples.

Management of trypanosomiasis: Evaluation of indigenous herbs, neem and pomegranate leaves showed *in-vitro* trypanocidal activity.

Respiratory diseases: In order to have baseline data for microbes present in the nasal tract of camels, the nasal passage culture was analysed, which revealed presence of *Staphylococus* spp., *Streptococcus* spp., *Pasteurella* spp., *Corynebacterium* spp., *Diplococci* spp. and *Bacillus* spp. bacteria. This will be used as the basis for comparing the microfloral change in diseased and healthy camels.

Capsid swapping for the construction of custom-engineered chimeric FMD virus

Regular vaccination with chemically inactivated FMD vaccine is the major means of controlling the disease in endemic countries like India. However, the selection of appropriate candidate vaccine strain and its adaptation in cell culture to yield high titer of virus is a cumbersome process. An attractive approach to circumvent this tedious process is to replace the capsid coding sequence of an infectious full-genome length cDNA clone of a good vaccine strain with those of appropriate field strains, to produce custom-made chimeric FMD virus. An efficient method based on megaprimer-mediated capsid swapping for the construction of chimeric FMDV cDNA clones, was developed. Using FMDV vaccine strain A IND 40/2000 infectious clone (pA(40/2000)) as a donor plasmid, the capsid sequence of pA(40/2000) was exchanged with that of the viruses belonging to serotypes O (n = 5), A (n = 2), and Asia 1 (n = 2), and subsequently generated infectious FMDV from their respective chimeric cDNA clones. The chimeric viruses exhibited comparable infection kinetics, plaque phenotypes, antigenic profiles, and virion stability to the parental viruses. The results suggested that megaprimer-based reverse genetics technology is useful for engineering chimeric vaccine strains for use in the control and prevention of FMD in endemic countries.

Mithun

Cell-mediated immune status of mithun and Tho-Tho cattle: MTT (3-(4, 5-dimethylthiazolyl-2)-2, 5-diphenyltetrazolium bromide) cell proliferation assay revealed a higher cell proliferation capacity of mithun compared to that of Tho-Tho cattle (*Bos indicus*) during all the physiological stages.

Chemical fingerprinting of medicinal herbs: Phytochemical analysis of an aqueous extract of 33 medicinal herbs collected herbarium revealed the presence of terpenoids, alkaloid, flavonoids and phlobotanins in the majority of herbs suggesting the anti-inflammatory, anti-viral, antibacterial and anti-oxidants properties.

Molecular identification of *Ixodes* ticks: The morphological features of the tick specimens and sequence analysis of ITS2 region revealed the prevalence of both *I. ovatus* and *I. acutitarsus* in mithun.

Molecular identification and pathology of hydatid cyst: The presence of mitochondrial enzyme nad1 and cox1 confirmed the prevalence of both *Echinococcus ortleppi* and *E. granulosus* in mithun. *E. granulosus* is the predominant species and provided an evidence for the circulation of *E. ortleppi* in mithun for the first time. Histopathological examination of hydatid cysts in the liver showed an extensive proliferation of fibrous connective tissue with eosinophilic and lymphocytic infiltration, whereas in lung parenchyma, severe emphysema with infiltration of alveolar macrophages and lymphocytic infiltration were observed.

Molecular characterization of *Mecistocirrus digitatus* in mithun: Sequence analysis of internal transcribed spacer region-2 (ITS-2) and beta tubulin gene showed 100% identity with other isolates of *M. digitatus*.

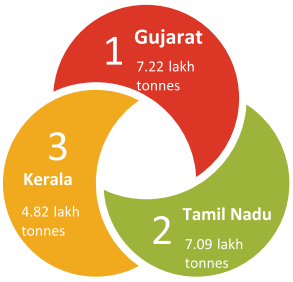
Poultry

Diagnostics and prophylaxis: The overall incidence of avian leucosis virus (ALV) in the farm was reduced to 3.35% with 6.16, 9.5 and 0 and 5.2% mortality in Nicrobari, Gaghus, Assel and layer respectively. Marek's disease virus (MDV) serotype 1, copies were detected in spleen, feather pulp and lymphocytes at all the 16 time intervals in vaccinated [HVT (Harpes virus turkey) +SB1 or HVT] and unvaccinated groups of birds under natural field conditions. These findings revealed that birds in all the groups were exposed to existing MDV serotype 1 circulating in the environment where the birds were housed. Gross and microscopic lesions were more severe in unvaccinated, less severe in HVT vaccinated and mild in HVT+SB1vaccinated birds.

Fish

Marine fish production: Marine capture fisheries production from mainland of India in 2015 was 3.40 million tonnes, representing a decline of 5.3% with respect to 2014. This decrease partly corresponds to drop in catches of Indian oil sardine. With the highest

catches of 7.20 lakh tonnes in 2012, oil sardine catches decreased to 2.66 lakh tonnes in 2015. Marine finfish species contributed more than 27.6 lakh tonnes to the total fish production, of which almost 18 lakh tonnes were pelagic species and 9.6 lakh tonnes were demersal. The remaining consisted of 4.2 lakh tonnes crustaceans and 2.2 lakh tonnes molluscs. The bulk of country's landings (63%) came from southeast and northwest regions. Gujarat remains by far the largest producer with an estimated landing of 7.22 lakh tonnes and contributed one-fifth of country's production. In all about 735 species were captured; maximum species diversity was found in Kerala and Tamil Nadu.



Valuation of marine fish landings during 2015 was estimated at ₹ 40,100 crore (26.30% increase over 2014) at landing centre (LC) level and ₹ 65,180 crore (24.48% increase over 2014) at the retail market (RM) level.

Guidelines for National Plan of Action for shark fishery: Guidelines for preparing National Plan of Action for conservation and management of sharks in India are spelt out by ICAR-CMFRI in a book entitled "*Guidance on National Plan of Action for Sharks in India*". Following the guidelines of Food and Agriculture Organization's International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks), adopted in 1999, the book outlines a theme-based action plan for shark conservation and management in India. The status of India's shark fisheries (including sharks, rays and skates), its trade, existing management and conservation measures are summarized in the book.

Stock assessment of Hilsa fisheries: Hilsa, *Tenualosa ilisha*, a high value fish, spends its adult life in marine environment and migrates to freshwater riverine habitats for breeding. The young ones migrate back to marine environment for growth. Stratified Multistage Random Sampling method involving 51 stations along the Hooghly-Bhagirathi river system and Northern Bay of Bengal estimated total Hilsa catch at 12,191 tonnes during 2015-16, which amounts to only 27% of the previous year's landing, indicating drastic decline in current year's catch. Maximum catch (98.6%) was realized from the marine sector. The catch per unit effort (CPUE) varied from 37.5-260 kg/boat/day for multiday gillnetters in peak fishing months (July-September), whereas in estuarine and freshwater zones, it was 0.4-14.0 and 0.08-1.25 kg/boat/hour, respectively, for single day gillnetters.

Based on exploitation pattern and population structure analysis, there is 20% overexploitation from maximum sustainable yield (MSY) levels and 72.4% decline in standing stock biomass. Exploitation ratio was 0.77, indicating over-exploitation. Estimated spawning stock biomass (SSB) was 23.7% of the virgin stock, indicating that SSB of the population is currently at minimum sustainable level. Bio-economic analysis also showed decline in maximum economic yield (MEY) by 9.3%. Time series analysis of catch data using Autoregressive Integrated Moving Average (ARIMA) model suggested progressive decline in production of hilsa in coming years in the Hooghly system.

β - Noda virus detection kit for marine broodstock fishes: ICAR-CMFRI, Kochi developed 'β-Noda detect' for the detection of beta noda virus in fish. The kit is highly specific, sensitive and rapid and can detect a single copy of virus in less than 1 hr. Positive reaction is diagnosed by a green fluorescence that can be visualized by naked eye under visible or UV light (using protective goggles) without the help of sophisticated equipment. Mainly intended to screen marine broodstock fish to ensure certified specific pathogen free eggs and larvae in a sensitive and rapid way, it will also aid in timely diagnosis and prevention of spread of disease in marine culture system.

❑

Early breeding of Indian major carps: A success story

Successful advancement in breeding period of Indian major carps was achieved by adopting ICAR-CIFA broodstock feed namely, CIFABROODTH. Demonstration of CIFABROOD^{TM} feed in farmers pond resulted in attainment of early maturity of rohu and catla. The usual breeding period, which commences from mid-June and extends up to September was advanced. Rohu and catla were able to breed from April and May, respectively. The fishes were able to breed again in June. The major advantage of early breeding of Indian major carps is the early availability of seeds for stocking for grow-out culture.

9. Mechanization and Energy Management

FARM MECHANIZATION

Farm mechanization saves time and labour, reduces drudgery, cuts down production cost in the long run, reduces post-harvest losses and boosts crop output and farm income. Various type of implements and machines were developed for improving farm mechanization in the country.

Seed-cum-fertilizer drill for two stage placement of fertilizer

A tractor drawn five-row seed-cum-fertilizer drill has been developed that can place fertilizer at two stages (first at level of the seed and second at 50 mm below the seed) in single pass. Field capacity of the machine is 0.5 ha/h at forward speed of 3.5 km/h with the cost of operation of ₹ 600/h. Two years experimental results on wheat and soybean crops, cultivated on permanent broad beds, showed marked improvement in root growth and maximum yield (increase of 15% for wheat and 22% for soybean) by applying the fertilizer at two stages, i.e. 40 mm away from seed at same depth and 50 mm below the seed.

Seed-cum-fertilizer drill equipped with two stage fertilizer placement

Spectral reflectance based variable rate top dress urea application system

The developed applicator can be mounted on back of operator (weight 5.5 kg without urea) and covers swath width of 4 m. The applicator consists of two Green seeker sensors, which sense the crop health through normalised difference vegetation index (NDVI), two metering units (fluted rollers) and dispensing units (spinning disks) mounted on an aluminium frame. The GPS enabled android based smart phone (android 2.3-5.0) with USB-OTG is used for its operation. A "Variable Rate Controller" app has also been developed. An estimated 8-15% savings in urea fertilizer can be achieved with use of NDVI based variable rate fertilizer applicator in wheat and rice crops in areas with spatial nitrogen variation.

Variable rate urea application system, integrated with spectral reflectance based sensor

Seed-cum-fertilizer planters for minor millets

Six different configurations of minor millet planters viz. manually operated single row, bullock drawn three-row (two prototypes with different metering mechanisms) and tractor drawn six-row machine (two prototypes with different metering mechanisms) and an attachment to power tiller have been developed. These equipments are suitable for sowing of minor millets and other small seeds such as kodo millet, little millet, proso millet, foxtail millet, barnyard millet, finger millet, mustard, jute, etc. Using the multi millet seed-cum-fertilizer planters, savings of 90% and 70% of seed is possible in comparison to that of broadcasting and drilling by traditional methods.

Bullock operated

Tractor operated

Power tiller operated

Pre-emergence herbicide strip applicator-cum-planter

It consists of a frame on which 6 flat fan spray nozzles are mounted by means of clamps, a single action piston pump with 9 l/min capacity, pressure regulator valve, and pressure gauge and pressure pipes. The spacing between the spray nozzles, angle and height of spray nozzles can be varied by adjusting the clamps. The developed system has the ability of strip as well as blanket application of herbicides. The machine was tested and evaluated during *kharif* season for soybean and pigeon pea crops. The field capacity of the developed system is 0.4 ha/h with an operating cost

Herbicide strip applicator-cum-planter

₹ 1,350/ha thus saving 40-50% herbicide. The same machine can be used as post-emergence herbicide/ pesticide applicator after the removal of furrow openers and increasing the height of nozzles from the ground. The initial cost of the applicator with inclined plate planter is approximately ₹ 70,000.

Paddy transplanter as an attachment to four wheel drive tractor

The VST Yanji Shakti make 8-row paddy transplanter is attached to 16.41 kW VST 4WD mini tractor. The power from tractor PTO is transmitted to drive the planting mechanism of the transplanter. The four wheels of the mini tractor are replaced with front and rear wheels of a transplanter to avoid sinkage under field condition. The height of the gear box and the top link are increased for more lifting height through hydraulic system. The effective field capacity of the machine is

The paddy transplanter as an attachment with the tractor

0.19, 0.24 and 0.29 ha/h with field efficiency of 53, 60 and 61% at an operating speed of 1.9, 2.1 and 2.5 km/h, respectively. The seedlings per hill are 2-4 and floating hills range 1-3% for all combinations.

Stem applicator as an attachment to power-weeder for cotton crop

The stem applicator attachment for a power weeder (2.6 kW) can apply recommended dose of herbicide on cotton crop. The herbicide was applied to one side of the plant stem at a time. The equipment is suitable for performing both weeding and herbicide stem application simultaneously in cotton crop. The effective field capacity and field efficiency of the equipment were 0.06 ha/h and 84%, respectively at a forward speed of 1.2 km/h. The fuel consumption was observed to be 1.2 l/h or 25 l/ha.

Stem applicator attached with power weeder for cotton

Animal lifting device for sick bullocks and equines

It comprises of a frame structure made of mild steel (50 × 4.5 mm); worm-gear type lifting winch with steel wire ropes and pulleys; slings with water proof fabric and padded broader belts; and transport wheels. The overall dimensions of the device when fully assembled are 3605 × 2330 × 2508 (L × W × H mm).

Animal lifting device

Sick bullock lifted with the device

The device is made collapsible for ease of transportation. Preliminary trials were successfully carried out using dead weight as well as a live bullock (535 kg). The animal was observed to be stress and anxiety free after being placed in the sling and lifted by the device to a standing position and after it was dismounted from the device.

Loose straw chopper for paddy straw management for wheat sowing

It consists of a comb type pick up conveyor as used in the conveyor wheat seeder for picking up and conveying the loose paddy straw into straw chopping unit. The straw chopping unit consists of chopping cylinder having serrated blades for chopping the loose straw into small pieces and uniformly spreading on the field without disturbing the standing stubbles. The working width of the machine is 1.7 m. The loose straw chopper was evaluated in combine harvested paddy field for chopping loose straw of paddy variety viz. PR 124 and Pusa Basmati 1121 at three chopping speeds of 700, 900 and 1,100 rpm for both front and rear chopping cylinders. The effective field capacity of the tractor operated loose straw chopper is 0.33 ha/h and average fuel consumption is 4.8-5.3 l/h. The percentage of chopped straw up to 70 mm size varies from 62 to 71% at chopping speed of 1100 rpm. The cost of operation of loose straw chopper plus happy seeder is ₹ 3,416/ha as compared to ₹ 3,164/ha under conventional sown condition.

Loose straw chopper operating in the paddy field before wheat sowing

Light weight paddy thresher cum cleaner

The electric motor (0.75 kW) operated light weight paddy thresher cum cleaner for paddy crop consists of main frame, wire loop type threshing unit, blower, sieving unit and power transmission unit. The separation of paddy grain from the straw is achieved due to combing action of the wire loops fitted on the threshing cylinder. The separated grains fall on the vibrating screen through the cleaning duct. A blower is used to blow off the chaff, dust and other light foreign materials from the grain. The vibrating screen separates sand, weed seeds and other heavy weight smaller size impurities. The threshing efficiency, grain output capacity and losses due to shattering of the machine are 99%, 143 kg/h and 2%, respectively.

Light weight paddy thresher-cum-cleaner

Mechanization package for sugarcane single bud technology

(a) Double head single bud cutting machine for sugarcane

The machine has two pairs of two circular blades made of high carbon steel, rotating at 2800 rpm. A spacer is provided between the two blades, which facilitates variation in the size of single bud sett as per the requirement. Two people can operate the machine simultaneously and can cut about 3000 single buds in an hour. The machine can be operated by 0.75 kW (1 hp) electric motor which powers both the sets of cutting blades. The cost of the equipment is about ₹ 25,000.

Single bud cutting machine

(b) Two row tractor single bud settling planter

A tractor operated two-row sugarcane settling planter

Single bud settling planter

has been modified for adjustments of spacing and depth of planting. The row to row spacing can be adjusted to 900, 1200 and 1500 mm. The depth of planting can be adjusted from 60 to 100 mm. The plant to plant spacing can be adjusted to 450, 600 and 900 mm. The cost of the equipment is about ₹ 1.00 lakh. The field capacity of the machine is 0.2 ha/h at 1200 mm spacing with a field efficiency of 70%.

Pedal-operated maize dehusker sheller

The machine performs operations of dehusking and shelling of maize. The capacity of the machine is 130 kg/h. The dehusking and shelling efficiencies of the dehusker sheller are 97% and 95%, respectively. The cost of the equipment is ₹ 28,000 (approx.).

Maize dehusker sheller

Bullock drawn earthing-up cum inter-culturing implement for sugarcane and turmeric

For bullock drawn implements, speed of the operation for inter-culturing, light earthing-up and final earthing-up is 3.0, 2.8 and 1.9 km/h, respectively for sugarcane and 3.1, 2.9, and 2.3 km/h, respectively for turmeric crop. Similarly, field capacity for inter-culturing, light earthing-up and final earthing-up operation is 0.15, 0.14 and 0.12 ha/h, respectively for sugarcane and 0.20, 0.18 and 0.13 ha/h, respectively for turmeric. The average power output for inter-culturing, light earthing-up and final earthing-up was 0.43, 0.54 and 0.40 kW for sugarcane and 0.46 kW, 0.57 kW and 0.49kW, respectively for turmeric crop.

Bullock drawn earthing-up-cum-inter-culturing implement

Package of animal drawn implements for cotton and soybean

A package of animal drawn implements for cotton and soybean in animal dominated areas of Malwa Plateau has been developed. An improved bakhar has been used to prepare the field for both the crops. Its field capacity is 13% higher in comparison to conventional blade harrow. It saves 14% of operational time and 10% of operational cost in comparison to conventional bhakhar. Seed drilling with 3- row seed cum fertilizer drill saves 12.5 kg seeds in comparison to tifan seed drilling. For weeding/inter-culture operation in cotton crop, an improved bhakhar of 500 mm is suggested

Animal drawn improved bhakhar

against conventional size of 325-450 mm Kolpa (Dora). Its field capacity is 8% more than conventional bhakar. It saves 7% (1 man-h/ha) labour and higher weeding efficiency by 12% in comparison to conventional one. For weeding in soybean, 3-row sweep cultivator has been modified to two rows to make suitable for guiding between rows. Draft, field capacity, weeding efficiency and labour requirement of two row sweep cultivator are 5.2 kg, 0.10 ha/h, 59% and 10 man-h/ha respectively. The use of this cultivator saves 40% time and labour requirement.

Package of single bullock operated implements for farm operations

This consists of blade harrow for tillage, two row planters for sowing and Twin Ferti hoe for weeding. The average draft requirement for blade harrow and planter is 348 N and 238 N, respectively. Field capacity of harrow, planter and Twin Ferti hoe is 0.06, 0.11 and 0.10 ha/h respectively. The average weeding

Seed drill operated with single bullock

efficiency has been observed as 88%. The output power of blade harrow, planter and twin wheel has been worked out to be 0.11, 0.13 and 0.19 kW respectively. Cost of operation for harrowing with blade harrow and weeding with twin ferti hoe has been estimated as ₹ 835.0/ha and ₹ 910.0/ha, respectively.

Light weight pneumatic wheel bullock cart

With a payload capacity of 1.0 tonne, the cart is provided with brakes and shock absorbers for smooth travel on rural roads. The weight of the cart is 100 kg. Under plain tar road condition, the average draft increased from 83.3 N to 305.7 N and the average speeds decreased from 3.96 to 2.73 km/h when pay loads increased to 800 kg on tar road. It has been observed as the small size bullocks could sustain pulling

Light weight bullock cart

of 800 kg payloads for three hours on the tar road comfortably with a fatigue score of 13. Under plain *kachha* road, the average draft increased from 92.1 to 324.4 N and the average speed decreased from 3.60 to 2.69 km/h when pay load increased to 800 kg. The small size bullocks could sustain pulling 800 kg payloads for three hours on the tar road comfortably with a fatigue score of 14.

Plastic mulch for potato cultivation under drip irrigation

Experimental trials were conducted to study the effect of plastic mulching duration and mulch colour on soil temperature, growth parameters and yield parameters of potato (variety: *kufri badhsha*) under drip irrigation. The duration of the plastic mulching varied from zero to the entire duration of the crop. Silver and black colour plastic films (0.03 mm thick) were used in the study. Plastic mulch films were removed after 60, 70 and 90 d (till the end of crop duration). Growth parameters such as plant height (51.6 cm), number of stem per plant (5.4), stem girth (6.6 mm) and SPAD value (50.3) were higher under the black mulch followed by silver mulch in comparison to no mulch conditions. Water use efficiency (WUE) was found highest under black plastic mulch removed after 60d (50 kg tuber/ha mm) over no mulch condition (34 kg tuber/ha mm). Similar results were found when the mulch film was removed after 70 and 90 d. In terms of yield, the treatment of black mulch film removed after 60 d gave maximum yield (30.12 t/ha) followed by silver mulch removed after 60 d (29.3 t/ha) and no mulch (20.8 t/ha). Similar yield trends were also observed in case of mulch film removed after 70 and 90 d. In terms of economics, cost of cultivation was higher under the mulching condition (₹ 100,307/ha) in comparison to no mulching (₹ 89,578 /ha). However, the net returns were higher under black mulch (₹ 189,193/ha) followed by silver mulch (₹ 176,693 /ha) than without mulch (₹ 116,622/ha). The B:C ratio was also higher under black mulch (1.89) followed by silver mulch (1.76) than without mulch (1.30).

Launch of multi-purpose green fishing vessel, FV Sagar Harita

ICAR-CIFT, Kochi launched the 19.75 m multi-purpose energy efficient fishing vessel, FV Sagar Harita on 18 April 2016. The vessel is built under the project "Green Fishing Systems for the Tropical Seas" funded by National Agricultural Science Fund (ICAR-NASF). The vessel has array of novel features such as hull is made of marine grade steel, and cabin and wheel house are made of FRP to reduce weight, improve carrying capacity and speed. It is powered by 400 hp main engine and has 400 watt solar powered emergency lighting, acoustic trawl telemetry system with under-water sensor, fishing gear handling equipment's (such as split trawl winch, long line setter and hauler and gillnet hauler) and two RSW (0 to -10°C) tanks of one ton capacity each.

ANIMAL ENERGY UTILIZATION AND MANAGEMENT

Assessment of work efficiency in different categories of yak

Work efficiency of yak was evaluated in different seasons to assess carrying capacity of yaks with different loads starting from 10 to 35% of their live bodyweight. The male yaks could carry a load up to 35% of the live body weight (135 kg) and are able to walk 14 km, with a speed of 4-6 km/h. The ambient temperature and percentage of load carried showed negative impact on work physiology of yak.

❑

10. Post-harvest Management and Value-addition

MACHINES/ EQUIPMENT DEVELOPED

Indigenous Pilot Plant for Production of Protein Isolates from De-oiled Cakes

ICAR-CIPHET, Ludhiana has designed an indigenous pilot plant for production of protein isolates from groundnut de-oiled cake. The capacity of the pilot plant is 40 kg of raw material/day. Isolates produced from this plant contained more than 90% protein. The de-oiled cake (DOC) left after oil extraction from major oilseeds viz. soybean, groundnut, mustard and sunflower is about 10 million tonnes (soy meal: 4 MT, groundnut cake: 3 MT, mustard: 2 MT, sunflower cake: 1 MT). At present, these cakes are either utilized as animal

Protein isolate pilot plant developed at ICAR-CIPHET

feed or being exported to other countries like China and Malaysia. Protein-isolate from these de-oiled cakes (rich in protein) can be incorporated into food products to combat protein malnourishment.

Live Fish Carrier System

This technology developed at CIPHET, Ludhiana

Live fish carrier system

is useful for transporting fish in live condition for marketing at premium price.

Live fish carrier system (LFCS) is an electric tri-cycle based live fish transportation system for short and medium distance (about 80 km) transportation of fish including the table carps (rohu, catla, mrigal, common carp, grass carp, silver carp, bighead carp) in live condition from one place to another for marketing, rearing, ornamental displaying and breeding purposes. It is devised with water filtration, aeration and cooling system providing good quality water to reduce fish mortality while transportation. It can travel a distance about 60-80 km with maximum speed of 25 km/h with total carrying capacity of 500 kg (200 kg fish + 200 kg water + 100 kg driver etc.). The invented new system reduces fish mortality to less than 5% for a journey period of about 4-5 hours. The system is convenient to handle fish by single person whereas 4-5 labours/trip are required in traditional method. The complete system costs ₹ 2.0 lakh.

Fish Conditioning-cum-Storage Tank

Fish conditioning cum storage tank of 200 litre capacity has been developed for storing fish harvested from culture ponds and marketing of live fish in the market. The dissolved oxygen was maintained at levels of 3.0-6.0 mg/litre by continuous aeration. The dissolved free ammonia was observed to be below 1.3 ppm at a pH near 7.0 and water temperature of 18.6-25°C. The water renewal was 25% every 12 h. A total fish load of 100 kg/container of Indian major carps (rohu, catla, mrigal) and two Chinese carps (bighead carp and silver carp) of mean size (length) 25-40 cm and weight 0.36-0.78 kg was tested for survival. 95% fish survived after storage for 48 hours. The storage tank is mounted on a trolley for easy mobility.

Fish conditioning-cum-storage tank trolley

Development of Portable Coconut Fibre Strength Tester

The tensile strength of coconut, sisal, and nylon fibres of different linear densities can be tested by this instrument. The instrument can test up to a load of 980N (10kg) at a test speed up to 50 mm/min. The

dimensions of the instrument are 320 mm (width) × 200 mm (depth) × 510 mm (height) and weight is approximately 16.0 kg. Since, coconut fibre is hard, gripping during tensile loading is a problem. This problem has been addressed by using hide for gripping the sample during testing. The instrument can be interfaced with the computer to record load, elongation, breaking time and breaking tenacity. Results obtained by the tensile tester using coconut, sisal, and nylon fibres of different linear densities were comparable to the results obtained from well-established commercially available universal tensile tester.

Coconut fibre strength tester

Ginger-Turmeric Washer cum Peeler

The machine developed by AICRP on PHET, Imphal Centre consists of a mild steel perforated revolving drum of size 600 mm (length) x 500 mm (diameter) and thickness 1.0 mm. The mild steel drum is mounted on bearings supported on the angle iron frame. The rotational speed of the drum at 100 rpm and 10 minutes residence time was observed to be optimum for removing the adhering dirt, stains, other foreign materials or caked dirt on the rhizome or between segments of the rhizome. The capacity of machine is 7-8 times more as compared to traditional method of washing and peeling. The estimated cost of machine is around ₹ 11,000 per unit.

Ginger-turmeric washer-cum-peeler

Seed extractor for Ash gourd and Cucumber (Tavanur Centre)

To reduce the drudgery and enable fast extraction of seeds, a seed extractor was developed for ash gourd (capacity: 350 kg/h) and cucumber (capacity: 215 kg/h) by AICRP on PHET coordinating centre, Tavanur. The principle of operation is to penetrate the rotating tool with handle, into the placental region after adjusting its diameter, which helps in scraping out the seeds along with the pulp from the centre and surrounding mesocarp portion. The seeds could be extracted without affecting the mesocarp.

The germination rates were 83% for ash gourd seeds and 90% for cucumber seeds. The technology is included in 'Package of Practices-15-16' of Kerala Agricultural University for popularization among small and marginal farmers.

Ash gourd and cucumber seed extractor

Solar-biomass Integrated Drying System for spices (Jorhat Centre)

Integrated drying system (IDS) using solar and biomass energy has been developed for drying ginger and turmeric rhizomes at AICRP on PHET coordinating centre, Jorhat. The capacity of the dryer is 100 kg/batch and its cost is ₹ 80,000/unit. Overall dimensions of the IDS are 3700 mm (H) × 4300 mm (L) × 2000 mm (B). Drying air temperature can be maintained at 50° to 55°C and 65ºC using paddy husk and wood stalks, respectively. Rehydration ratio values of ginger samples dried in IDS was highest in comparison to samples from other drying methods. As far as colour, volatile oil and oleoresin content, no significant difference was observed in dried ginger obtained between IDS and normal sun drying**.** Effective moisture diffusivity in case of turmeric drying was nearly 21% more in comparison to ginger drying. Energy utilization efficiency by the solar collector assembly was found to be 49.27%. Energy utilization efficiency of the bio-waste fired assembly was found to be 62.32%. Considering total heat available in the plenum chamber and latent heat of evaporation, the IDS showed 39.33% of overall energy utilization efficiency.

Solar-biomass integrated drying system for spices

Pilot Plant for Probiotic Fruit Juices (PAU, Ludhiana Centre)

A pilot plant (50L capacity) was established by AICRP on Post Harvest Engineering and Technology (PHET) PAU, Ludhiana centre for production of probiotic fruit juices from kinnow, mango and guava. The probiotic guava, kinnow and mango juices were successfully formulated with stable and viable beneficial lactic acid bacteria content in the recommended dose (10^6 cfu/ml) with a shelf-life of one month (Patent filed, No. 614/DEL/2013). The various components of the pilot plant are juicer for kinnow (automatic electric screw type); pulverizer for pulp extraction of mango and guava; stainless steel bin (Food grade) for juice/pulp collection; batch pasteurizer; autoclave (SS 304, vertical) for sterilization of glassware, culture media for probiotic culture preparation; cold centrifuge

Pilot plant for probiotic fruit juices

for harvesting of probiotic cells; Horizontal Laminar Airflow (Size 3′×2′×2′) for providing an aseptic chamber for housing the bottling unit and for addition of probiotic culture; BOD Incubator for incubation of probiotic cultures; Pneumatic bottling unit and refrigerator for storage of probiotic juice. The total cost of machinery excluding cold centrifuge, BOD incubator and refrigerator was ₹ 4.97 lakhs.

Mechanization package for rope making from outer sheath of banana pseudo stem

The package consists of equipment for splitting the outer sheath of banana pseudo stem and equipment for twisting and winding of split strands from outer sheath of banana pseudo stem. This package of equipment would greatly help in value addition from banana waste and the total value of the produce generated from this waste would be about ₹ 1.0 lakh per hectare.

Equipment for splitting the outer sheath: The equipment contains a pair of rotating nylon rollers with HSS circular cutting blades embedded on the first roller. The second roller has the grooves on its surface such that the blades embedded on the first roller exactly fit into the grooves of the second roller. The first roller is mounted on a shaft rotated at a preset speed by a 0.5 hp variable speed motor. The outer sheath of banana pseudo stem is fed in between the two rotating rollers, at 150 rpm. As the outer sheath passes between the two rollers, the sheath is split into various strands. The rollers are to be changed for different width of strands of sheath required viz., 2 mm, 3 mm and 4 mm. The cost of the machine is approx. ₹ 20,000 and the capacity is 3-3.5 m/min.

Banana sheath splitter

Equipment for twisting and winding of splitted strands: The equipment contains a mechanism for twisting and another mechanism for winding the twisted strands on four bobbins through a bobbin building mechanism. Provision is made to vary the number of twists with the help of speed control mechanism, based on the requirement of the end product. Two 0.25 hp single phase motors with suitable power transmission mechanism are provided to operate the drawing, twisting and winding mechanisms. The initial cost of the machine is ₹ 90,000. The capacity of the equipment is 4,800 m/day.

Banana sheeth rope making machine

Banana fibre and rope

Millet flaking machine and process for fermented millet flakes

It comprises of two sets of stainless steel rollers running at a differential speed, in opposite direction. The machine is powered by a 0.5 hp single phase motor. Raw material is fed to the flaking rolls by a polygonal teflon feeder. The minimum flake thickness achievable by the machine is about 0.5 mm with flaking efficiency of about 92%. A process has also been developed for fermenting the sorghum grains with suitable cultures. The fermented grains were steamed and flaked. The appearance and texture of flakes prepared from fermented grains was observed to be better in comparison to non-fermented grains.

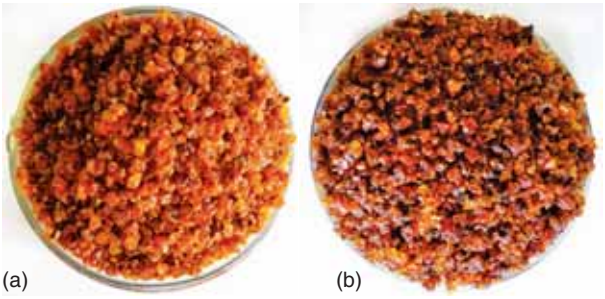
Millet flaking machine

Integrated Lac Processing Unit

An integrated lac processing unit (capacity – 100 kg/day) was developed. The operations of crushing, grading, pre-soaking and washing are completed in single unit. Bucket conveyors have been used for movement of raw materials in the unit to reduce the

labour requirement. The washing barrel in the unit has tilting mechanism for batch washing of crushed sticklac and easy removal of wash water and prepared seedlac. The unit is suitable for mechanised production of seedlac from sticklac. The quality parameters (*i.e.* flow, life, acid value and moisture content) of the seedlac obtained from the unit was observed to be comparable with seedlac manufactured through available small scale lac processing units (SSLPU).

Integrated Small Scale Lac Processing Unit



(a) Seedlac manufactured in integrated small scale lac processing unit; (b) Seedlac manufactured in small scale lac processing unit

Advantages of integrated lac processing unit: Lighter colour seedlac with impurity content of around 2% (approx.), reduced requirement of water (5-6 times of the raw material) and manpower are some of the key advantages of the unit. Lighter colour lac dye with dye content above 50% could be produced from wash water of first batch washing through Integrated Small Scale Lac Processing Unit compared to 30–35% dye content from wash water of conventional and continuous washing process. To recover lac dye from wash water, only wash water of first batch washing was taken which is 8 – 10 times less in volume and enabled easy handling during the process of lac dye recovery.

PROCESS PROTOCOLS DEVELOPED

Process Protocol for De-Bittered Kinnow Juice

The bitterness in kinnow fruit juice is mainly caused by inherent naringin and limonin present in different portions of kinnow (initial bitterness). With maximum being observed in seed (224.37±5.58 ppm) while peel/albedo portion contained the highest amount of naringin (13589.82±6.86 ppm). Also, during processing and storage of juice, an enzyme mainly present in seeds (Limonoate-D-ring lactone hydrolase/LDLH), catalyses the conversion of limonoate A-ring lactone/LARL (a non-bitter precursor) to bitter limonin in acidic condition and thereby results in delayed bitterness of extracted kinnow juice. To overcome this problem, ICAR-CIPHET, Abohar has developed a process protocol for de-bittering of kinnow juice using different enzymes and adsorbents. The developed process reduces limonin to undetectable levels and considerably curtails the activity of LDLH enzyme. The complete process protocol for de-bittering of kinnow juice involves following sequential steps.

Detection of Safflower adulteration in Saffron by SCAR markers and DNA barcodes

At the CIPHET Centre, Genomic DNA was isolated by method of Moller *et al.,* 1992 with minor modifications from safflower, saffron and their mixtures where the concentration of Safflower in Saffron was kept 1%, 3%, 5%, 7% and 10%. PCR based SCAR markers: ScCt131 (Torelli *et al*., 2014), SAF L-40, SAF L-4 (Javanmardi *et al.,* 2011) and DNA barcodes: ITS2, psbA-trnH (Chen *et al.,* 2010) primers were synthesized and used for detection of Safflower adulteration. Gradient PCR with varying Magnesium concentration was performed for the optimization of annealing temperature for all set of primers. In case of SCAR markers SAF L-40, SAF L-4 and ScCt131, an annealing temperature of 55ºC and 2mM $MgCl_2$ was found to be optimum. Amplification products of 414 bp for SAF L-40, 412 bp for SAF L-4 and 131 bp for ScCt131 were observed.

Safflower concentration as low as 1% could be detected by using primer SAFL-40 and ScCt131 which gave the amplification product of expected size 414 bp and 131 bp, respectively.

PCR amplification of safflower and saffron with DNA barcodes ITS2 and psbA-trnH were also optimized. An annealing temperature of 50°C and 2mM $MgCl_2$ was found to be optimum in all the cases that yielded the product of approximately 500 bp with ITS2 and 500bp with psbA-trnH in safflower. In case of saffron, a product of approximately 500 bp with ITS2 and 650 bp with psbA-trnH was obtained. Therefore, the psbA-trnH barcode could be used for detection of safflower adulteration in saffron. Safflower concentration (500bp amplicon) of as low as 1% was detected by using primer set psbA-trnH and it could also detect saffron (650bp amplicon).

Amplification of safflower and saffron with psbA-trnH. Lane no. M: 100bp DNA ladder; Lane 1-7: pure safflower , 1% safflower in saffron, 3% safflower in saffron, 5% safflower in saffron, 7% safflower in saffron, 10% safflower in saffron and pure saffron

Pear Canning in non-nutritive sweetener

A process for canning of pear slices was developed at ICAR-CIPHET by using stevia extract as non-nutritive sweetener in order to produce a low calorie food. Sugar syrup of 40 ºBx and stevia extract to the taste of 40 ºBx were prepared and mixed in five different proportions of 100:0, 75:25, 50:50, 25:75 and 0:100 for using as a canning syrup. The composition of non-

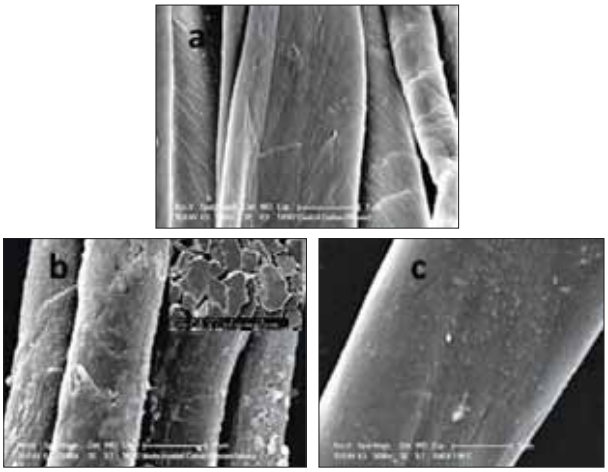
Canning of pear slices in stevia extract

nutritive sweetener was optimized based on sensory score and calorific value of canned pear slices. The drained weight after 20 days of canning was found to be in the acceptable range (426 to 434 g) for most of the treatment combinations. However, highest sensory score was obtained when the pear slices were canned in canning syrup of 50:50 followed by 75:25 and 25:75 for sugar and stevia extract, respectively. Incorporation of stevia extract to the canning syrup not only reduced the browning of syrup and slices but also reduced the solid gain in pear slices indicating a reduction in calories (120 to 47) with every increase in the proportion of stevia extract in the canning syrup.

Cotton textiles using *in situ* generated nano-ZnO for high end applications

The advent of nano science and nanotechnology has opened a new frontier in the realm of textile finishing, i.e. nano-finishing for imparting various functional properties to the cotton materials. A method has been developed for the functional finishing of cotton fabrics using nano zinc oxide particles, synthesized *in situ* by reacting zinc nitrate and sodium hydroxide.

The inherent physical and mechanical properties of fabrics were found to be unaffected in this method. Low stress mechanical properties evaluated by KESF indicated that the total hand value of the treated textile changed from 3.54 to 3.40. This method of textile finishing allows one to obtain long lasting finishes even after 30 washes, exhibiting UV protection (UPF Value 40) and 99% antibacterial properties against strains of *Staphylococcus aureus* and *Klebseilla pneumonia*.



SEM images (a) control (b) nano-ZnO treated (c) nano-ZnO treated fabric sample after six cycles of washing. Inset (b) fibre cross section of treated fabric

Nanocellulose based product development with improved functionality

Nanocellulose, a novel nano-sized cellulosic material, exhibits very high strength, large surface area to volume ratio, novel rheological and optical properties, and have proven applications as reinforcing agents in bio-composites, additives in high-end papers and paints etc. ICAR-CIRCOT has developed novel chemo-mechanical processes for production of nanocellulose from cotton linters/waste and cotton stalks and following products with nanocellulose as additive for improved functionality.

Rubber

Kraft Concrete

Products with nanocellulose as additive

(a) Natural Rubber composite with Nanocellulose as a filler, improved the strength by 15-20% and reduced the permeability by 20-25%. This can replace the carbon fillers and thereby reduce the cost of production.

(b) Kraft paper (recycled) with nanocellulose as additive, exhibits 15% increase in the tensile strength and reduces the requirement of virgin pulp and hence the cost.

(c) Cement Concrete with nanocellulose as filler improves the curing process and reduces the porosity, thereby increasing the shelf-life of cement concrete. Also the mechanical properties like compression strength and flexural strength improved by 10-15%.

PRODUCTS DEVELOPED

Protein snack food with spinach

Protein rich expanded snack food was developed from maize, defatted soy flour, sesame seeds and spinach powder. The best combination had 74% maize, 15% defatted soy flour, 5% sesame seeds and 6% spinach

powder. The product obtained had 18.2% protein and 3.01% total minerals. The antioxidant activity was observed to be 24.61%, flavonoids 7.66 mg/ 100g and overall sensory score as 8.11. The expansion ratio, water absorption, water solubility index and whiteness index were observed to be 3.36, 5.41g/g, 28.08% and 54.89 respectively.

Protein rich snack food with spinach

Identification and Cloning of Putative Key Genes involved in Terpene Biosynthesis of the Indian Lac Insect, *Kerria lacca* (Kerr)

One of the main components of lac resin is sesquiterpenes. The biosynthesis of sesquiterpenes is through the mevalonate pathway and the precursor for all sesquitepenes is farnesyl pyrophosphate (FPP). The enzyme involved in the formation of FPP is farnesyl pyrophosphate synthase (FPPS). Since it is one of the key steps in sesquiterpenoid biosyntheis, the cloning of FPPS gene was attempted. After the sequencing and assembly of the partial FPPS fragment and 3'RACE product, it resulted in 769 bp sequence of *K.lacca* FPPS encoding gene. The final product revealed a great homology with the mitochondrial isoprenyl diphosphate synthase gene reported in bird cherry-oat aphid (*Rhopalosiphum padi*). The expression profile study revealed that this gene expression got up regulated in settled larvae and adult female lac insects in comparison to crawlers.

Horticulture

Enhancement of green life of banana: A technology to store and increase the green life of 'Grand Nain' and 'Poovan' bananas during glut and natural calamities was developed. Treatment with 1-methylcyclopropene enhanced the green life of pre-climacteric bananas for four months at 14ºC and for 15 days at ambient temperature over the untreated controls without any adverse effects on physiological, biochemical and qualitative parameters.

Banana (Grand Nain) hands of 46, 48 and 50 calliper size (mm) dipped in *Trichoderma asperellum* (prr2) and packed without ethylene absorbent extended shelf-life up to 75 days at 13.5°C. There was no incidence of anthracnose and crown rot as compared to control banana hands packed with ethylene absorbent (50 days) and control (17 days).

Banana products: Banana fruit juice and central core stem based jellies were developed by blending fruit juice or stem juice with sugar and citric acid. It contains 65ºBrix TSS and 0.2% acidity which were highly accepted at hedonic scale rating**.** Banana central core (stem) juice based squash contains 45ºBrix TSS content and one per cent acidity. Banana central core (stem) juice based syrup, soup mix and ice cream mix were developed with high level of consumer acceptance.

Grape wine: Grape wine prepared from cv. Cabernet Sauvignon using ß-glucosidase producing yeast strains VSI-1106 and SPR was found to contain higher quantities of several aroma compounds including 13 aroma compounds produced by ß-glucosidase positive yeast strains.

The aroma compounds 1-methyl-4-(1-methylethyl)-1,3-Cyclohexadiene (lemon aroma) and Benzeneacetaldehyde (floral and honey aroma) were present only in wines produced by yeast strain SPR whereas propanoic acid, 2-methyl-, 1-Nonanol and 1-Decanol compounds were uniquely present in wines prepared with yeast strain VSI 1106 and are related to release of fruity aromas.

Extending storage of litchi pulp: Litchi pulp pasteurized and treated with 1500 ppm potassium metabisulphite (KMS) was acceptable in quality and colour up to 10 months storage at low temperature (6±1 °C). Litchi flesh pre-treated with 50 °Brix osmotic sucrose solution in the pulp solution ratio of 1:2 gave highest overall acceptability (7.96) with minimum hardiness (2749.52 g) and drying time (15 hr.) after 9 months of storage. Three blending ratio, i.e. 25% sweet cherry+ 75% sour cherry, 50% sweet cherry + 50% sour cherry, 75% sweet cherry + 25% sour cherry with 100% each of sweet and sour cherry with and without treatment of 0.1% Sodium Benzoate and stored at 4±2° C were studied. After six months of storage, it was observed that blend of 50% Sweet cherry + 50% sour cherry treated with sodium benzoate retained desirable quality attributes like brightness, redness and freshness to maximum when compared with other blending combinations. Three blending ratio, i.e. 25% apricot + 75% plum, 50% apricot + 50% plum, 75% apricot + 25% plum with 100% each of apricot and plum juice with and without treatment of 0.1% sodium benzoate stored at 4±2° C was studied and after six months of storage it was found that blend of 75% apricot + 25% plum treated with sodium benzoate retained maximum desirable quality attributes like brightness, redness and freshness when compared with other blending combinations.

Fruit wine from pears: Of the three cultivars of pear, viz. *Jagner*, Sand pear and *Kakria* evaluated, pear ginger wine from sand pear having TSS of 22ºB with 2.5% ginger was superior both immediately after preparation and at six months after storage.

Edible coating of capsicum: Coating with shellac resin in capsicum significantly increased the shelf-life up to 30-35 days during storage at 10ºC as compared to 10-12 days in control. The firmness and green colour values decreased from 4.02N to 2.8N and from -12.1 to -8.1 after 35 days of refrigerated storage. Vitamin C content also decreased from100-102 mg/100g to 65-70 mg/100g during refrigerated storage for 35 days. The overall sensory acceptability after refrigerated storage was 7.5 on 9- point Hedonic scale.

Dehydration of potato slices: Dehydrated potato dices/shreds were produced in a process where moisture is removed from the product which maintains the fresh taste, natural color and texture of potatoes. Dehydrated potatoes with low moisture content (3-6%) could be safely stored at ambient temperatures up to 9 months. They could be fully rehydrated prior to consumption as curried vegetable, *Jeera Aaloo*, *Pulao* or potato snack (noodles). They are ideal products for long term food storage and emergency preparedness. They are rich in protein, vitamin C, vitamin B3, potassium, magnesium, calcium, phosphorus, zinc, copper, besides good source of fibre and carbohydrates.

The technology has been registered as process for "Dehydration of potatoes" vide patent application No. 1273/DEL/2014 by ICAR-CPRI, Shimla.

Dipsticks technology of glucose estimation: Sugar accumulation in potato tubers is one of the most serious problems for potato processing industry. Storage of potato at low temperature results in accumulation of reducing sugars (primarily glucose) which leads to "cold-induced sweetening". Reducing sugars participate in 'Maillard reaction' during frying, thus producing dark colored finished product. The suitability of potato tubers for development of processed products such as chips and French fries etc. is mainly determined by the amount of glucose present in potato tubers. In general, glucose levels below 0.1 percent (1000 ppm) on a fresh weight basis are acceptable for chips and French fries production. As per the normal practice in India, farmers transport their potatoes to the processing industry and upon reaching the industries sites, their potato consignments are rejected due to its higher glucose content by the industry.

To overcome this problem, a simple and quick method for estimation of glucose level by the farmers and small processing units in taking appropriate decision for its post-harvest marketing /selling targets/ destinations dipsticks have been developed. The technology is highly sensitive (can detect glucose upto 50 ppm concentration), quick (2 - 5 min.) and simple (anyone can perform). The technology has been filed for obtaining patent.

Value added products of tubers: Particle boards were developed from dried and powdered cassava stem incorporating different types of binding materials viz., urea formaldehyde, phenol formaldehyde and melamine urea formaldehyde. Maximum density was obtained (1,167 kg/m^3) for the board made with resin urea formaldehyde.

Starch can be used as a binding material along with limited amount of resin to get comparable physico-functional properties of particle boards. A solid adhesive mix, devoid of caustic alkali has been prepared from oxidized cassava starch and can be stored easily and mixed at the time of use.Moisture resistant corrugating adhesive has been successfully formulated using native cassava starch, which exhibited very good tack and fast drying properties.

Slow release starch: RS4 type resistant starch was made by octenylsuccinylation of cassava and sweet potato starches. The cooked starches of octenylsuccinylated cassava starch showed slowly digestible starch (SDS) and resistant starch (RS) from 20.5-38.4% and 1.5-27.9%, respectively.In modified sweet potato starch, the SDS and RS values ranged from 16–22.6% and 24.8 to 37%, respectively. There was a decrease in glycemic index from 91.3 to 64.8 for cassava and 86.3 to 63 for sweet potato starch.

Slow release curcumin: Slow release curcumin, incorporated in cassava starch-poly vinyl alcohol nanocomposite matrix was synthesized and characterized. *In vitro* dissolution of curcumin from the nanocomposite films was determined at simulated gastric (pH 2.1) and intestinal fluids (pH 7.4). A water soluble curcumin, loaded on a modified nanocassava starch, and with significantly higher bioavailability, anticancer properties and non-toxicity was synthesised and characterized. The study showed that compared to pure curcumin, nanocurcumin increased the curcumin bioavailability by 71.27%.

Milk

Cattle and buffalo

Study using UV-VIS spectrometric and gas chromatography analysis indicated that ruminant fats are very good sources of natural CLA and can be considered as potential nutraceuticals in the market.

Detection of pesticide residues in milk: A paper strip assay was developed which is an innovative, efficient, high throughput and easy-to-use system that could be applied successfully for surveillance of pesticide residues in milk at dairy farm, processing units and referral testing centres. The assay can be carried out within 1.0 h after pesticide extraction from milk.

Presence of lard in ghee: Lard is an adulterant fat, which is commercially available in the refined form. A methodology was developed to isolate DNA from ghee containing lard as an adulterant. Developed methodology has the potential to confirm the presence of lard in ghee to the tune of minimum 10%.

Detection of aflatoxin M1: An electrochemical aptasensor for detection of trace amounts of aflatoxin M1 (AFM1) was developed. This was achieved by sequentially layering dithiodipropionic acid, streptavidin and biotinylated-tetraethylene glycol-aptamer**.** Peak current in square wave voltammogram was inversely related to logarithmic concentration of AFM1. Dynamic range of sensor was 1 ppt to 10^5ppt AFM1**.**

Large scale production of *Lactobacillus* biomass: Bioprocess for large scale production of *Lactobacillus* biomass was developed that could be used as starters/ functional supplements for value addition of fermented and non-fermented dairy products.

Goat

Gaddi goat milk had higher level of fat (%) and total solids (%) in comparison to local goat milk.

Antioxidant capacity was highest in Gaddi goat milk whey (26.27±1.40 mg/100 ml) and casein fractions (38.00±2.36 mg/100 ml). Formulation and processing conditions for milk based bread was standardized and the shelf-life of ready to eat products such as Milk Rings and Milk Slices was determined.

Camel

Camel milk sugar free *lassi* was prepared using routine starter cultures and NCDC-167 and NCDC-263 with different concentrations and its incubation was standardized for different time intervals. Saffron, rose and pineapple flavours were found to be acceptable.

Yak

Value addition of different yak milk products like *churpi* (loose cheese), paneer, low fat paneer, designer paneer, *churkam* (milk candy), *dahi*, *ghee*, *lassi* and cream were carried out. Vegetable extended paneer, enrobed paneer finger, ginger flavoured yak milks' *churkham* are new addition value added yak milk product.

Meat

Sheep

Vacuum packaged meat snacks: In a study conducted for enhancing meat snacks life at ambient storage, one batch was packaged aerobically while another batch was vacuum packaged in laminate (12 micron PET+ 55 micron nylon polymers). The evaluation for physicochemical, microbiological and sensory attributes revealed that lipid oxidation and tyrosine values were lower for vacuum packaged snacks. Throughout the storage the microbial counts were within the acceptable limits. The vacuum packaging could be useful in enhancing the keeping quality of the mutton snacks at ambient storage.

Goat

Carbamide-urea based indicator and chromogenic edible film for monitoring temperature abuse conditions and quality of meat and meat products during storage was developed.

Pig

Shelf stable pork products: Mix Veg Pork Curry was standardized for retort processing, keeping in mind the universal acceptability of the product. Formulation and proportion of different ingredients used for the product were standardized after doing intensive trials and undertaking sensory evaluation studies. Filled-in retort pouches were sealed with impulse sealing machine. For mix veg pork curry the F0 of 12.86 mim was adequate. Total process time was 57.33 min. Preliminary experiments showed that retort processed Mix Veg Pork curry was highly acceptable for appearance, flavor, texture, saltiness, consistency and overall acceptability.

Success story

Farm to Fork

The National Research Centre on Pig is undertaking training in the area of clean pork production to ensure quality of pork and pork products. The technologies developed were commercialized through Public-Private-Partnership mode. Three well established pork brands were developed out of the technologies developed under this project viz. LUIT PORK, CHOICE PORK NATURAL and PIGZEE'S.

The unit has standardized/ refined the technologies for processing different value added pork products suited to the taste of the people of NER. Formulations were modified based on the suggestions received during the pilot scale marketing phase, to ensure market acceptability of the products. Scientific interventions were introduced in the packaging of pork and pork products to improve the brand value of the products during marketing.

Poultry

Egg rasmalai: Process for development of Egg Rasmalai was standardized using whole egg liquid (60%), maida (5%), skimmed milk powder (35%), sugar, cardamom powder etc. Egg Rasmalai thus prepared contains less fat but higher protein content than traditional Rasmalai since prepared using dehydrated skimmed milk powder, refined wheat flour etc. Processing cost is very less and required only simple machineries and utensils for its preparation.Shelf-life is 5 days at refrigeration temperature (4±1 ºC) under aerobic packaging condition and the processing cost is Rs 140/kg (approximately).

Chicken sausages: Incorporation of essential oils and their blends controlled microbial load and enhanced shelf- life without affecting sensory qualities of chicken sausages.

Chicken *seekh* kebabs: Production of *seekh*-kebabs using three different cooking methods viz. charcoal grilling, smoking and hot air oven were optimized.

Chicken breast fillets (CBF) from spent fowl: Processing technology and marinade formulation for development of CBF were standardized. Since the formulation of breast fillets utilizes tough meat from culled stock chicken it can be well adopted for income generation and employment even in rural set up with less investment and without requirement of expensive equipments. Moreover, the meat become more nutritious

and tender and is better acceptable than the traditional fillets. The shelf-life of the product is 15 days at refrigeration temperature (4±1 ºC) under aerobic packaging condition with a processing cost of Rs. 240/ kg (Approx.)

Inactivating *Salmonella* Typhimurium and *S.* Enteritidis on dressed chicken meat:

Processes were standardized to produce hygienic dressed poultry meat. Generally accepted as safe (GRAS) antimicrobials such as carvacrol or acidified sodium chlorite or trisodium phosphate were used, followed by thermal treatment of carcass. The process involves pre-dipping of dressed poultry carcass in pre-standardized concentration of either of these chemicals for pre-calibrated time period, followed by hot water dipping of carcass and lastly dipping of heat treated carcass in chilled water. The data were generated on inactivation of *Salmonella* Typhimurium.

Meat species identification: Total protein separation using 2-dimensional gel electrophoresis (2DE) (pH 4-7, 13cm IPG strips) and identification of myosin light chain isoforms indicating meat species using MALDI-TOF/TOF mass spectrometry (MS) analysis was achieved for raw and cooked meat mix containing different proportions of buffalo, sheep and goat meats.

Baseline data on antibiotic residues in fish and chicken samples from different parts of Hyderabad for Oxytetracycline and Chlortetracycline of tetracycline class and Ciprofloxacin and Enrofloxacin of Flouroquinole class were generated. The results indicated that out of 50 samples tested, 29 samples (58%) were positive and contained residues of one or more antibiotics.

Wool

Apparel yarn: Dumba sheep has two type of wool cover; outer cover (coarse wool) and inner cover (fine wool). About 20% of total wool produced by Dumba belongs to fine wool type which is used for manufacturing hand spun yarn. It possesses lower tenacity and elongation at break. Woven fabric from the yarn possesses high values for bending and shear rigidity, fabric formability and thickness. Fabrics of Dumba wool-BM wool-Nylon (40:20:40) in semi worsted spinning system were spun and used for different woolen products.

Use of industrial waste wool: Waste sheep's wool is mostly deposited in landfills resulting in loss of nutrients present in the wool. Studies carried out to observe effects of wool waste use on moisture conservation and plant growth indicated:

- Incorporation of wool waste in soil improves water holding capacity in pot culture and enhanced growth of barley and fenugreek.
- An increase of 20 to 25% was observed in moisture retention capacity of sandy loam soils which enhanced plant growth.

Incorporation of wool dust and sheep manure in 1:1 ratio significantly reduced soil pH when incubated for 45 days (8.23 to 7.33). Major nutrients in sheep manure i.e. N, P and K were also increased remarkably due to addition of wool dust.

Value addition in yak wool: Polymorphic chemical composition of yak hair was confirmed for the first time. The yak hair has interrupted medulla with long flattened cells and air gap in between. This feature is helpful to prepare value added yak wool products.

A new creative design of door mat was prepared through blending of equal proportions of sheep and yak wools. Besides preparation of pure wool, jackets and table runner were prepared after blending yak wool (80%) and jute (20%). The products were developed in collaboration with ICAR-NIRJAFT, Kolkata and Fabric Machinery was installed at ICAR-NRC on Yak.

Fish

High value byproducts from fish and shellfish processing discards: (1) *Chitosan beads*: Chitosan beads of uniform size were prepared from degrees of deacetylated (DA) chitosan. Chitosan beads with 86% DA had high sorption capacity (69%) at pH 8. (2) *Microencapsulation of squalene*: Process for microencapsulation of squalene (an oily liquid hydrocarbon that occurs in shark liver oil) by emulsification-spray drying technique was developed. A combination of maltodextrin and whey protein proved better for microencapulation taking into consideration their higher encapsulation efficiency and oxidative stability.

Cadalmin™ ADe - Antidiabetic Nutraceutical from Seaweeds: An Antidiabetic Nutraceutical "Cadalmin™ Antidiabetic extract (Cadalmin™ ADe)" from seaweeds was developed by the ICAR-Central Marine Fisheries Research Institute (CMFRI), Kochi (Indian Patent Appl. No. 3366/DEL/2015). The product was commercialised on 25 April 2016 and a Memorandum of Understanding was signed for its commercial production and marketing.

Cadalmin™ ADe contains 100% natural bioactive ingredients and is effective in combating type-2 diabetes without any side effects. The bioactive ingredients in Cadalmin™ ADe competitively inhibit dipeptidyl peptidase-IV (DPP-IV) and tyrosine phosphatase 1B (PTP1B) thereby reducing the insulin resistance in cells leading to hindering the occurrence of type-2 diabetes.

Seaweed enriched NutriDrink: ICAR-CIFT has developed a seaweed enriched nutraceutical drink (NutriDrink), in which grape juice has been fortified with seaweed extract. Addition of seaweed extract in grape juice improved its micronutrient profile. Unique seaweed phyto-chemicals such as fucoidan and fucoxanthin get supplemented in this nutraceutical drink. Fucoidan and Fucoxanthin have health promoting activities such as antioxidant, antidiabetic, anticancer, cardioprotective etc. NutriDrink is free of seaweed like smell and exhibits excellent cardioprotective activity in animal experiment. Pasteurization and packaging procedures have been established and the product has shelf-life of more than six months under refrigerated conditions.

Seaweed fortified pangasius sausages: Dietary fibres from three seaweeds namely *G. edulis, S. wightii* and *U. lactuca* were added to pangasius fish mince and stuffed in polyamide (5 cm diameter) sausages with sausage stuffer and cooked in closed water bath at 85-90ºC for 30 minutes. After cooking, sausages were immediately cooled in ice-cold water for 5 minutes. Each sausage weighing approximately150-200g was packed in flexible low-density polyethylene pouches and stored at refrigerated temperature.

MRSA clone identified from seafood and aquatic environment: Staphylococcal protein A (*spa*) typing of a methicillin-resistant Staphylococcus aureus (MRSA) clone identified from seafood and aquatic environment of Kerala was assigned a new clone status t15669. This clone was identified by amplification and sequencing of whole spa gene. A molecular source tracking study conducted in the seafood production chain from landing centre to retail market revealed that seafood get contaminated with MRSA from environment and is transmitted to the retail fish markets. ❑

11. Agricultural Human Resource Development

Agricultural Education Division of the ICAR undertook various activities for strengthening and quality assurance of State Agricultural Universities (62 SAUs), Deemed-to-be-Universities (5 DUs) and Central Universities (4 CUs) with Agricultural faculties under the National Agricultural Research System (NARS) to address the challenges of agricultural growth and upgrading quality of higher agricultural education. The Division, through the implementation of Scheme-Strengthening and Development of Higher Agricultural Education in India, assists the AUs to plan, undertake, aid, promote and coordinate agricultural education in the country. The scheme has enabled these institutions in building excellence in specific strategic areas in education and research through Niche Area of Excellence (NAE), promoting holistic higher agricultural education by blending knowledge, skill and attitude through Experiential Learning Units, RAWE, and related aspects concerning infrastructural development, gender mainstreaming and capacity building of the students with the total outlay of ₹ 358.00 crore.

Infrastructural support

In the XII Plan, a total of 17 girls, 6 boys and 5 international hostels, 6 examination halls and 3 auditoriums were supported in 24AUs.The infusion of development grant continued during the year for renovation and refurbishing of structures, purchase of new equipments, maintenance of equipment, support for improving course curriculum delivery, student and faculty amenities, personality development leading to overall strengthening of infrastructure in AUs. A total of ₹ 242.25 crore were provided to complete these facilities during the year.

Girls Hostel at College of Horticulture, Dr YSRHU V. Gudem

Smart classrooms, supported by the Council enabled effective delivery of course curriculum, ensuring enriched learning experience. The support for the curriculum delivery enabled revision and modification of the practical manuals leading to improvement in conducting practical classes in important areas of agriculture and allied sciences. For increasing awareness in latest techniques and research in cutting edge areas support was provided for student and faculty amenities/ tours/capacity building and participation in seminars, symposia, workshops etc. With the support from Council the AUs initiated short courses/workshops/lectures on overall personality development leadership programmes as well as spoken English.

The support for major and minor repair/ renovation and refurbishing of structures, overall strengthening of infrastructure in AUs, maintenance of major equipments, student and faculty amenities, etc. continued during the year.

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

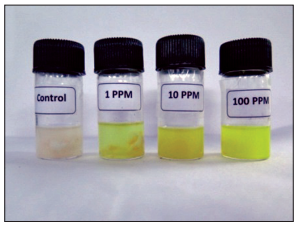
Niche Area of Excellence

For strengthening capacity building and creating excellence in specific cutting edge areas support of ₹ 18.50 crore to ongoing 26 centres of Niche Area of Excellence (NAE) on "Genetic improvement of Kinnow mandarin for fruit quality: biotic and abiotic stress tolerance" at PAU, Ludhiana; "Crop regulation for increasing productivity of alphonso mango under climatic condition in Konkan region", Dr. BSKVV, Dapoli; "Study of *Clostridium perfringens* and *Dichelo bacternodosus* (Anaerobic Bacteriology)", SKUAST, Srinagar, was extended during the year. Presently, fourteen programmes are being supported , and fifteen programmes were concluded in the last financial year.The X Annual review meeting to review the programmes was organized at New Delhi on June 2, 2016.

Significant achievements under the programmes were:

- Identification and functional characterization of 2 cellulase, 1 multifunctional **GH26** and 1 phytase recombinant clones by the centre at AAU, Anand from metagenomics library.

- Beside *beta2*-adrenoceptors, existence of *beta3*-adrenoceptor in buffalo myometrium was reported for first time in buffalo myometrium, at DUVASU, Mathura.
- Dietary supplementation of pomegranate peel extract (as a source of polyphenols) and supplementation of *Lactobacillus johnsonii* CPN23 was found effective in alleviating DSS-induced colitis in rat model, at IVRI, Izatnagar centre.
- Another centre at IVRI, Izatnagar developed bead based immunoassay(s) using recombinant proteins for sero-diagnosis of PPR.
- Haematobiochemical and immunohistochemical studies were conducted for canine cancer, at KVAFSU, Bidar.
- MAFSU, Nagpur, developed listeriolysion O (LLO) based ELISA for listeriosis which detected 15.73% antibodies to LLO (ALLO).
- Spore enzyme based sensor on paper strip was optimised for solvent volume 0.5 ml required for extraction of pesticide from food matrix at NDRI, Karnal.
- Pulsed field gel electrophoresis (PFGE) protocol for strain differentiation of *C. perfringens* was optimized at SKUAST-K.
- TANUVAS, Chennai, developed LAMP assay for IBV and IBDV and Recombinant TK antigen based LAT for DPV.
- *Janthinobacterium,* a specific spoilage organism (SSO), was isolated and reported for the first time from Indian squid and kit for detection of formalin in fish was developed at TNFU, Toothukudi.

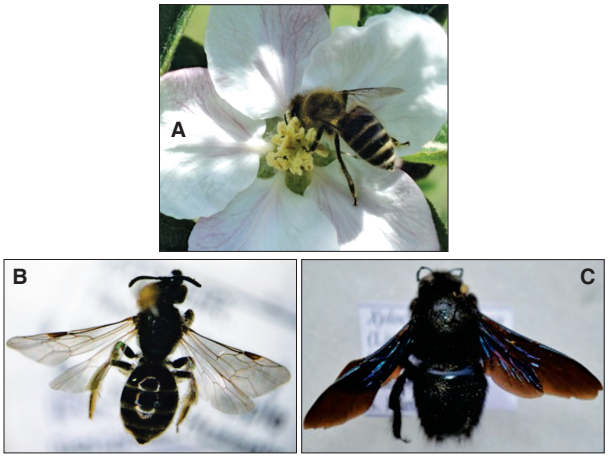


Formalin detection kit for fish

- An outer membrane protein vaccine for *E. tarda* was developed by the centre at WABUFAS, Kolkata.
- An interactive e-learning website with different course categories ranging from residential courses, distance education courses, MOOC and other vocational courses established at NAARM, Hyderabad.
- Extruded reconstituted rice with cooking time of approximately 4 min. and improved protein content ~15% was developed at IARI centre.
- The rotary unit of 13 hp Power Tiller was modified for *Biasi* rice cultivation by the centre at IGKV, Raipur. Mechanized Biasi machine was found suitable under rainfed rice cultivation because of their higher field capacity, better quality of work and more benefit cost ratio.


Modified Power Tiller for Biasi operations in rainfed rice

- A web based Agriculture Expert System (AES) was designed and developed for advising farmers for managing threat of yellow rust disease in wheat by the centre at GBPUAT, Pantnagar. In addition to diseases, the advises on other farm operations are being issued considering the weather forecast.
- Ideal approach of rainwater management as per the recommendations of the centre at PDKVV, Akola is presently adopted on more than 55,000 ha area through the network of 10,500 farm ponds by about 35,000 farmers in Vidarbha region.
- The most suitable module for soil conservation and for checking ravine development was agri-horti followed by silvi-pastoral as suggested by the centre at RSKVV, Gwalior.
- Seventy-eight percent of apple trees experience 80-40% pollination deficit. Six promising pollinators were identified, by the centre at SKUAST-K. These are *Lassioglossum marginatum, Apis cerana, Apis mellifera, Xylocopa spp., Andrena spp.,* Syrphids.



(A) *Apis cerana*; **(B)** *Lassioglossum marginatum*; **(C)** *Xylocopa* spp

- The centre on taxonomy of insects and mites recorded new species of spider mites (Acari: Tetranychidae) from India with new records and redescription of species
- Introgression for high grain weight was done at PAU, Ludhiana and increased grain width and grain length of recurrent parent PBW621 and BC_2F_1 derived from cross PBW114/*Ae. tauschii*3747//PBW621
- Resistance to stripe rust and Karnal bunt identified in triticale x bread wheat derivatives and their transfer into high yielding bread wheat lines is underway at PAU, Ludhiana.
- KMP175, a superior rice cultivar developed as an outcome of the physiological breeding programme combining root and WUE traits has been released for cultivation in water limited southern dry zone-6 of Karnataka state from the centre at UAS, Bengaluru.

- A total of 6 promising lines of groundnut transgenic events expressing Alfin:PDH45:HSF4A were developed by the centre at UAS, Bengaluru. The transgenics showed 23=27%improved productivity as compared to control under drought stress.

Control Transgenics Control Transgenics

- The centres organized 164 long (>10 days) and short (2-10 days) duration training programmes/ awareness workshops/camps leading to capacity building of 908 faculty and 368 students. About 3,648 farmers and 2502 other stakeholders viz. extension workers, veterinary officers of State Animal Husbandry Departments were imparted knowledge for adopting the technologies generated through farmers meet/ demonstrations and workshops. During the year 69 students completed degrees and 120 students are pursuing research for MSc/MVSc/MTech/ Ph.D utilizing the facilities developed under NAE programmes.The support has resulted in 55 publications in peer reviewed journals, including 29 papers in journals assigned NAAS rating of 5 and above. As a result of the workshops and awareness camps conducted under the programme some of the trainees took up entrepreneurship. Fifteen people in fabrication of machines/tools, and 8 in beekeeping and other pollinizers for pollination of apple orchards. Eight patent applications have been filed and the revenue of ₹ 44.44 lakh was generated during the year. Total of eight technologies have been commercialized, including formalin detection kit for fish, OMP vaccine, vaccine for Newcastle disease, biosensors for diagnosis of PPR etc.

Entrepreneurship Development

Support was extended for starting experiential learning modules under 'Student READY' program to instil confidence, provide hands on training and to encourage UG students to take up entrepreneurship. Skill oriented training to the undergraduate students is being imparted to promote entrepreneurship, knowledge as well as marketing skills through practical end–to-end approach in product development. Twelve new modules were established during the year in 8AUs.New modules were supported in various profitable areas, like fish processing for value addition, protected cultivation of high value horticultural crops, goat rearing units, bioagents, biopesticide and biofertilizer production, and quality seed production etc.

The salient outcomes were:

- Students were sensitized about maintaining micro irrigation facilities.
- Operation and maintenance of the processing plants imparted knowledge on production of value added products and insights into post harvest techniques.
- Trainings have been imparted for effective management of insect pests and production of *Trichogramma.*
- ELP on seed production helped students acquire experience on hybrid seed production in various crops, including guava layers, rice sweet corn, soyabean etc.
- ELP on protected cultivation of high value crops enabled the students to learn construction of polyhouses and growing vegetables with the knowledge about best package of practices. They also developed skills for growing vegetables under protected conditions and nursery management.

Biofertilizers produced under ELP

- Trainings on large scale production of bio-inputs like bio-fertilizers and bioagents were imparted to students.
- The ELPs on pig rearing and animal feed manufacturing trained the UG students in the area. The students were made aware of the advantages of setting up such enterprises in their areas for the benefit of the community.

Experiential Learning Modules pig rearing unit

- In apparel production modules skill of handling technologically advanced machines and textile designing software were acquired.
- Designing and preparation of facilitating materials such as charts, posters, leaflets, folders, extension bulletins etc. for dissemination of agricultural technology was undertaken in ELP on product design.

Rural Agricultural Work Experience (RAWE)

Under (RAWE) the students are exposed to various ITKs and rural agricultural practices under natural setting of the village situations, work with the farm families, identify their problems and make use of various extension tools for transferring the latest agricultural technologies. The students got opportunity to study the crop production and protection including horticulture based commercial farms in villages. The knowledge about crop protection methods was imparted along with the components of organic farming in certain

villages. Experience on managing commercial horticultural farms was also gained in some villages. They also studied various aspects of processing, marketing of the produce. The students were given rigorous orientation and familiarization on various issues and problems expected on farmers' field and hence gain competence and confidence for solving problems related to agriculture and allied sciences. Hence, students experienced the practical aspects of farming under the supervision of faculty. Activities also focused on intensive observations /analysis of socio-economic and technological profile of the farm families in rural areas, and interaction with progressive farmers. The students also gained information on complete package of processing the produce through visits to agro based processing industries. Eight thousand and four hundred and forty four students benefited under RAWE through Council's support. Soil testing was also done as integral part of RAWE by the students. RAWE is a component of the "student READY" programme from the year 2016-17, and stipend has been enhanced to ₹ 3000/ student/ month for a maximum of 6 months for the duration of village/ rural training.

National Talent Scholarship (NTS)

Merit based support through National Talent Scholarship to the undergraduates (UG) in AUs was provided to the candidates admitted in AUs in located in a State other than the State of domicile, through ICAR All India Entrance Examination (AIEE). This year, 2300 UG students from 47 AUs were provided NTS. The NTS is now extended to post graduate (UG) students also who are admitted through AIEE from the academic session 2016-17. The scholarship rates have been enhanced to ₹ 2000/student/ month for UG and ₹ 3000/student/month for PG students.

Library Strengthening

The libraries in AUs and its constituent colleges play pivotal role in providing scientific and technical information to the students as well as faculty. The support of ₹ 29.30 crore from the Council enriched and strengthened the libraries at AUs for library automation and digitization of resources; adding new titles to the existing collection, strengthening of book banks, and ensured procurement of need based journals not covered under CeRA. The addition of latest literature in agriculture and allied subjects helped strengthen the academic programmes as well as research due to availibilty of latest learning resources.

Library facilities strengthened at RSKVV, Gwalior

The support was provided to thirty-five Agricultural Universities and to e Granth, IARI, New Delhi. Under e Granth eighteen new Universities were added taking the total number of registered AUs to forty. MSc and PhD thesis were digitised and uploaded in the Krishikosh. Presently, eighteen thousand thesis are available on e-granth.KrishiKosh Institutional repository of NARS provides open access to institutional knowledge.At present KrishiKosh has more than 16 million digitized pages in more than 56,000 digital items (volumes) like old books, old Journals, reports, proceedings, reprint, thesis, research highlights, training manuals, historical records.

Digitization and online access to the literature ensured equity and availability of learning resources in the main campus as well as off campuses colleges. Book banks for the underprivileged students were established in some AUs.A National workshop on "Strengthening and sustainability of e-Granth was organized for sensitization of the librarians.

Information System on Agricultural Education (NISAGENET)

NISAGENET portal for universities was supported during the year and universities updated the data as per the listed requirements. The newly established univeristies were also included and 71 universities uploaded the requisite data. The profile The NISAGENET operational architecture which is a three tier web architecture makes it possible to directly enter/update data not only from university but also from the respective constituent/affiliated/college(s).

Support under Tribal Sub-Plan

Tribal welfare programmes were supported under Tribal Sub-Plan during the year. A financial support of ₹ 20.00 crore was provided to the 14 State Agricultural Universities for implementation of the programmes covering 48 tribal districts in these states. Various programmes were executed through 202 training programmes, workshops and demonstrations leading to the capacity building of 8,616 tribals in rural areas.

The capacity building programmes on value addition and postharvest management of agri-horticultural produce were initiated. In addition, the tribals were imparted trainings on improved agricultural and animal husbandry practices, apiculture, goat breeding etc. The tribal population in North-East was made aware about the benefits of new varieties of horticultural crops and cereals like maize. The capacity building programmes were conducted in backyard poultry, pig and goat rearing as well as dairy, fish and duck farming in Chhattisgarh, and Leh Ladakh. Animal health awareness camps were also organized by the universities. In Himachal Pradesh, quality planting material of apples was introduced in fields of tribals and they were also trained about pruning

operations and regarding benefits of organic farming. In LehLadakh regions the high return vegetables were introduced in target villages through introduction of trench technology. The tribals in target villages were made self sufficient in fodder production. TSP interventions in Nyoma district checked the mortality of pashmina goats due to CCPP and increased the yield of pashmina per animal with awareness about supplementing normal grazing with animal feed. The income was enhanced due to better inputs and management practices and integrated farming at Uttarakhand, Rajasthan and Maharashtra districts.

Strengthening and quality assurance of higher agricultural education through active coordination at various levels

To actively review, refine and strengthen various programmes implemented by the Education Division of ICAR the annual meetings of Vice Chancellors was held on 22-24 January, 2016, New Delhi. This also provides an opportunity to the Vice-Chancellors of AUs to interact with each other and develop strategy for effective functioning in order to maintain quality standards in higher agricultural education in the country.For maintaining uniformity in governance and financial management system comptrollers of the agricultural universities were sensitized on December 28, 2015, NAARM, Hyderabad. All 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 8-9 July, 2016, at MPUAT, Udaipur and they were informed about the scheme and its various components. They were also made aware about the guidelines pertaining to various components and timelines for the submission of the various documents to the Education Division for smooth coordination of all the activities.

In addition, librarians from across the AUs were invited for one day workshop cum meet on August 11 2016, at New Delhi. This helped them understand the efforts of the Education Division, ICAR, towards digitization process. The librarians were informed about the 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.

Accreditation of Agricultural Universities

Quality assurance in higher agricultural education is being pursued through accreditation of agricultural universities along with their constituent colleges and degree programmes. The following agricultural universities have been accredited during the year by the National Agricultural Education Accreditation Board (NAEAB):

1. CIFE, Mumbai
2. MPUA&T, Udaipur
3. RVSKV, Gwalior
4. RAU, Pusa, Samastipur
5. OUAT, Bhubaneshwar
6. SKUAST, Srinagar
7. KVASU, Wayanad, Kerala
8. JAU, Junagadh
9. CSAUAT, Kanpur
10. IVRI, Izatnagar
11. UAS, Bangalore
12. CAU, Imphal
13. ANGRAU, Lam, Andhra Pradesh
14. PJTSAU, Rajendranagar
15. DR YSRHU, Venkatramannagudem
16. SKLTSHU, Rajendranagar, Telangana
17. VNMKV, Parbhani
18. BSKKV, Dapoli
19. PDKV, Akola
20. MPKV, Rahuri
21. NDRI, Karnal
22. NDPCVV, Jabalpur
23. CKV, Durg
24. AAU, Jorhat
25. SKNAU, Jobner
26. AU, Kota
27. SVBPUAT, Meerut
28. WBUAFS, Kolkata
29. RAJUVAS, Bikaner
30. TNFU, Nagapattanam
31. AAU, Anand
32. BAU, Ranchi
33. UAHS, Shimoga
34. BCKV, Mohanpur
35. LUVAS, Hisar

Netaji Subhas-ICAR International Fellowships

Based on the priority areas of study related to plant sciences, animal sciences, social sciences, fisheries, agricultural engineering, food processing and natural resource management, 30 candidates were selected for their Ph.D. study including 23 Indian candidates at internationally recognized foreign universities in the countries viz. USA, UK, Germany, Belgium, New Zealand, South Korea, Austria, Spain, Netherlands and Australia and remaining 7 candidates from Iran, Rwanda, Sudan, Ghana, Nigeria, Ethiopia and Afghanistan at Indian SAUs/ICAR DUs.

During this year, 22 candidates have joined their overseas laboratories for pursuing Ph.D. and 30 candidates have completed their degree programme so far.

India-Africa Fellowship Programme

India-Africa Fellowship Programme has been implemented by Government of India for a period of 4 years; from academic session 2010-11 to 2014-15. Under the programme, a total of 195 candidates (119 Master's and 76 Ph.D) have joined higher degree programmes in 35 Indian Agriculture Universities. Out of which, 173 candidates (114 Master's and 59 Ph.D) have successfully completed their programmes. A gender wise break up reflects the participation of 162 males

and 33 female candidates under India Africa Fellowship Scheme.

India-Afghanistan Fellowship Programme

India-Afghanistan Fellowship Programme has been implemented in 2010-11 for providing fellowships to Afghan nationals for attaining higher education in Agriculture and allied sciences in identified Indian Agricultural Universities (AUs). A total of 211 candidates (71 Bachelor's; 140 Master's) have joined higher degree programmes in 38 Indian AUs. Out of which, 36 candidates (3 Bachelor's; 33 Master's) have completed their programme successfully. During 2016-17, a total of 133 Afghan candidates (23 Bachelor's; 110 Master's) have been recommended for admission in Indian AUs. Twenty nine candidates (5 Bachelor's; Master's 24) have joined the session 2016-17. To attain maximum enrolments of Afghan candidate, the tenure of programme is extended up to 2020-2021.

Fifth Deans' Committee Report

The V Deans' Committee, constituted for revision of curricula for undergraduate programmes of agricultural education, has submitted its report to the Council, which has been approved for its implementation in the agricultural universities. The report has been prepared by considering various aspects like defining UG degrees to cater the needs of general market and for specialist jobs and uniformity in UG and PG degree nomenclature, restructuring of UG programmes for increased practical and practice contents, central assistance for strengthening of Higher Agricultural Education, guidelines for assessing training needs and performance of teaching faculties, reforms in governance of SAUs and preparation of DPRs for establishment of new colleges. The syllabus for the following disciplines has been developed:

1. Agriculture
2. Agricultural Engineering
3. Biotechnology
4. Community Science (Home Science)
5. Food Nutrition and Dietetics
6. Dairy Technology
7. Fisheries
8. Food Technology
9. Forestry
10. Horticulture
11. Sericulture

The Committee kept in consideration that India's agricultural education needs to be stimulated and improved to increasingly enable India's participation in global markets through export of agricultural commodities and technologies, support to domestic and international agribusiness, and development of new bio- and knowledge-based enterprises, including those for rural and agro-industrial services. Hence, while preparing the report, the V Deans' Committee adopted a "hub" (ICAR) and "spoke" (AUs) model by undertaking comprehensive consultations and a bottom up approach for curriculum development. Inputs from different stakeholders of agricultural education were obtained at different levels.

Considering the fact that the Private Sector is now an eminent employer of agricultural graduates with a large demand for suitably trained and equipped graduates in agricultural sciences to meet the rapid expanding growth in the modern food and agro industry, new academic programmes have been developed and existing curricula revised and upgraded to meet the requirements, including the Student READY programme. Adequate coverage has been provided in respect of new technologies such as biotechnology, information technology, bioinformatics, GIS, remote sensing, precision agriculture, hi-tech cultivation, secondary agriculture, conservation agriculture, organic farming, international agriculture, processing and value addition, agribusiness management, and communication skills. The course curricula have been restructured and reoriented to develop much needed skills and entrepreneurial mind-set among the graduates to take up self-employment, to sustainably enhance rural livelihood security, and to propel agricultural transformation through science informed policy options and actions.

The Committee has made efforts to include relevant practical skills and entrepreneur aptitude, and to impart confidence among graduates. To reorient graduates of Agriculture and allied subjects for higher employability and greater entrepreneurship, the Student READY (Rural and Entrepreneurship Awareness Yojna) programme has been introduced in all the Agricultural Universities as an essential prerequisite for the award of degree to ensure hands-on experience and practical training. Considering the variation in different streams of agricultural education and feasibility, the Committee has proposed to include following components, which are interactive and are conceptualized for building skills in project development and execution, decision-making, individual and team coordination, approach to problem solving, accounting, quality control, marketing and resolving conflicts, etc. These are:

(i) Experiential Learning/Hands on Training
(ii) Skill Development Training
(iii) Rural Agriculture Work Experience
(iv) In Plant Training/ Industrial attachment
(v) Students Projects

Due attention has been given to areas of training and institutions for improving faculty competence for the purpose. The Committee has also recommended that some of the courses like Environmental Studies and Disaster Management, Communication Skills and Personality Development, Information and Communication Technology, Entrepreneurship Development and Business Management, Agri-Informatics and Economics and Marketing need to be taught in all the undergraduate programmes of agricultural sciences, as these are must for personality development and to deal with the unforeseen circumstances.

The Committee has distributed the courses in a

systematic way so as to teach basic courses first followed by principles and finally skill development. It is planned to keep courses related to basic fundamentals in first year, theory/practicals and principles with present state of Art of Technology in second year, modern and frontier area of education in third year and Student READY programme of one year in final year.

ICAR had constituted committees for preparation of Minimum Standards for Higher Agricultural Education for different disciplines of Agricultural Sciences. The Deans' Committee considered the reports of the committees to arrive at the minimum requirements for establishment of new colleges in Agriculture and allied disciplines. These minimum requirements have been compiled and published. A copy of these requirements has been sent to all the Vice Chancellors of Agricultural Universities, Principal Secretaries for Agriculture and Chief Secretaries of all states in order to ensure maintenance of quality of Agricultural Education.

Manpower development

- **All-India Entrance Examination for Admission to UG:** The 21st 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 (NTS) was conducted on May 21, 2016. The examination attracted a record 1,24,995 applications, out of which 1,06,321 candidates appeared and 1351 candidates were finally recommended for admission in 38 AUs through counselling. All the candidates, who joined a university outside their State of domicile, were awarded NTS of ₹ 2000/month.
- **All-India Entrance Examination for Admission to PG**: The examination was conducted on May 22, 2016 for admission to 25% seats in PG programmes at 45 accredited AUs, including award of ICAR Junior Research Fellowship (JRF). A total of 23,728 candidates appeared in the examination, out of 25,545 applicants, and 1986 candidates were finally recommended for admission. In all, 474 students were awarded JRF in 20 major subject groups. From academic session 2016-17 and onwards, the non-JRF candidates who join the Master degree programme in the allowed university shall be eligible to get NTS (PGS) of ₹ 3000/-per month for two years subject to fulfilment of prescribed terms and conditions of JRF (PGS).
- **All-India Competitive Examination for Ph.D. admission and award of Senior Research Fellowship**: The examination was held on May 22, 2016 at 20 centres across the country. A total of 4186 candidates appeared in the examination, out of 4709 applicants, and 414 candidates were finally admitted for Ph.D. admissions at 41 accredited AUs. Based on the merit, a total of 176 Senior Research Fellowships were awarded in 16 major subject groups.
- **Globalization of agricultural education:** One hundred and seventy-four students from 36 countries like Afghanistan, Bangladesh, Bhutan, Egypt, Eritrea, Ethiopia, Fiji, Guyana, Ghana, Iran, Kenya, Liberia, Mauritius, Mozambique, Namibia, Nepal, Nigeria, Rawanda, Sudan, Sri Lanka, Syria, Swaziland, Tanzania, Comoros, Palestine, Trinidad and Tobago, Sierra Leone, Zambia, South Africa, Ghana, South Sudan, Zimbabwe, Cote-d-Ivoire, Cameroon, Yemen, Thailand, Vietnam and Uganda, exercised their preference to join various agricultural universities under different fellowships or as self-financed candidates.

Capacity Building

Summer/Winter Schools and Short Courses: Summer and Winter Schools (SWS) and Short Courses of 10 and 21 days duration (62 SWS of 21 days and 55 Short Courses of 10 days) were organized at ICAR Institutes and State Agricultural Universities in key areas of agriculture and allied sciences like, Micro-irrigation and fertigation; Concepts and techniques in development of health foods; Processing, value addition and waste utilization technologies; Engineering Interventions in Conservation Agriculture; Climate Change Mitigation; Technopreneurship Opportunities; Quantitative Genetics and Statistical Genomics; Participatory Extension Research and Management; Extension Methodologies for Agricultural Development; Extension Strategy for Entrepreneurship Development; Management in Agro Processing and Value Addition; Gender Mainstreaming for Resilient Agriculture; Technical Textiles & Functional Clothing; Nutrition Security; Cross Sectoral disaster Risk Reduction Strategies in Livestock Sector; Functional Genomic Concepts; Quality Ruminant and Poultry Production; Farmers' Empowerment and Entrepreneurial Development; Disease Diagnosis and Management; Value addition and Challenges in Quality Control; Molecular Techniques in Gene Regulation and Functional Genomics; Molecular Breeding Approaches for Genetic Enhancement; Integrated Pest and Disease Management; Biotechnological Approaches for Adaptation to Climate change; Forecast Modelling; Agro Ecosystem; Resource Conservation; Management Practices and Bio-security; Hi-Tech Intervention; Preservation and processing technologies; Sustainable Production; Protected Cultivation; Biofuels-Current Innovations and Future Trends; Food Safety Management Systems; Educational Methodology & Instructional Technology, etc.

Centres of Advanced Faculty Training: The 31 Centers of Advanced Faculty Training provided training to about 1000 scientists/ faculty members from the National Agricultural Research System through 47 training programs in cutting edge areas of agricultural and allied sciences. All the training programs sponsored by Agricultural Education Division were monitored through workflow based online management system.

A Capacity Building Program Vortal exists to provide information on all training programmes, training proposal submission and evaluation, submission of application by a trainee, availability of e-books/lecture notes of a training and reports for all categories of users and several other features.

Promotion of Excellence and HRD

ICAR National Professor Scheme

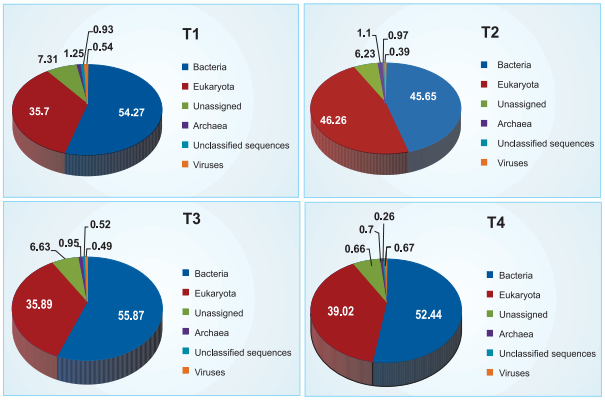
For promoting excellence and creating a culture of basic research at national level, ten positions of National Professors have been created. Major achievements of ongoing ICAR National Professorial scheme are:

***Changing consumption pattern in India: Opportunities for diversification towards high value commodities through production and marketing linkages*:** Analysis of changing consumption trend towards different livestock products among Indian households indicated their increasing share in total food expenditure necessitating improved value chains for these products. Analysis of organised alternate formats of marketing such as Contract Farming, E - Marketing and Super Markets indicated their emergence as viable alternatives to APMCs. However, they need policy support for expansion, offering competition and improving the efficiency of APMCs. The co-existence of APMCs is strongly advocated being democratic organizations receiving continued Government support.

***Broadening the genetic base of Indian mustard (Brassica juncea) through alien introgressions and germplasm enhancement*:** A very large number of CMS based determinate × indeterminate and indeterminate × indeterminate mustard hybrids were evaluated and identified, some for multilocation evaluation. Population genetic and transcript analysis recognized loci associated with flowering (*FLC* and *CO* in *B. rapa*; *FLC* and *LFY* in *B. juncea*), seed size and oil (*AP2* and *ARF2* in both *B. rapa* and *B. juncea*; *DA1* and *CYP78A5*) and pod shattering (*SHP1*, *SHP2*, *RPL* and *NAC*) that might be under directional selection. Genotypes with very high shattering resistance in mustard were: MCP 633 (11.0 mJ) followed by NR 3350 (10.5 mJ) and Albeli 1 (10.3 mJ). RNA-seq data allowed high-resolution mapping of the chloroplast-derived transcripts to a reference *B. rapa* chloroplast genome. Resistance to sclerotinia stem rot of introgressed lines though declined at higher temperatures, these remained significantly higher than the susceptible mustard check.

***Development of cisgenic chickpea (Cicer arietinum L) resistant to pod borers (Helicoverpa armigera)*:** Seeds of a *Helicoverpa* mild resistant cultivars (ICC 506 EB) and wild relatives (*Cicer bijujum, C. Judiacum* and *C. microphylum*) along with a susceptible variety (JG 11) were collected from ICRISAT, Patancheru. Seeds were sown in the greenhouse for transcriptome assays. Total RNA was extracted from the young leaves, flower and pod wall of a cultivar DCP 92-3. Two Suppression Subtractive Hybridization (SSH) libraries have been prepared. The libraries will be used for identification of genes that are highly expressed in the flower and pod wall in order to isolate their regulatory sequences.

Metagenomics analysis and manipulation of buffalo rumen ecosystem to improve fibre utilization and reduce methane production: Four adult fistulated buffaloes, in 4*4 Latin square design, were subjected to four treatments viz., T1: Control (without additive); T2: sulphur @ 0.05% of DMI (through sodium sulphate); T3: BPb (mixture of plant additives) @ 1.5% of DMI and T4: sulphur + BPb (doses same as in T2 and T3). Methane production was significantly lower in T3 and T4 while average body weight gain tended to increase (P=0.058) in T3 group of animals containing plant products as feed additives. The rumen enzyme and



Microbial diversity of the rumen of buffalo fed sulphur and plant secondary metabolites

microbial profile were not affected. The analysis of metatranscriptomic libraries comprising 20.17 Gbp, high quality data of rumen microbiome of buffaloes, i.e. 6 domain, 64 phyla, 272 genera and 89 CAZy enzyme families were obtained. Contribution of major fibre degrading bacteria Ruminococcus and Fibrobacter highlighted the fact that there were other microbes which were also important for fibre degradation and needed to be worked out.

***Assessment, prediction and enhancement of biotic carbon sequestration in agricultural soils*:** Geo-spatial analysis of organic carbon (C) stocks in soils of Punjab was performed to estimate C sequestration potential and to characterize organic matter composition in relation to crop, land-use and agricultural management. Inorganic C (SIC) stocks in soils ranged between 0 and 36 Mg/ha, which were generally < 1 Mg/ha in the north-eastern region and more than 7 Mg/ha in the south-western region. Organic C concentration in soils was related to silt and clay content and there were indications of saturation and depletion of soil organic C. Adoption of management practices such as organic farming in rice-wheat system reduced tillage in dryland maize-wheat systems and resulted in C sequestration and improvement of biochemical health of soils.

***Development of chromosome segment substitution lines (CSSLs) of rice from elite × wild crosses to map QTLs/genes for yield traits*:** CSSLs are a library of back cross inbred lines representing entire donor

introgressions as overlapping segments in the genetic background of elite cultivated genotype. These are important prebreeding resource for mapping and cloning of QTL or genes of interest. Seven popular Indian rice varieties; Swarna, MTU1010, Dhanarasi, Rasi, Krishnahamsa, Vandana and Varadhan were used as recurrent parents and 3 accessions *O. rufipogon* and *O. nivara* with high photosynthetic rates as donor parents. Crosses from MTU1010 × *O. rufipogon* and Swarna × *O. rufipogon* were advanced upto BC_4F_1 generation by genome-wide genotyping and backcrossing.

Swarna × *O.nivara* BILs crosses were screened at field conditions and high yielding stable BILs were used to develop F2:3 mapping populations.104 Swarna × *O.nivara* BC_2F_8 BILs were phenotyped during Kharif 2014, 2015, 2016 for yield traits and a CSSLs set with 51 lines using 120 polymorphic SSR markers was identified. Major effect yield trait QTLs *qPW5.1*, *qYLDP8.1* and *qBY12.1* with phenotypic variance 15% to 48% were identified in each year. 94 backcross inbred lines of Swarna × *Oryza nivara* IRGC81848 (BC_2F_8) were field evaluated and genotyped using 118 polymorphic SSRs. These QTLs and CSSLs would be useful in dissecting yield traits and in rice breeding.

ICAR National Fellow Scheme

With an objective to provide support and develop strong centers of research and education around outstanding scientists, 25 ICAR National Fellow positions have been provided in National Agricultural Research System. Highlights of the ongoing projects are:

***Method for detecting the presence of any virus signal in clinical samples of fish developed*:** Interferon mediated cell signalling leads to elevated levels of an interferon stimulated gene (ISG) Mx. Mx protein, is an indicator of viral infection, an innate immune mechanism of host against viral infection. To develop a diagnostic tool for detecting any viral infection, an attempt was made by applying the expression of this ISG. Therefore, the complete coding region of Mx was identified from snow trout, *Schizothorax richardsonii* using RACE and sequenced (Accession number KU529282.1). The promoter of this gene was also identified and sequenced. Further, a construct, pGL3-Neo-GFP-MxPro, carrying green fluorescent protein as a reporter gene, is ready for further studies.

Soy and multi-grain based nutritionally balanced functional foods for children developed: Eggless refined flour free cake rusks: Cake rusks were developed using RSM for optimization of time and temperature for the process of drying of refined flour free eggless cakes. The optimized time and temperature for drying each of the products were egg-Banana refined flour rusk (control)- 125 °C for 65 min, Egg-Banana composite flour rusk (T1)- 125 °C for 75 min and Eggless Banana composite flour rusk (T2)- 125°C for 100 min. The quality parameters of the developed rusks were compared to commercially available rusks in the market. The hardness (N) of T1-54 was highest followed by T2-53 and C -35. T2 was closest to the commercial rusk (53) in terms of hardness. Overall acceptability of the control was the highest at 9 followed by T2 at 8.5 on the 9 point hedonic scale.

Composite flour laddoo was formulated using a mix of cereals, sprouted legumes, malted millet, dairy ingredients, fruit, oil and jaggery. The laddoo was significantly softer in texture, resulting in ease in biting, chewing and swallowing. The laddoo contained protein (24.6g), iron (10.4mg) and phosphorus (287.5mg), phenolics (123.0 GAE) mg flavonoids (6.9 QE) mg and antioxidant activity (62.6% RSA) in 100g. Organoleptic evaluation also showed higher acceptability.

CIAE-Nutri-Laddoo

***Environmental tracer based study on erosion induced loss of soil organic carbon and its impact on agronomic productivity and environmental quality*:** The main objective of the project was to estimate erosion-induced loss of soil organic carbon from a soil affected by different phases of erosion. An uneroded reference site in a flat area covered with perennial vegetation, located about 500 m far from the runoff plots was selected for evaluation of the total local fallout input of ^{137}Cs. Four profiles from this area were sampled by a depth incremental sampling procedure. The sample of each layer was stored for ^{137}Cs activity determination as well as for chemical and physical analysis. Data from 8 runoff plots were analyzed for quantification of soil and carbon erosion.

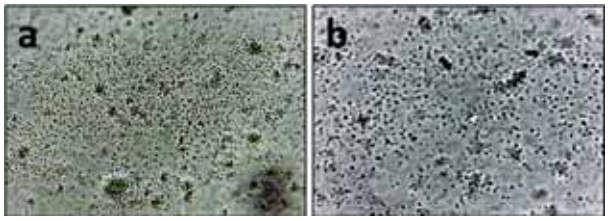
Study region showing the reference and eroded site

Robust and efficient small area estimation methods for agricultural and socio-economic surveys and their application in Indo-Gangetic plain: Small Area Prediction of Counts under a Non-stationary Spatial Model: There is a growing need for current and reliable counts at small area level. The empirical predictor under a generalized linear mixed model (GLMM) is often used for small area estimation (SAE) of such counts. However, the fixed effect parameters of a GLMM are spatially invariant and do not account for

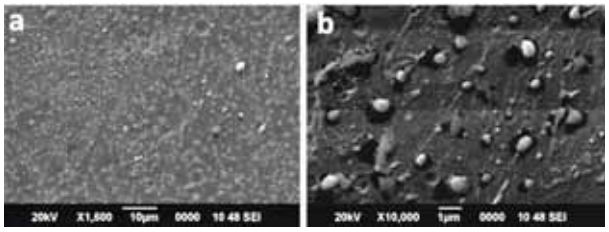
the presence of spatial nonstationarity in the population of interest. A geographically weighted regression extension of the GLMM was developed, extending this model to allow for spatial nonstationary, and SAE based on this spatially nonstationary model (NSGLMM) was described. The empirical predictor for small area counts (NSEP) under an area level NSGLMM is proposed. Analytic and bootstrap approaches to estimate the mean squared error of the NSEP were also developed, and a parametric approach to test for spatial nonstationarity was described. Developed SAE method was also applied to obtain reliable estimates of poverty incidence, i.e. proportion of poor households at district levels in the State of Uttar Pradesh by using survey data from the Household Consumer Expenditure Survey 2011-12 of National Sample Survey Office 68th round and the Population Census 2011. Subsequently, a poverty map for state of Uttar Pradesh was produced which provides important information for analysis of spatial distribution of poverty in the state.

***Novel immunopotentiator molecules from fish host and pathogens for broad spectrum disease control in Freshwater Aquaculture developed*:** Host preference of *Argulus siamensis* was studied by taking eight different species (*Labeo rohita, Cirrhinus mrigala, Catla catla, Hypophthalmichthys molitrix, Cyprinus carpio, Ctenopharyngodon idella, Carassius auratus* and *Labeo fimbriatus*). *L. rohita* was found to be the most susceptible and *C. idella* the resistant species to this parasite. High level of expression matrix metalloproteinase 2 and major histocompatibility class II genes in skin during parasite induced inflammation was found in *C. idella* compared to *L. rohita,* and therefore appeared to be involved in the early protective response against *A. siamensis*. Lysozyme G gene of rohu having antimicrobial activity was cloned, and expressed in bacterial expression system, and the recombinant protein was characterized for its biological activities.

***Biomodulation of marine biopolymers for the preparation of biomaterials of health care importance*:** High pure acid soluble collagen (ASC) with potential antiulcer property has been extracted and purified from the airbladder of the fish *Pangasius hypophthalmus*. The purified collagen was found to belong to type I collagen, comprising of two different α chains (α_1 and α_2). Biocompatible chitosan, chitosan/ zinc acetate, chitosan/ chondroitin sulphate and chitosan/ zinc acetate/ chondroitin sulphate films were developed. Biocompatible chitosan based gel/sol having salicylic acid as the key ingredient was developed for treating skin problems such as warts, corns and calluses. Anthocyanin loaded chitosan nanoparticles with potent antioxidant activity were developed by ionic gelation method for nutraceutical applications. Particle size distribution analysis showed that the particles possessed a mean hydrodynamic diameter of 274nm.



Light microscopic images of anthocyanin loaded chitosan nanoparticles (a) at 40× magnification and (b) at 100× magnification

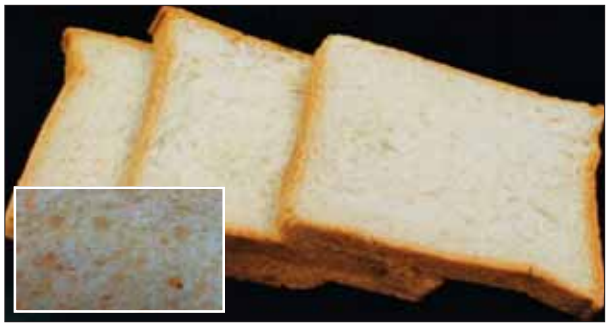


SEM images of anthocyanin loaded chitosan nanoparticles (a) at 1500× magnification and (b) at 10000× magnification

***Activin receptor type IIB gene silenced in chicken myoblast cells*:** Activin receptor type IIB (ACVR2B) is the receptor of myostatin being involved in inhibiting muscular growth in chicken. Five shRNA molecules were designed and synthesized for transient RNAi silencing of ACVR2B gene in myoblast cells. A significant ($P<0.05$) reduction in the levels of ACVR2B mRNA was observed in myoblast cells transfected with all types of shRNA molecules. The percent knock down of ACVR2B mRNA varied significantly ($P<0.05$) from 87% (shRNA 1) to 43% (shRNA 5). Silencing of ACVR2B gene significantly up-regulated the *in vitro* expression of pathway associated genes (MyoD and MyoG) and immune response genes (IFNα, IFNβ and MHCII).

Environmentally Sustainable Termite Control: Identification of alate-termites via molecular tools facilitated the study of swarming. Swarming in *Odontotermes* was correlated with rainfall and heat units. The ever existing ambiguity whether *O. indicus* is the synonym for *O. feae* was cleared; *O. indicus* was found to be a junior synonym of *O. feae* based on gene-sequence similarity. Post-harvest observation showed that termites prefer surviving on stubbles of previous crop-residues (maize) rather than same used as mulch. Combinatorial efficacy and compatibility of insecticides were investigated for seed treatment for groundnut *in vitro* and field trial with bio-fertiliser (*Rhizobium)* and bio-fungicide (*Trichoderma harzianum*).

***Development of food biopolymer based micro and nano scale delivery systems for bioactive ingredients in functional foods*:** Process parameters for preparation of nano emulsion of flax seed oil, garlic oil and lecithin in water using high pressure homogenizer and also by ultrasonication were optimized. This emulsion was encapsulated in alginate microcapsules. The microcapsules were characterized by FTIR and scanning electron microscopy. The encapsulation efficiency of flax seed oil, garlic oil and flax seed oil+ garlic oil hybrid microcapsules were found to be 85, 69 and 92 % respectively. Functional bread was developed by incorporating microcapsules of flax seed oil, garlic

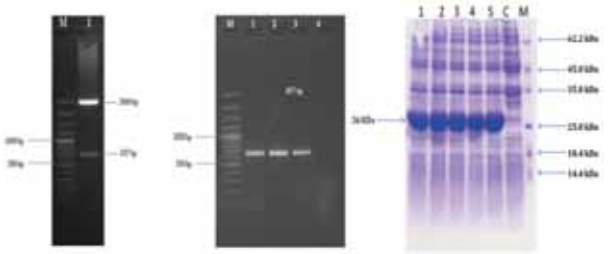


Bread fortified with microencapsulated flaxseed oil plus garlic oil

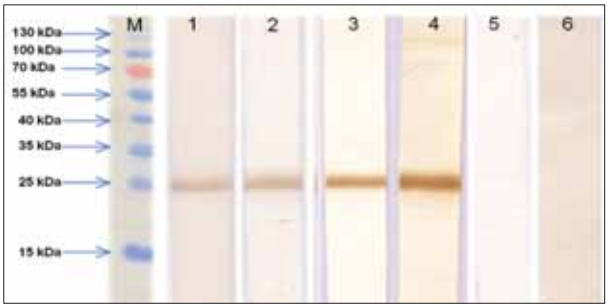
oil and flax seed oil plus garlic oil at the rate of 5g/ 100g of dough with improved oxidative stability.

***Identification of nanoparticles as feed additives that regulate expression of immunomodulatory and anti-stress genes in fish*:** Dietary administration of iron oxide nanoparticles significantly down-regulated expression of IL-1β (9 fold), TNFα (3 fold), and complement component C3 (2 fold) genes and upregulated lysozyme C-type and transferrin protein (28 fold) genes. In addition, dietary administration of Zinc oxide nanoparticles significantly down-regulated expression of different oxidative stress genes of Rohu, *Labeo rohita* under laboratory conditions. A floating feed was formulated using these micronutrients in nano forms for use in pond trial.

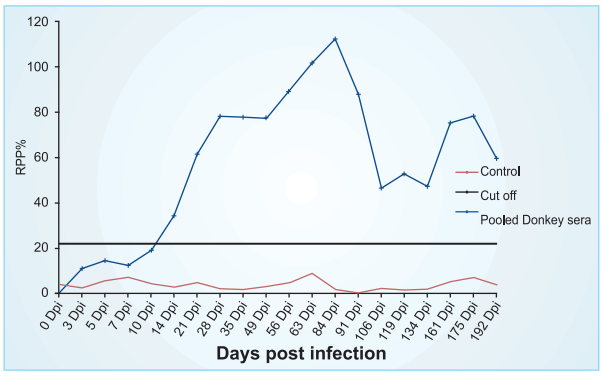
***Development of a flagellar recombinant antigen based indirect ELISA for detection of Trypanosoma evansi in equines*:** A flagellar recombinant antigen based ELISA was developed for detection of *T. evansi* infection in equines. The gene fragment was cloned and expressed in prokaryotic expression system. The recombinant antigen revealed a immunoreactive band



Cloning and expression of flagellar gene fragment



Immunoblotting with *T. evansi* infected equine serum samples, Lane M: prestained protein marker, Lane 1-2 Experimentally infected donkey serum samples, Lane 3-4: *T. evansi* positive equine field serum samples, Lane 5: *t. evansi* negative equine serum samples, Lane 6: *TIheileria equi* positive serum sample



AIntibody detection by r-ELISA with *T. evansi* experimentally infected donkey serum samples from day 0-192 post infection

of 26 kDa on immunoblotting with experimentally infected donkeys and naturally infected equine serum samples. Further, an indirect r-ELISA was developed and the assay detected antibodies from 14th day post infection onwards in *T. evansi* experimentally infected donkey serum samples. The diagnostic specificity and specificity of r-ELISA was found to be 0.92 (0.82-0.95) and 0.98 (0.96-0.99) in relation to WCL- ELISA, respectively.

Development and implementation of novel algorithms and software modules for PGR informatics: Map-based data retrieval provides easy and intuitive access to PGR information. The process is vital for developing mobile apps. Computational algorithms for map based applications in PGR were developed and were implemented as an interactive application called "PGR Map". A user friendly PGR Map was designed, developed and implemented to provide a personalized quick access to passport information to PGR workers, breeders, students and research managers and administrators. The module is available at http://pgrinformatics.nbpgr.ernet.in/pgrmap. The PGR Map is designed to be compatible with old and new computers, tablets and smart phones. The PGR Map figures are dynamically updated as and when passport information is updated.

Development of computational modules to link Genebank and Genbank: In continuation of the work to link information on genomic resources submitted to Genbank (public database) with the source cultivar, genotype or landrace conserved in genebanks around the world, a module is being developed for native pulses, rice, wheat and pearl millet by collating as many as 4,914,210 genbank accessions and 5,09,439 genebank accessions. Further work is in progress.

***Volatiles induced by egg deposition mediate niche partition in tephritid fruit flies*:** Volatiles induced by herbivory affect composition of plant-associated arthropod communities. However, the role of volatiles induced during egg deposition by herbivorous insects, and their consequences on niche partition remain poorly explored. The findings of the project imply that egg deposition into fruits can induce specific volatiles that may mediate niche partition in tephritid flies. Further, this may also give an opportunity to prospect kairomones that may aid in avoiding oviposition on to fruits and may be helpful in push-pull strategy. Complex volatiles play a major role in the behaviour of *Bactrocera dorsalis*. It was found that protein, methyl eugenol and host fruit had a vast influence in the life history of the fly, e.g. males not fed with proteins were not attractive to other males or females. For males, they may not pose a competition and for a female, they may not be healthy fathers.

Molecular platforms for point-of-care detection of major enteric viruses responsible for neonatal mortality in animals developed: Whole genome sequencing was completed for a unique isolate of bovine rotavirus A which exhibited multiple independent interspecies transmissions as well as re-assortment events between co-circulating bovine, porcine, ovine and human rotaviruses. Molecular epidemiological investigation confirmed very high incidence rate (91%) of rotavirus D infection in poultry. In porcine samples Astrovirus was detected (13%) along with Rotavirus A and Picobirnavirus. A novel enzyme immunoassay based on peptide-and recombinant VP6 protein for detection of rotavirus A in bovine was developed and performance characteristics of the new immunoassay were found comparable to those of commercially available ELISA kits. The work on identification of immunogenic regions in avian rotavirus D structural capsid proteins for overexpression of virus specific recombinant protein with an aim to develop rapid and economic indigenous biologicals for rotavirus detection are underway.

Emeritus Scientist Scheme

The ICAR continued to operate Emeritus Scientist Scheme as a structural method of utilizing Skill Bank of the outstanding superannuated professionals of NARS. Some of the major findings of the projects under this scheme are:

- Sugarcane varieties Co 86032 and Co 62175 were transformed with a codon optimized gene coding for somatropin, a human growth factor with 192 amino acids. The protein is targeted to the lytic vacuole of the parenchyma cells of sugarcane stem so as to extract the protein from the sugarcane juice.
- Multi protein Bridging Factor 1 (MBF1) is an important gene that regulates the process of thermal tolerance in plants. In chickpea also, this gene is significantly up-regulated. Towards characterizing this gene, the coding sequence of this gene has been cloned under the control of CaMV35S promoter and these constructs have been mobilized into *Agrobacterium* strains. These strains have been used to transform *Arabidopsis* using floral dip method.
- Priority wild related species were delineated (385 from nearly 2500 species) using a) distribution data at Indian and global levels, b) potential as sources of tolerance to abiotic/ biotic stresses and nutritional quality traits vis-à-vis crop, and c) characters for identification in closely allied taxa of *Oryza*, *Elymus*, *Vigna*, *Cajanus*, temperate forages, etc.
- The ultrasonographic picture of liver and gall bladder of goats from first to six months of age were studied in order to identify the developmental changes occurring in their anatomy. The liver in goats aged one month appeared uniformally echogenic with smooth borders. The gall bladder, hepatic ducts, cystic duct, bile duct and hepatic blood vessels were visualized but the pattern of hepatic and portal vasculature was not very clear. In the goats aged two months, the hepatic parenchyma appeared a little coarser. The dimensions of gall bladder showed a definite increase. The coarse texture of hepatic parenchyma increased further in goats that had already attained three months of age. The position of different liver lobes could be predicted with greater accuracy at this stage. The vascular pattern and hepatic parenchyma echo-texture did not show any further appreciable change at four months of age. However, the cranial and caudal boundaries of gall bladder were clearly visible at this stage. The liver and gall bladder of five months old goats were sonographically almost similar to those aged four months. In six months old goats, 2-D ultrasonography showed prominent hyper-echoic hepatic capsule surrounding the coarse parenchyma. Additionally, the anechoic gall bladder and hepatic and portal vessels were all distinct at this age.
- Risks factors such as village demography, village level livestock population data and village level data were identified for the incidence of four major livestock diseases *viz.,* Foot and Mouth Disease (FMD), Haemorrhagic septicaemia (HS), Black Quarters (BQ) and Peste des petits ruminants (PPR) for the development of risk maps using GIS technology.
- A prototype software was developed for aquatic animal diseases surveillance.
- With an aim to strengthen establishment of Veterinary and Animal Science Educational Museum at Indian Veterinary Research Institute, Izatnagar, UP, approximately 1000 exhibits received or collected were restored/ renovated/ identified and displayed in the museum. These exhibits included rare veterinary literature, animal paintings, vintage scientific equipments, laboratory glasswares, animal driven carts, biological

specimens, animal harnesses and accessories, coins and postage stamps depicting animals and birds. Illustrated sunboard panels on the history of veterinary and animal science were prepared, printed and displayed. In addition, e-inventory, introductory folder and web page of the museum was prepared and published. Museum was made functional and visited by more than 2000 visitors including dignitaries of ICAR and other organizations.

- Six species of high value marine finfishes *viz. Gnathanodon speciosus, Lethrinus lentjan, Lutjanus argentimaculatus, Pristipomoides typus*, *Caranx heberi, C.sexfasciatus* and *C. gymnostethus* were evaluated for reproductive parameters for captive broodstock development and breeding. Based on the reproductive parameters investigated the Golden trevally *Gnathanodon speciosus* was evaluated as a very good species for broodstock development, breeding and seed production for marine aquaculture. It is an excellent table fish which is in high demand in the domestic market and fetches ₹400/- to 500 per kg.


Golden trevally

- **Extramural Research:** This was launched during 2015-16 to sponsor and support short term result oriented extramural projects addressing acute and felt needs to enhance the quality of agricultural education on identified thrust areas. Thirty eight (38) New Extramural Research Projects on agricultural education were sanctioned during 2016-17.

Pandit Deen Dayal Upadhyay Unnat Krishi Shiksha Yojana (PDDUUKSY)

The Division has launched Pandit Deen Dayal Upadhyay Unnat Krishi Shiksha Yojana (PDDUUKSY) under "Unnat Bharat Abhiyan" to build skilled human resource at village level relevant to national needs towards organic farming and sustainable agriculture, to provide rural India with professional support in the field of organic farming/natural farming/rural economy/ sustainable agriculture and to extend other activities of Unnat Bharat Abhiyan at village level. To achieve the set objectives, 100 training centres have been identified across the country to impart training to at least 15,000 farmers during 2016-17.

New Inititiatives

- Declaration of UG degrees in Agriculture and allied subjects as professional degree courses.
- Declaration of 3rd December as 'Agricultural Education Day' throughout the country.
- Enhancement in the number of positions of Emeritus Scientists from 50 to 100.
- Initiation of Emeritus Professor Scheme for filling up 100 positions of Emeritus Professors to help in teaching specialized courses and mobilizing a movement in science to reduce regional imbalances in agricultural development.
- Initiated the process for establishment of 9 new Centres of Advanced Faculty Training (CAFT).
- Support for green initiatives such as establishment of solar energy utilization, rainwater harvesting, composting and waste water recycling, noiseless generators and e-governance to all the accredited AUs.
- Establishment of digital library in all accredited SAUs.

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12. Social Science

Revisiting groundwater depletion and its implications on farm economics in Punjab

The empirical evidences showed a significant declining trend in groundwater level in Punjab over time due to injudicious and unrestricted withdrawal of groundwater over its replenishment level. The estimate of rainfall effect on groundwater recharge was weaker than recharge potential of canal irrigation. Therefore, integrated water resources management plays a crucial role in augmenting groundwater resources of the state. However, the synergy between surface and groundwater has not been emphasized in the state. On an average, Punjab farmer incurred ₹ 0.46 for extracting one cubic meter groundwater for irrigation and small and marginal farmers incurred 2-3 times higher groundwater extraction cost as compared to large farmers. The inverse relationship between groundwater extraction cost and farm-size was because of over-capitalization of GEDs on smaller land holdings and presence of economy of scale at larger farms. The depleting groundwater level further increases the groundwater cost and the effect of such cost escalation is born more adversely by the small and marginal farmers. Therefore, for smaller land holdings, installation of community based GEDs and promotion of groundwater market will be an economically viable alternative.

The energy pricing is an important tool for sustainable management of groundwater resources. In a scenario of withdrawal of subsidy, groundwater extraction cost will increase to double which will adversely affect net returns from the crop production. However, reduction in net return would vary across crops depending on the extent of groundwater use and crops will still be covering at least variable cost of cultivation. On the positive side, de-subsidization of energy will prompt farmers to improve groundwater use efficiency which will result in 29-82% saving in existing groundwater use in different crops in the state.

Market intelligence and price analysis

Fluctuations in prices of different agricultural commodities are a matter of concern among farmers, policy makers and stakeholders. A Network Project was implemented at 14 centres covering 13 major states and more than 40 major agricultural commodities of the country. The price forecasts were developed based on scientific modelling framework along with validation of price expectations of stakeholders (farmers, traders, exporters, etc). During 2015-16, the mean absolute percentage error varied between 1.98 for rapeseed and mustard in Uttar Pradesh to 9 for apple in Jammu and Kashmir.

States under Network Project on market intelligence and price analysis

Continuous efforts were made to strengthen the dissemination efforts for price forecasts to farmers and other stakeholders through print media like newspapers, magazines, brochures, pamphlets, news bulletins; electronic media like television, radio; internet and emerging e-social networks like websites, agropedia portal, YouTube, Facebook, WhatsApp pages, etc. Stringent efforts are also being made to personally disseminate the price forecasts to the farmers through personal meetings, group meetings, farmers' fairs and also through telephone and customized messages before sowing and before harvesting of selected commodities.

Mainstreaming adaptation policies in development planning to enhance resilience of Indian agriculture

There has been increasing consensus amongst planners and policy makers to mainstream the adaptation agenda into the developmental plans. This study after analysing climate change associated risks in Indian agriculture, formulated 6 broad thematic groups, namely, *Rural livelihood Security, Natural Resource Management, Production Augmentation and Productivity Enhancement, Risk Financing, Food Grain*

Management, and *Research and Extension.* Based on the pertinence to these groups, from the total of 53 ministries prevailing in government of India during 2015-16, the study identified 24 ministries associated with the Development-Adaptation continuum responsible for livelihood support in rural India. The study has further disaggregated these six thematic groups into 24 sub-groups and 52 categories. Thus an extended classification was in consonance with the stated objectives of the identified schemes/ programmes across the 24 ministries. Such a cross cutting and thematic/ need based convergence of different programmes will ensure mainstreaming the developmental agenda as per the relevance of the programme to climate change adaptation. This approach envisages to sensitize policy makers towards the programme duplication issue and in ensuring effective utilization of the available financial resources thereby bringing prudency, effective targeting and outcome oriented approach towards enhancing the resilience of Indian agriculture/vulnerable section or region.

Organic manure production: A source of livelihood for women groups

Eight unemployed women from Mazhuvanoor Grama Panchayath, district Ernakulam, Kerala identified by Kudumbashree Mission, a Government of Kerala women-empowering project, were selected to venture into organic manure production and marketing. They were registered under Joint Liability Group (JLG) and imparted rigorous hands-on-training on formulation of organic inputs, labelling, packing and packaging. Lessons on business plan and marketing strategies were also imparted. ICAR-CMFRI, KVK facilitated them in obtaining various mandatory licences and test marketing of their products. A business entity Jeeva Kudumbashree Micro Enterprise was inaugurated at Mangalathunada, Airapuram, district Ernakulam. Products from the venture are being marketed under Kudumbashree brand which includes neem cake, neem oil, grow bags, grow bag mixture, sea fish extract, panchagavya and dolomite-neem cake-groundnut cake mixture. With an initial investment of ₹ 4.5 lakh, they earned a profit of ₹ 1.05 lakh in two months.

Efficiency, inclusiveness and financing of dairy value chains

Despite growing dairy industry in India, farmers' lack of access to organized markets and institutional credit remains one of the major hindrances in improving the scale and productivity of dairy. These constraints also eased smallholder dairy farmers' transition towards commercialization using a value chain approach. A study in Punjab (survey of over 600 dairy farmers) evaluated efficiency, inclusiveness and financing of formal dairy value chains. It revealed that 62% of the sample farmers representing 69% of the total milk sales were connected with formal value chains driven by co-operatives, multinational companies and private domestic processors, while, majority of small dairy farmers with informal value chains. The farm-level performance indicated more profits for farmers in cooperative value chain. More than half of the farmers borrowed credit both from within and outside the chain for dairy related activities. Chain-based financing was restricted to only one-fourth of the borrowers, mostly to farmers associated with informal value chains. Financing by commercial banks and other financial institutions was limited to only 9% of the borrowers, mainly large farmers. The socially-disadvantaged and small farmers were often neglected in institutional lending because of their lack of physical assets to use as collateral against loans. Value chain approach, due to its product market orientation, can serve as an entry point for financial institutions to improve their outreach to smallholders. The innovative financial products, such as 'dairy credit card' and 'contract as collateral' would enable them to adopt yield-enhancing technology and inputs and also to scale up their dairy activity.

IT approach to agricultural marketing: e-Mandi system

The study examined operation of e-tendering system for Red Gram in Gulbarga APMC, identified determinants of traders' participation in e-marketing, assessed the impact of electronic auctioning on the various stakeholders - farmers, traders, commission agents and market revenue, and studied perception of the market participants on the e-auctioning mechanism of marketing of red gram. The results showed that e-tendering system has contributed towards an increase in the market revenue. The participation of traders in e-tendering system depends on type of licence held by the trader or commission agent, computer knowledge, quantity traded, traders' perceptions on the unified market platform. Further, marketing through e-tendering took less time (2.6 hr) as compared to manual tender and open auction where average transaction time was 4-4.50 hr. As per farmers' perception, increased market competition and transparency were the most important attributes of the e-tendering system. The traders perceived, time saving as the major attribute of the e-tendering system. Majority of the traders (94%) also felt that the system has limited scope for price manipulation.

Women in livestock production and children's nutrition

The role of livestock in improving women's income and bargaining power in intra-household resource allocation and its effects on children's nutritional status were examined. Both men and women participated in animal husbandry, but it was women particularly the illiterate ones who were more engaged in animal husbandry. On an average, with an additional illiterate female worker, a household realized more than 7% higher income from livestock activities, whereas the effect of male worker was not significant. Further, there was a negative relationship between livestock income and land size, implying livestock were relatively a more important income source for small landholders. The effects of ownership of different livestock species on children's nutritional outcomes were mixed across age-

groups. Ownership of large ruminants improved nutritional status (in terms of weight) particularly of children between 2 and 5 years of age. The nutritional outcomes are affected by interplay of various factors such as child and household characteristics, etc., and the results indicated that the likelihood of children being malnourished reduced with an increase in mother's age, her educational status and household's monthly expenses.

Mapping livelihood assets of fishers of Ganga river basin

For mapping livelihood assets of fishers of Ganga basin, survey was conducted in Jharkhand, Uttar Pradesh and Bihar. The preliminary analysis revealed that the livelihood issues and assets of fishers of Ganga basin in these states are distinctive.

Jharkhand: In district Pakur, 91% of the sampled population belonged to fishermen caste (SC) with poor literacy rate. The main source of income was fishing and annual income was about ₹ 47,390. In addition they worked as labourers in stone chip mines, etc. which contributed about 44% to the total family income. Around 40% of the fishermen community members were indebted due to social obligations like daughter's marriage, etc. and their average indebtedness was about ₹ 11,000.

Uttar Pradesh: In district Varanasi the average annual income of fishers was about ₹ 42,000 and the average family size was seven. Almost all the fishermen were illiterate and due to financial constraint they were unable to send their children to schools. In district Allahabad, the average annual income from fishery was about ₹ 46,000. Only 17% fishermen had membership in fishery co-operatives society. Though fish marketing system is organized, but fish markets are not specified in Allahabad city area, this also causes lower income to fishermen.

Bihar: In district Siwan average annual income of fishers household from fisheries activities was about ₹ 60,000. Around 50% of the fishers' household have Kisan credit card. Many aquaculture farms have come up in last 3-4 years in this district. In district Saran average annual income of fishers from fisheries activities was about ₹ 48,000. Riverine fishers of Pahlejaghat do fishing in Ganga for only four months and migrate to Rihand reservoir in district Sonbhadra, Uttar Pradesh to work on wage basis. In Gopalganj average annual household income from fisheries was ₹ 53,000. Fishers involved in aquaculture generate higher income compared to riverine fishers.

Socio-economic evaluation of fishers of Torsa river: Among the important rivers of sub-Himalayan Terai region of West Bengal, Torsa is one of the major rivers and lifeline for a large number of native populations. Survey conducted by ICAR-CIFRI revealed that the fisher folk of Torsa river area have annual average family income of ₹ 46,574 and average land holdings 1.25 *katha*. Most of them have *kachha* houses.

In upper stretch from Totopara to Jaldapara, involvement of women in fishing activities is greater than men, 52% women were involved in fishing and 48% were involved in fish marketing. Fishing contributed 62% to average family income followed by livestock rearing (17%), agricultural labourer (9%), tea garden/ forest labourer (7%) and farming (5%).

In *Rabha* tribe, in addition to agriculture, considerable sections are engaged in fishing. Female are involved in community fishing with hand-made traps, called *jhakoi, tapai*, *thusi, burung,* etc. They are fond of small indigenous fishes and prawns. Fishing is integrated in their culture in the form of dance, etc.

National Marine Fisheries Census

National Marine Fisheries Census was conducted by ICAR-CMFRI. Information on fishermen population, their socio-economic, educational and occupational profile, ownership of crafts and gears, migration of fisher-folk, electronic equipment for communication and fish finding, lifesaving implements and infrastructure facilities in the marine fishing villages were collected from all the maritime states and two Union Territories of the country during February – March 2016. About 882,263 households spread across 4,057 marine fishing villages along the mainland were covered by trained enumerators. The information collected under this process will aid in facilitating formulation of fisheries related plans and policies in the marine sector.

Gender mainstreaming in marine fisheries sector

Impact assessment of 400 women self-help groups (SHGs) involved in fisheries and related activities in Kerala, Karnataka, Tamil Nadu, Odisha and Andhra Pradesh was done in terms of their 'Level of Performance' and 'Empowerment Index', and the success cases of Entrepreneurial Capacity Building of SHGs with special reference to gender perspective were documented. Under the entrepreneurial activities namely, Fertifish unit, Chinese dip net, Aqua-tourism, Fish Aggregating Devices (Social Entrepreneurship), Pickling unit, Dry fish and fresh fish procuring, Mussel culture, Quarry fish culture, Cage farming, Paddy cum fish culture and Seaweed farming the average level of performances were more than 70 and correspondingly the average empowerment indexes were also higher about 0.80 and above.

Web based online data collection system for marine fish landings

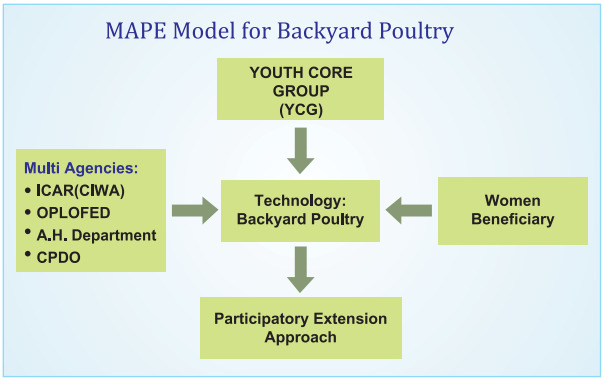
Web based online software for uploading marine fish landings data directly from landing centres/ fisheries harbours was developed. This will enable fast data transmission and estimation of species-wise, fishing gear-wise and zone-wise marine fish landings for all nine maritime states and union territories of Puducherry and Daman & Diu. The application has four components namely (i) Online data entry using PC tablets, (ii) Utilities for scrutiny of data, (iii) Analysis and estimation, and (iv) Report generation. With the GPS enabled tablets, data collection process can be efficiently monitored.

EMPOWERING WOMEN IN AGRICULTURE

Some of the women working in fields, dairies, or rearing poultry and animals in backyard may be illiterate but they are highly professional in the jobs they are involved. Realising their potential in improving the overall agriculture the extension has made the women its most coveted target audience. The Central Institute for Women in Agriculture (CIWA), Bhubaneshwar, is functioning for developing women specific technologies under different production systems.

Livelihood improvement of rural women

A Multi Agency Participatory Extension Model was tested with women perspective for sustainable backyard poultry production by involving different government agencies, Youth Core Groups (YCGs) and farm women. The roles and responsibilities of the multi-agencies were well defined. The capacity of the YCGs and the farm women was built on regular basis to enhance their knowledge and skill in the areas of care and maintenance of mother units, vaccination of the birds, their feeding and drinking, record maintaining, etc. through various skill trainings, demonstrations and exposure visits. The knowledge gain revealed that the



MAPE Model for Backyard Poultry

highest knowledge was gained by the farm women in disposal of eggs/birds (70%) followed by meaning and concept of backyard poultry (66.66%) and housing of birds (64.66%). The youth core group gained knowledge in meaning and concept of backyard poultry (78.33%), disposal of eggs/birds (78.33) and vaccination (76%). Out of eight YCG members, one woman and one man come out and independently contacted agencies (CPDO, OPOLFED, AH Department) and purchased day-old chicks (100 each), feed, vaccination, etc. to rear in mother unit. Two successful case studies were recorded under the project.

Nutrition and livelihood enhancement of tribal families

Multi-sectoral package of practices: The project was carried out to document the gendered access to assets, and researchable issues in the tribal eco-system, and to facilitate capacity building and skill upgradation through need based and sustainable interventions for improving livelihood. Two case studies were recorded on Status and Challenges in Land Rights among Tribal Women in Odisha and Gender Differences in Information Needs and Communication Behaviour among Tribal Families in Odisha. Eight field level Capacity building and skill upgradation programmes covering tribal farm families were conducted in Gajapati and Mayurbhanj districts in Odisha. Programmes organized were: Awareness creation-cum-skill upgradation programme on improved methods of vegetable cultivation; Stakeholder meeting for assessing the seed needs; Input support programme (distribution of mini kits of seeds such as beans and green leafy vegetables); and Advisory on the drudgery reducing implements and tools for harvesting, stripping, and decorticating groundnut.

Horticulture: The project aims at development of livelihood and nutritional improvement of tribal farm women in a national perspective, covering arid zones, Himalayan region and horticultural rainfed conditions with the introduction of need based basket of horticultural technologies/ varieties. The project was implemented at ICAR-CIWA, Bhubaneshwar as lead centre and with collaborating centres, viz. ICAR-Central Arid Zone Research Institute at Pali, ICAR-Indian Institute of Vegetable Research at Varanasi, ICAR-Central Institute of Temperate Horticulture at Mukteshwar, and ICAR- National Research Centre on Litchi at Muzaffarpur. The bench mark survey of the locale of study was carried out by each centre. Observations of the survey on socioeconomic conditions, gender participation, role, issues, and programmes in horticultural production system were recorded. New vegetable crops were introduced in villages through technology interventions. Existing varieties were replaceed with high yielding varieties in both main field and homestead land. Seeds of improved varieties of brinjal, tomato, chilli, okra, bitter gourd, pumpkin, ridge gourd, cluster beans, cowpea, cucumber, etc. were distributed to the stakeholders. Improved nursery raising methods like raised bed method and raising seedlings in pro-tray using coco pith were introduced among the farming community. Knowledge and skill were imparted on improved package and practices of vegetable cultivation. Pro-tray and coco pith were also distributed among adopted farmers for production of healthy seedlings of vegetables.

Livelihood and nutritional improvement of tribal farm women through horticulture

Empowerment of farm women for improved quality of life

In this project focus was on the following for improving the quality of life of farm families:

- Assessment of nutritional status of farm families, nutritional challenges faced by them and suggestive interventions for the management of malnutrition
- Introduction of drudgery reducing technologies for enhanced efficiency
- Need based technological empowerment of farm women for income generation and livelihood security.

Households from two to three selected villages were identified for conducting base line survey on health and nutritional status, resource availability, drudgery reducing activities and need assessment for income generating activities at all the four centers (CIWA, Bhubaneshwar; ATARI Zone-I, Ludhiana; ATARI Zone-VI, Jodhpur; ATARI Zone-VII, Jabalpur). At each

Empowerment of farm women for improved quality of life

collaborative centre 40 households were selected for conducting intervention and action research, and 160 households for interventions. At each centre, 40 nutrition gardens were established in this year to reduce the malnourishment problem in children and women, especially anaemia and vitamin A deficiency and focus was given on green / yellow and protein rich vegetables. Seeds of spinach, fenugreek, carrot, turnip, coriander, amaranth were distributed besides seedlings of *rabi* tomato, cauliflower. Emphasis was given to grow vegetables without using any insecticides/pesticides, and intake of such vegetables will help them improve the health status.

Gender knowledge system in agriculture

The project is being carried out in collaborative mode with partners, viz. ICAR-Central Institute of Cotton Research, Nagpur; ICAR Research Complex for NEH regions, Meghalaya; and Tamil Nadu University of Veterinary and Animal Sciences (TANUVAS), Chennai. The main objectives were to develop gender related data/knowledge bases in agriculture, to facilitate wider sharing of gendered information/ knowledge through appropriate modules and user-friendly interfaces and bring out knowledge products on various issues concerning women and agriculture. Under this project a Gender Knowledge Portal was developed.

Gender in agriculture partnership (GAP)-India: The proposal to create GAP-India hub was approved under XII Plan EFC. The goal of GAP-India is to engender agricultural research and extension for empowering women and girls, who are an important human resource in agriculture, to achieve higher level of human development and gender inclusive agricultural growth through effective institutional collaboration'.

Gender Knowledge portal

A user-friendly gender knowledge portal was developed. The portal would provide the stakeholders access to gender related information under thematic areas, viz. women friendly technology, programmes and policies, information and statistics, resources and gender based knowledge. The portal would host different databases and information capsules generated through studies under the project and compiled from other sources. The portal would provide a platform to the R&D stakeholders working on gender issues and women empowerment to share their information and facilitate cross learning among professionals. Information and databases on the portal may serve as sources of inputs for researchers in formulation of projects.

Aqua and poultry feed from fish and shellfish wastes

Fish silage was prepared from fish dressing waste, which otherwise go as waste, obtained from the local market. The suitability of fish silage to be used as feed ingredient in poultry feed was tested through experiments in layering quails, Vanaraja and broiler birds. Supplementation of acid treated fish silage up to 10% in broiler diet reduced the feed cost per kilogram weight of the bird by ₹ 5.

AICRP on Home Science

Home Science Extension and Communication Management component has projects – *Dynamics and performance of women groups in agriculture and allied sectors* and *Techno socio-economic dimensions of women empowerment*, under which data on group dynamics, activities and income generation,

entrepreneurship and empowerment status were collected from 2,832 SHGs in the selected districts of 10 states. A campaign was organized for creating awareness on kitchen and herbal gardens and vermin composting units.

Family Resource Management component has a project *Characterization of drudgery of women in the production environment and assessment of technology packages in mitigating drudgery,* in which drudgery of women was characterized for three crops and five production systems in the operational villages. Twelve technologies were refined / developed and tested. Seed cum fertilizer dibbler, rice picker, evaluation of sapling transplanter and flower harvest bag technologies were ergonomically evaluated after field interventions. Twenty-six technologies were up-scaled as per the need and for dissemination among SHG groups.

In Food and Nutrition component, under the project *Food and nutritional strategies to combat nutritional problems among farm families*, socio-economic, nutritional, clinical, knowledge and anthropometric assessment of the adolescent girls was done. A total of 2,932 school going adolescent girls out of 5,069 were screened out with haemoglobin level less than 12g /dl in rural areas. Among all the 10 centres the mean energy intake for both control and experimental group was lowest for Rajasthan centre and highest in Karnataka centre, which meets only 40.87 and 35.90% and 93.58 and 101.55%, respectively, of the Recommended Dietary Allowances. Three protein rich recipes, viz. mix pulse shev, proteimix powder, peas stick and millet and moringa powder based value added products were developed and transferred into rural entrepreneurship.

The Textile and Apparel Designing component has projects *Functional clothing to combat occupational health hazards of farm workers* and *Utilization of plant sources for textile processing*. Functional clothing kit was designed and assessed for its suitability and acceptability among workers at KVKs, *Kisan* Club, SAUs and EEU. Shopping bag, pen stand, purse, tea cozy, pot mat, coaster, file cover, seed pot etc. were prepared from *bhindi* fibre and non woven fabric.

Developing competency and management of socio-emotional problems of rural youth

Projects–*Developing competency of rural youth in agriculture through vocational intervention, and Sensitizing rural families for management of socio-emotional problems of youth*— were initiated in Human Development and Family Studies component. Out of 1,167 academically backward children from 10 centres, students from Jorhat, Hisar, Palampur, Pantnagar, Udaipur and Ludhiana showed high external resilience in case of school, home, community and peer assets. Socio-economic and socio-emotional status of 349 school dropout youth was assessed and found that children of two centres suffer from severe emotional problems and 5 centres have mild problems.A Counseling centre was established at Hatichungi Komar Gaon, AAU, Joraht.

STATISTICS

Knowledge management system for agriculture extension services in Indian NARES: The KVK Portal (http://kvk.icar.gov.in/) was developed which helps in online monitoring of Krishi Vigyan Kendras (KVKs)—reporting of major events on regular basis and submission of monthly reports online—besides providing information on different services being offered by a KVK. The forthcoming events are available on the website which will benefit farmers and rural youths in joining different training programmes at KVKs. Farmers' query will be addressed by the scientists at KVKs through this portal. Agriculture contingency plan for all the districts of India are available online. Farmers, scientists of KVKs and ATARIs, agricultural officers may register themselves and seek information related to KVKs. The website had more than 1.5 lakh hits since its launch on 8 July 2016.

Knowledge management system for agriculture extension services in Indian NARES

Estimation of area and production of horticultural crops: This alternative methodology for "Estimation of area and production of horticultural crops" was developed, tested and validated in five states, namely, Andhra Pradesh, Tamil Nadu, Maharashtra, Himachal Pradesh and Karnataka. It may be implemented at national level from 2017-2018.

Mobile Assisted Personal Interview (MAPI): The software was developed to collect the data on crop area, yield, production and other demographic and social parameters. It is available online at http://sample.iasri.res.in/ssrs/android.html, free of cost. The online data analysis software will help the user to

draw simple statistical conclusions from the data within the device just after completion of the survey.

Estimation of seed, feed and wastage ratios for major food grains: The estimates of seed, feed and wastage ratios of major food grains were obtained through a survey organized in Uttar Pradesh, Karnataka, Madhya Pradesh, Rajasthan and Odisha. It indicated that overall ratios had gone down by 4.5% approximately as compared to the factor ratios (12.5%) used since long for estimating the total availability of food grains for human consumption in the country. The results indicated that these estimates were within a reasonable degree of precision. These seed, feed and wastage ratios to the production of major food grain crops are of immense use for planning and formulation of future policies by the Government and policy makers for the economic development of the country.

KRISHI: ICAR Research Data Repository for Knowledge Management in Agriculture called KRISHI (Knowledge based Resources Information Systems Hub for Innovations) portal (http://www.krishi.icar.gov.in) was launched as a centralized data repository system of ICAR consisting of Technology and Data. This portal consists of repositories for (i) Technology, (ii) Publication, (iii) Experimental data, (iv) Observational Data, (v) Survey Data, and (vi) Geo-portal.

Several online resources available/ developed at different ICAR institutes are now accessible through KRISHI portal. Technology repository has been enriched with information related to Crop Production, Plant Protection, Soil and Water Management, Horticulture, Animal Science, Fisheries and Agricultural Engineering on popular/commercialised/ready for commercialisation technologies.

A geo-portal initiated to provide spatially referenced information on (i) ICAR Institutes/Regional Centres locations/KVKs from Zone 2 and Zone 3; (ii) Soil maps (1:1 million), slope, soil depth, soil erosion, surface texture maps; (ii) Agro-ecological regions and sub-regions; (iii) Vulnerability map and climate layers; (iv) Wind Erosion Map; (v) Crop Residue State wise data; and (vi) Fire locations related to paddy residue in the State of Punjab and Haryana. KRISHI Geoportal version is being upgraded to enable Web Map Service (WMS) for seamless importing of data layers available from other geo-portals, such as ISRO portal Bhuvan providing valuable information to policy makers and researchers.

An online software *web*FMC for the generation of symmetric and asymmetric factorial with minimally changed run sequences was developed and made available in public domain at http://webfmc.iasri.res.in. This software provides freely available solution for the researchers and students working in this area. The software can generate symmetric and asymmetric factorial with minimally changed run sequences for any parametric combinations.

Tool for comparison of protein 3D structures using elastic shape analysis: An efficient tool was developed for comparing protein 3D structure using Elastic Shape Analysis (ESA). The performance of the developed methodology was tested and found to be more efficient, i.e., running time reduced by 33-45% and the accuracy increased up to 6-10%, when compared with the existing methods. The proposed algorithm was implemented in R.

A user friendly web-based application called ProtSComp was developed using above algorithm for comparing protein 3D structures (http://backwin.cabgrid.res.in:8080/ProtSComp). The web portal has provision to either upload PDB file(s) or give the PDB ID(s) and select a model and a chain for each protein under consideration out of available models and chains. Protein structures can be compared using different criteria based on geometric and auxiliary information. Finally, result outputs can be seen in terms of geodesic distance along with optimal matching superimposed structure, which can be visualized in separate window.

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13. Information, Communication and Publicity Service

The ICAR- Directorate of Knowledge Management in Agriculture (DKMA) is mandated to act as the nodal centre of ICAR for information, communication and knowledge management related activates of the Council. This Directorate also contributes significantly as a knowledge resource centre of National Agricultural Research System (NARS) with linkages across ICAR research institutes, Krishi Vigyan Kendras, Agricultural Universities, CGIAR institutions, other scientific and educational institutions and international organizations in related fields. Besides outreach, publicity and enhancing visibility of the ICAR are other thrust areas of the DKMA. The DKMA undertook a wide range of activities including development and creation of information and knowledge products in print and electronic format; maintenance and content management of ICAR and DARE websites, ICAR pages on social media; trainings and workshops in knowledge management and communication; organization of events for showcasing ICAR technologies; library services including collection, storage, retrieval and dissemination of information; and publicity and public relation services.

The DKMA is impending two projects, viz. 'Development of e- publication system for UG/PG e-textbook' and 'KRISHI- Knowledge based Resources Information Systems Hub for Innovations in Agriculture' with support from ICAR Extramural Fund.

Social media

The Council shares the knowledge resources of ICAR with scientific community, students and public on social media platforms. The facebook page has attracted > 135,000 likes and twitter handle has 8,614 followers. The YouTube Channel of ICAR includes video films, animations, lectures/interviews by dignitaries and eminent scientists, proceedings of national and international events, etc. Some of the popular documentaries have received more than 250,000 views each. Contents for Social Media are conceptualized and developed to lay emphasis and spread awareness on Government schemes and programmes along with new varieties and technologies.

ICAR /DARE websites: During the reported period more than 1,200 new pages were created and more than 1,500 pages were updated with latest inputs. Specific weather based agro-advisories and contingency plans for agricultural activities were updated on the websites regularly to benefit farmers and extension functionaries. Crucial advisories were developed and posted from time to time in view of natural calamities.

Currently, DKMA is revisiting its strategies in the light of open access policy, quality policy and e-governance modules. The gestation period of knowledge and information products is being reduced by adopting innovative management practices and latest IT tools. Linkages are being developed with international organizations to project the Indian agricultural research on global fora. DKMA, with all its efforts, is sensitizing and catalyzing ICAR system towards a new information and communication regime ensuring outreach of agricultural research to its stakeholders. The ICAR website (www.icar.org.in) presents knowledge and information in bilingual mode (English and Hindi) for a wide range of stakeholders that include researchers, students, policy planners, farmers and civil society. The website is updated regularly with news, success stories, announcements, circulars, tenders and other relevant content. Currently, on an average more than three lakh hits per month from visitors across the globe are recorded with a significant percentage of new visitors. The ICAR website was updated on regular basis, 1,285 new pages were created, and 5,282,012 visitors (2,539,352 unique visitors) from 221 countries visited the website from across the globe; the top five countries include India, United States of America, Union Arab Emirates, United Kingdom and Phillipines.

E-publication platform

The ICAR website also hosts e-publishing platform textbooks (http://epubs.icar.org.in/ebooks) of the Council that includes e books, catalogue of textbooks, etc. The

on-line availability in Open Access mode has enhanced visibility and improved the global reach. The top ten countries those read ICAR literature are China, Iran, Turkey, USA, Pakistan, Egypt, Mexico, Brazil, Philippines and Indonesia. Research journals have about 20,000 registered readers and total registered users on the e-publishing platform of research journals are more than 75,000. In all the epubs platform Indian Agricultural research journals (http://epubs.icar.org.in/ejournal) hosts 36 research journals published by the Council or professional societies in agriculture. Viewership analysis revealed that on this portal—total sessions were 253,376 by 139,865 users, and they viewed 1,459,581 pages in 188 countries. Open access archives pertaining to the *Indian Journal of Agricultural Sciences, Indian Journal of Animal Sciences, Indian Farming* and *Indian Horticulture* have 511 issues with more than 13,000 articles. Two abstracting journals, i.e. *Indian Agricultural Sciences Abstracts* and *Indian Animal Science Abstracts* were published half-yearly by DKMA.

Trainings and workshops

A joint workshop on 'Communication and Knowledge Management in Animal Science Research and Development' was organised with the International Livestock Research Institute, Kenya. Write-Workshops were also organized to motivate and train young authors in scientific writing. Trainings on 'Online article processing' and editorial assistance were provided to various various stakeholders for printing and publishing of scientific on-line journals.

Knowledge and information products

The Council publishes twelve regular publications that include research journals, semi-technical (popular) periodicals and in-house newsletters (eight in English and three in Hindi). Review articles from leading experts appear as a regular feature in research journals. Accent issues and special issues of semi-technical periodicals were brought out on topical themes these include 'Small Millets' and 'Agronomy for Sustainable Management of Natural Resources, Environment, Energy and Livelihood Security to achieve Zero Hunger Challenge' (*Indian Farming*, March and November 2016, respectively); and 'Vegetables for nutritional and livelihood security' and 'Doubling farmers income through Horticulture' (*Indian Horticulture,* January-February; and November-December 2016) respectively. In addition, nearly 110 publications were brought out in English and Hindi as technical books, monographs, textbooks, handbooks, technical bulletins, brochures etc.

Special emphasis was given on bringing out the publications in Hindi to cater the farmers and other stakeholders for dissemination of information about the new technologies, scientific farming and other related issues. Several special issues of the popular monthly Hindi magazine *Kheti* were published during this period, including special issues on *Antarrashtriya Dalhan Varsh-2016, Safalta Gatha Visheshank,* A booklet in Hindi *Avashist se Sampada* which was compiled based on the technologies related to recycling and processing of agricultural waste. Leaflets published by various ICAR institutes were edited and republished for distribution in *Krishi Unnati Mela*, 2016.

ICAR as the national input center for the AGRIS database of FAO, prepared and supplied 2,000 inputs to FAO in WebAgris software to enable on-line search by users. Training programmes were organized on data indexing and preparation of input for AGRIS database for the participants from ICAR Institutions and Professional Societies.

Documentary films for creating awareness among farming community were produced by DKMA, i.e. '*Grand Groundnut - A film on success story of groundnut in India', 'Fisheries for small farmers'* and *'Genetic diversity of rice for food security'*. A short-film based on the interviews of beneficiary farmers was also launched during this period.

Showcasing of new technologies

The Council organized and participated in 16 exhibitions for the showcasing of new technologies on the occasion of national and international events, and sale of ICAR publications and e-products (January-December 2016). Notable exhibitions in which ICAR participated are: *India International trade Fair 2016, Vibrant Gujarat 2017, Agrovision 2016,* and *India International Science Festival.*

Consortium for e-Resources in Agriculture

The Consortium for e-Resources in Agriculture (CeRA) provided online access to scholarly literature by making available over 3,800 research journals to scientists, students and research scholars of 152 member institutions including ICAR research institutes and agricultural universities across the country. During the period over 25 lakh full text articles have been downloaded by member institutions of CeRA and over 4,000 Document Delivery Requests were successfully fulfilled by member libraries. To create awareness among scientists/ faculty/ students of member istitutions of CeRA, region-wise training-cum-awareness workshops were organized for western region at Navsari Agricultural University, Gujarat on 8 October 2016. Over 60 participants from 29 member institutions/SAUs of CeRA participated. The participants have also provided feedback and made suggestions for improvement in access of online journals.

In 2016, DKMA has initiated the steps for making CeRA as a complete e-Resources platform for researchers by making arrangements for introducing E-books (Elsevier) and other useful e-Resources/ databases, i.e. Indiastat/ Indiaagristat and ISO standards. Besides, 84 new scientific Journals from Wiley are being subscribed for CeRA in 2017. ❑

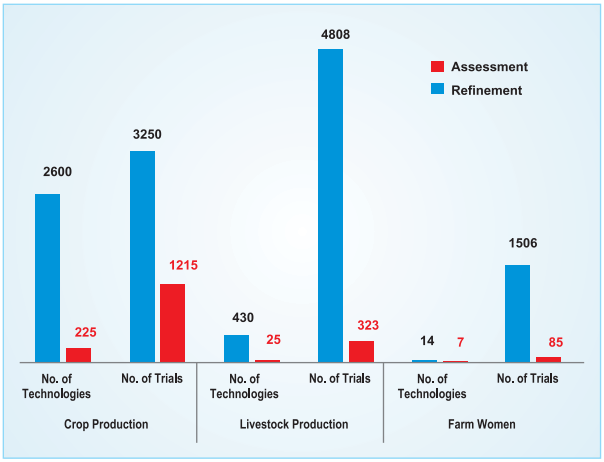
14. Technology Assessment, Demonstration and Capacity Development

Krishi Vigyan Kendras (KVKs) play very important role as frontline extension system and are mandated mainly for technology assessment and demonstration for its application and capacity development under different farming situations across the country. During the reported year, 20 new KVKs were opened taking the total number of KVKs to 662 in the country. The major activities of KVKs are conducting on-farm trials (OFTs) to identify location specific technologies in various farming systems; frontline demonstrations (FLDs) for exhibiting the production potential of the technologies and skill-oriented training for farmers, farm women, rural youth and extension personnel. To show the potentiality of technologies, KVKs provide technological inputs, information and knowledge, and also serve as the knowledge and resource centre at the district level in the country.

Technology assessment and refinement

Assessment: During the reported year, 2,600 technology interventions were assessed across 3,250 locations by laying out 21,868 trials on the farmers' field on various crops under different thematic areas, viz. cropping systems, disease management, drudgery reduction, farm machineries, integrated crop management, integrated disease management, integrated nutrient management, integrated pest management, integrated weed management and varietal evaluation for cereals, pulses, oilseeds, fruits, vegetable crops and commercial crops.

In livestock, 430 technology interventions across 583 locations covering 4,808 trials on animals under the thematic areas of disease management, evaluation of breed, feed and fodder management, nutrition management, integrated farming systems, production and management, processing and value addition were taken up for assessment. The major livestock species covered were cows, buffaloes, sheep, goats, poultry birds, pigs and fisheries.



Technology assessment, refinement and demonstration

As many as 14 technologies related to rural women were assessed at 183 locations through 1,506 trials under the thematic areas of drudgery reduction, health and nutrition, processing and value addition, energy conservation, small-scale income generation, and storage techniques. The major enterprises included were mushroom cultivation, vermi-compost production, nutritional gardens, processing of fruits and vegetables etc.

Refinement: Total 225 technological interventions were refined across 254 locations by laying out 1,215 trials in the farmers' fields under various thematic areas, viz. cropping systems, farm machineries, integrated crop management, integrated disease management, integrated farming system, integrated nutrient management, integrated pest management, integrated weed management, processing and value addition, resource conservation technologies and storage techniques. The major crops included cereals, pulses, oilseeds, fruits and vegetables.

Besides, 25 technological interventions at 32 locations were also refined through 323 trials on livestock, poultry and fisheries enterprises under the thematic areas, viz. disease management, feed and fodder management, nutrition management and production and management. The major livestock enterprises included were cows, buffaloes, poultry birds, sheep, goats, and fisheries.

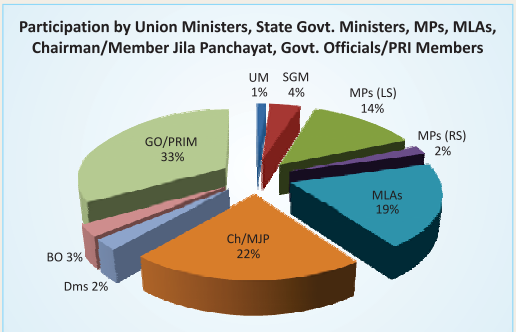
In addition, seven women specific income generating technologies were also refined by conducting 85 trials in 10 locations under the thematic areas, viz. drudgery reduction, health and nutrition, processing and value addition.

Frontline demonstrations

During the reported period, 129,678 demonstrations covering an area of 42,145 ha were organized to demonstrate the production potential of the newly released improved varieties/production technologies in crops/animal husbandry and other agricultural enterprises. Of these 117,659 (90.73%) demonstrations covering an area of 40,906 ha were on cereals, millets, oilseeds, pulses, commercial crops, fiber crops, spices, medicinal plants, plantation crops, fodder crops, horticultural crops etc.

Awareness on Soil Health

The KVKs across the country celebrated World Soil Day on 5 December 2015. Soil Health Cards were distributed by 599 KVKs. The farmers were sensitized about soil analysis, and that application of inputs are taxing on soil health as well as monetary losses. In these programmes, more than 1.62 lakh soil health



Praticipation by Union Ministers, State Government Ministers, MPs, MLAs, Chairman/Member Jila Panchayat, Government Officials/PRI Members

cards were distributed to the farming community. Public representatives, 7 Union Ministers; 26 State Government Ministers;107 MPs; 131 MLAs; 147 Chairmen/Members of Zila Panchayats, 17 District Collectors, 19 bank officers, 225 Government Officers and PRI Members, besides more than 2,500 scientists participated in the programme. On this occasion, 352 exhibitions were also organized by KVKs to create awareness on improved technologies and soil health card based application of the fertilizers in the fields.

Harvesting rainwater for yielding dividends in NEH region

Under National Innovations in Climate Resilient Agriculture (NICRA) project, the KVK, Tura assessed the water related problems in West Garo Hills district of Meghalaya, and ventured into popularizing low-cost rainwater harvesting structure (*Jalkund*) for harvesting of rainwater during the rainy season and its subsequent use during dry periods. In these *Jalkunds* of size - 5× 4× 1.5 m^3, low cost raw material

like pond line HDPE Silpaulin was used. Each *Jalkund* has a water storing capacity of 30,000 litre. Farmers are earning the net return of ₹ 107,500 from 2,000 m^2/year by raising nursery of cauliflower, cabbage, tomato, radish, knolkhol, etc and selling the vegetables and seedlings.

Cereals: A total of 25,285 demonstrations covering an area of 9,666 ha were organized on rice, wheat, maize, barley etc. The yield increase of about 30% was observed in the demonstration plots over the farmers' practice. The average yield advantages for these crops were 30, 25, 35 and 28%, respectively.

Millets: A total of 3,115 demonstrations in an area of 1,114 ha were organized to show the production potential of millet crops, viz. sorghum, barnyard millet, finger millet, pearl millet etc. The average yield advantages for these crops were 36, 35, 26 and 41%, respectively.

Oilseeds: During the reported year, 22,804 demonstrations were conducted in oilseed crops, which included groundnut, sesame, soybean, castor, linseed, niger etc. in about 9,704 ha. The average yield advantage was 35, 40, 44,19, 51 and 38%, respectively. About 37% overall average yield increase was observed in the demonstration plots over the farmers' practice.

Pulses: Under demonstrations of various pulse crops about 37% overall increase in the yield was observed in 38,445 demonstrations covering 13,944 ha during the reported period. The pigeon pea, black gram, lentil, field pea and green gram were demonstrated. The average yield advantages for above crops were 37, 42, 37, 57 and 32%, respectively.

Commercial crops: Under commercial crops, 2,432 demonstrations were conducted in 912 ha. Of these, 1,542 (64%) demonstrations covering an area of 533 ha were covered under cotton crop and rest under sugarcane and potato crops. In cotton crop, 18% increase in yield was observed over the farmers' practice. The average yield advantages for sugarcane, potato and cotton crops were 35, 43, and 19%, respectively.

Fodder crops: FLDs on fodder crops like berseem, sorghum, maize etc. were conducted in 327 ha in 2,207 demonstrations. The average yield advantages for these crops were 22, 41 and 34%, respectively.

Horticultural crops: Demonstrations (16,718) organized on horticultural crops were: 13,626 in vegetable crops, 2,408 fruit crops, 495 flower crops, and 189 in plantation crops. The yield advantage was recorded up to 34% in fruit crops. The average yield advantages for above crops were 33, 34, 35 and 49%, respectively.

Hybrids: Production potential of hybrids (cereals, commercial crops, fodder, vegetables, millets, oilseeds such as mustard etc.) was exhibited through 3,446 demonstrations on 1,239 ha by 482 KVKs. The average yield increase was 25% in cereal crops, while 19% for cotton. In demonstration of fodder crops, the yield increase was 20.33% in hybrid Napier, while 22% in pearl millet hybrids over existing varieties. In papaya hybrid demonstration, 44% yield gain was recorded in demonstration plots over farmers' practice. Highest yield advantage of 57% was recorded in beans.

Farm mechanization: To showcase the effective and efficient use of improved tools and implements, 2,493 demonstrations were conducted on farm operations like planting/sowing (896), post-harvest operations (344), weeding (420), plant protection (60), harvesting and threshing (294), and land and seed bed preparation (479).

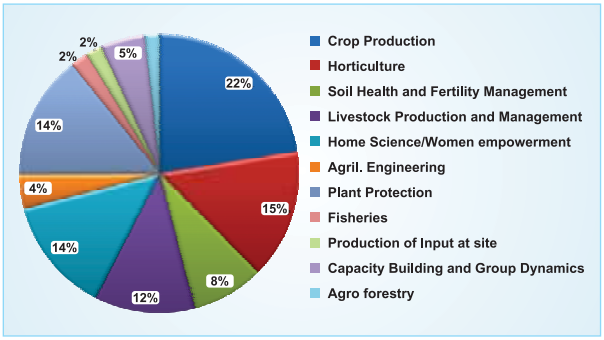
Livestock and fisheries: Large number of demonstrations (6,080) were conducted covering 5,676 dairy animals, 1,508 sheep and goats, 3,079 backyard poultry units, 56 ducks units, 20 pig units, 2 rabbit units, and 462 units of fisheries.

Other enterprises: Farmers (896) and farm women (68) were involved in conducting demonstrations on beekeeping (50), sericulture (30), oyster mushroom production (113), vermi-compost production (531), button mushroom production (214), nutrition gardens (905) and value addition (97).

Capacity development

As many as 48,983 training programmes were organized through which 13.21 lakh farmers/farm women, rural youth and extension personnel were benefited.

Farmers and farm women: For the benefit of 10.42 lakh farmers and farm women, 37,612 training courses were organized on various technologies to update their knowledge and skills. These courses were on productivity enhancement of field crops (22%), horticultural crops (15%), empowerment of rural women (14%), plant protection (14%), livestock production



Subject wise training programmes for farmers and farm women

and management (12%), soil health and fertility management (8%), farm machinery, tools and implements (4%), capacity building and group dynamics (5%), production of input at the site (2%), fisheries (2%), agroforestry (2%) and others (2%). Out of these courses, 33% were conducted on campus (12,654) and 67% were organized off-campus (24,958). The participants included 2.56 lakh farm women in the crop production training. Among the crop production technologies, about 22% of the training courses were on integrated crop production technologies, followed by weed management (9%) and seed production (15%). Out of 5,659 training courses on horticulture, 3,091 were on vegetable crops, 1,577 fruit crops, 285 spice, 259 ornamental, and 115 courses on medicinal and aromatic crops.

Rural youth: Skill-oriented vocational training courses (7,118) were organized for 1.74 lakh rural youth, including 54,232 young women (31%) during the reported year. These courses were on integrated farming, mushroom production, value-addition, dairy farming, seed production, vermi-culture, nursery management of horticultural crops, beekeeping, protected cultivation of vegetables, repair and maintenance of farm machineries and implements, sheep and goat rearing, poultry production, production of organic inputs and small-scale processing.

Extension personnel: Capacity development programmes (4,253 courses) were conducted for 1.042 lakh extension personnel, out of which 22,889 (22%) were women participants. These courses were organized for extension functionaries working in government and non-government organizations who were directly or indirectly related with the development of agriculture and allied sectors.

Sponsored training: A total of 5,358 sponsored training courses were conducted benefiting 2.59 lakh farmers and farm women, rural youth and in-service extension personnel. The sponsored courses covered on-site input production, economic empowerment of women, processing and value-addition, methods of

Punjab- Marching forward with Direct Seeded Rice

District Muktsar of Punjab has set an example in large-scale adoption of Direct Seeded Rice (DSR) technique. Starting with 900 farmers three years ago, the area under DSR in the district has now increased up to 28,000 ha, which is 25% of total area under DSR in Punjab. DSR technology decreased—use of water (saves 4-5 irrigations), solved the problem of labour shortage particularly during transplantation of paddy, took 7-8 days less for maturity, and the yield was at par with manual transplanting. The paddy growers of district Muktsar could save approximately ₹ 8.25 crore by adoption of DSR technology (₹ 3,750/ha). Besides, the DSR technology saved irrigation water up to 20-25%.

Zero tillage of vegetable pea in rice fallow: Sikkim

The East Sikkim district of Sikkim is climatically vulnerable and mostly affected by acute scarcity of water during *rabi*. Zero tillage of vegetable pea cultivation was evaluated and compared with mono-cropping system of rice cultivation and fallow after the harvesting of *kharif* rice. Since, there was no rain throughout the cropping period, the growth and yield parameters in vegetable pea were better in zero tillage than conventional tillage due to residual soil moisture after rice harvest.

As a result, farmers are getting 13% higher green pod yield under the resource conservation practices over the traditional practices. The resource conservation technology of vegetable pea cultivation in the rice fallow also enhanced the cropping intensity of the area to the tune of 150 to 155% and income increased by 18.57% over the traditional practice.

protective cultivation, farm machinery tools and implements, fisheries management, household nutritional security, animal nutrition management, animal disease management, drudgery reduction of women and fisheries.

Extension programmes

For creating awareness among farmers about improved technologies and to provide timely advisory to farmers, KVKs organized different extension programmes. A total of 4.69 lakh extension programmes/ activities in the form of advisory services, diagnostic and clinic services, celebration of important days, exhibitions, exposure visits, ex-trainees *sammelan*, farm science club conveners' meet, farmers' seminar, farmers' visits to KVK, field days, film shows, group meetings, *kisan ghosthi, kisan melas*, lectures delivered as resource persons, *mahila mandal* conveners' meetings, method demonstrations, plant/animal health camps, scientists' visit to farmers' field, self-help group meetings, soil-health camps, soil-test campaigns, workshops and others were organized which were attended by 198.67 lakh participants of which 191.29 lakh were farmers and 7.38 lakh extension personnel. The KVKs also organized 1.95 lakh other extension programmes through electronic media in the form of TV programmes, radio talks, CDs/DVDs, and print media, viz. extension literature, newspaper coverage, popular articles, leaflets, folders and books/booklets to have wider coverage in the districts.

Production of technological products

KVKs produced large quantity of technological products like seeds and planting materials of improved varieties and hybrids, bio-products and elite species of livestock, poultry and fish which benefited 15.43 lakh farmers in the country.

Seeds: During the year, 3.39 lakh quintal seeds of improved varieties and hybrids of cereals, oilseeds, pulses, commercial crops, vegetables, flowers, fruits, spices, fodder, forest species, medicinal plants and fiber crops, were produced and provided to 3.06 lakh farmers.

Planting materials: In all, 820.31 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 10.84 lakh farmers.

Bio-products: Bio-products like, bio-agents, bio-pesticides (609 q), bio-fertilizers (5,509 q), vermi-compost, mineral mixture etc. were produced and supplied to 1.32 lakh farmers.

Livestock, poultry and fingerlings: Improved breeds of cow, sheep, goat, buffalo and breeding bull were produced and supplied to 1,465 farmers. Different strains/breeds/eggs of poultry birds (chickens, quails, ducks and turkey) were provided to 15,026 farmers. Improved breeds of pigs were provided to 565 farmers. KVKs also enabled 56 farmers to establish rabbit rearing units by providing rabbits. A total of 655.38 lakh fish fingerlings were produced and supplied to 2,670 farmers.

Broiler duck: The golden bird for Sunderban area

Broiler ducks (Pekin) production, having more tolerance to climatic aberrations, now-a-days, is considered as a profitable venture for the unemployed youth of Sundarban. The entrepreneurs usually maintain stock in 200 birds/batch with a gap of 7 days up to maximum 10 batches/ year. Total period of cultivation is 60 days within which one single duck gains the body weight of 2.8 to 3.2 kg with an average dressing percentage of 68. The cost of cultivation is ₹ 210-215/ duck for the entire period. The average benefit is ₹ 185-190/ duck. Incidence of disease is minimum and only 1-2% of paralytic symptom is observed. Ducks are raised in open-sided naturally ventilated sheds. The droppings of the bird are utilized to produce good quality of compost, which is afterwards used for agri-horticultural fields and the washed out shed water is directly connected with fish pond by which the cost incurred for fish feed is substantially reduced. Daily cleaning of house along with three times watering is highly essential for keeping the farming profitable.

Soil, water and plant analysis

A total of 6.35 lakh samples (comprising 5.73 lakh samples of soil, 0.57 lakh of water, 0.05 lakh of plant, and 0.002 lakh of manure) were analyzed benefiting 6.43 lakh farmers belonging to 0.73 lakh villages and revenue generating to the extent of ₹ 336 lakh.

Technology week

Technology week, under public-public and public-private partnership mode, was organized by KVKs benefiting 20.60 lakh farmers, farm women, extension personnel, rural youth and members of self-help groups. The events also included 25,223 extension activities such as seminars, demonstrations, film shows, field visits, exhibitions and scientist-extension personnel-farmer interactive sessions.

Mobile advisory

Mobile advisory was provided for timely and need based information to the farming community. During the reported year, 557 KVKs were involved in this service through various service providers. Information on weather, market, various farm operations, outbreak of pest and disease incidence and their control measures were given to farmers through Short Message Service (SMS). As many as 56,107 SMSs were sent to benefit 155.22 lakh farmers on various aspects of agriculture, horticulture and animal husbandry, weather forecast, and pest and disease.

Technology demonstration for harnessing pulses productivity

A total of 36,361 demonstrations on 14,544.24 ha were laid out on mung bean (2,824.4 ha), urd bean (720 ha), chick pea (5,515.4 ha), field pea (2,024.6 ha), rajma (21 ha) and lentil (3,438.84 ha) with full package of practices showing productivity gains of 35 to 45% over local check.

For 2016-17, demonstrations (77,500) were planned on important pulse crops. During *rabi* 2015-16, yield of chickpea was 14.93 q/ha, lentil 10.50 q/ha, field pea 18.65 q/ha, mung bean 10.24 q/ha, urd bean 7.50 q/ha and rajmash 14.78 q/ha. These yield gains were significantly higher i.e., 54.23, 69.96, 55.54, 30.44, 38.88% and 46.62%, respectively, for above crops over farmers' practices. Pulses seed hubs (97) are also being established at KVKs for producing quality seeds in participatory mode involving farmers with effective processing and storage facilities.

Demonstrations on climate resilient technologies

Under the Technology Demonstration component of National Innovation in Climate Resilient Agriculture, 98,504 farmers were covered in 151 villages of 121 districts. Integrated packages of proven technologies were demonstrated in at least one village of every selected district for adaptation and mitigation of the crop and livestock production system to climate vulnerability. During the reported year, 121 KVKs carried out 31,354 demonstrations on natural resource management covering 8,728 ha; 17,261 demonstrations on crop production technologies covering 4,696 ha and 8,728 demonstrations on fodder and feed production covering 1,006 ha area. Besides, 41,265 animals/birds belonging to 25,354 farmers got benefited from the demonstrations related to livestock and fisheries. Capacity-building interventions and the extension activities like exposure visits benefited 1.28 lakh farmers.

Capitalizing the fragrance of Jasmine in Maharashtra

Floriculture or *Fulsheti*, has emerged as an alternative source of livelihood for small- and marginal-farmers of Palghar district of Maharashtra over the years. The income from floriculture, however, was very low due to fragmented land holdings and poor management practices followed. An improved jasmine cultivation model which included fertilizer management, spraying of water soluble fertilizer and low cost drip irrigation system in place of flood irrigation was demonstrated. The floriculture model gained quick acceptance by the tribal farmers because of low resource requirement, ease of management and good access to markets. The model includes cultivation of 200 jasmine plants on 500 sq. m (0.05 ha) of land, with an investment of ₹ 3,000. The yield of jasmine increased by 34% due to improved nutrition management and drip irrigation. A net income of ₹ 27,000 was realized from 0.05 ha area (500 m^2) in this method. Now 1,904 farmers are involved in floriculture as an income-generation activity in Palghar district. Collective marketing of the flowers fetches ₹ 55,000 to 60,000 annually to each member of *Eklavya Pushpa Utpadak Sangh*. Not only has this money helped improve the quality of life, education and health of the farmers, but also helped them build their asset base by constructing homes and wells, buying vehicles and other agricultural implements to aid floriculture.

Commercial nursery raising of onion: A viable option for Doon Valley

Realizing the importance of onion crop in Doon Valley, the KVK, Dehra Dun produced about 18 q seedlings and supplied to the farmers of three tribal blocks of Dehra Dun during the last year. This particular variety gave up to 340 q/ha yields on the farmers' fields. Its keeping quality was also very good as compared to local varieties. The bulb size, compactness and pungency content were also widely acceptable to the farmers. About 100 ha area was covered under Agri-found Light Red variety in Doon Valley with the intervention of KVK, Dehra Dun. Gradually, Agri-found Light Red variety has been popular in several districts of Uttarakhand as a potential variety for commercial-seedling raising. The technique of nursery raised under poly-tunnel has also attracted the attention of farmers. Farmers are raising good quality nursery of onion and other vegetable crops and getting premium price from the vegetable production and nursery.

Technological backstopping

The Directorates of Extension Education (DEEs) of SAUs/CAUs organized 253 capacity development programmes for updating the technical know how of 4,869 staff of KVKs. The Agricultural Technology Application Research Institutes (ATARIs) upgraded the knowledge and skills of 5,009 staff of KVKs by arranging 105 capacity development programmes at various SAUs and ICAR institutes.

Besides, DEEs also organized 268 workshops and meetings for effective implementation of programmes of KVKs. The officials of these directorates made 1,961 visits to the KVKs during scientific advisory committee meetings, field days, technology weeks, workshop/ seminar, training programmes etc. to review and monitor the activities of KVKs in the operational areas of

Protected cultivation of Rose fetches higher return

Shri Gajendra Nayke, resident of village Sirsoda, Burhanpur has become protected rose cultivator with the intervention of KVK, Burhanpur. Production of different field and horticultural crops on his farm was decreasing due to extreme weather situation and consequently income per unit area was also decreasing. As an alternative, he opted for cultivating rose under protected environment. In 1,000 sq.m.

polyhouse, by adopting all improved packages for rose cultivation, he is harvesting fresh rose @650 kg/day regularly for 240-250 days a year. His net income is ₹ 5.93 lakh with a B:C ratio of 5.94 through rose cultivation in poly-house from 1,000 sq.m. area as compared to ₹ 64,650/ha from field crop cultivation under open condition.

respective directorates. They also made1,871 field visits to review and monitor activities at farmers' fields like on-farm trials, frontline demonstrations, farmer-scientist interaction and exhibitions. These directorates also provided technological backstopping to KVKs by making available high quality technology inputs and products like seed to 238 KVKs; planting materials to 169 KVKs; bio-products to 143 KVKs; livestock breeds to 43 KVKs; livestock products to 49 KVKs; poultry breeds to 180 KVKs; and poultry products to 27 KVKs. The DEEs published 124 technology inventories for the benefit of farmers and other stakeholders.

Agricultural Technology Information Centre

Forty-seven Agricultural Technology Information Centers (ATICs) in the country served as single window delivery systems by providing technology information, technology services and technology inputs to the farmers. In all, 4.67 lakh farmers visited the ATICs for the technological solutions during the reported year. Technological information was provided to about 4.59 lakh farmers, both through print and electronic media. Farmers (3.66 lakh) got quality technological inputs namely 39,648 q seeds, 16.08 lakh planting material, 11,052 livestock, 0.72 lakh poultry birds and 951.31q bio-products.

Pradhan Mantri Fasal Beema Yojana

The Government of India has initiated *Pradhan Mantri Fasal Beema Yojana* (PMFBY) across the

country for ensuring risk safeguarding from the damages caused to farmers owing to natural vagaries. Under this scheme, farmers need to pay a very low premium for insuring their crops which will be 2% for *kharif* crops, 1.5% for *rabi* crops and 5% for commercial and horticultural crops. The remaining amount of the premium will be borne by the Government of India.

Shri Radha Mohan Singh, Union Minister for Agriculture and Farmers Welfare, inaugurated Farmers

Backyard poultry as a group activity for tribal farmers in Maharashtra

The tribal farmers in Satpuda hill ranges of Nandurbar, Maharashtra, are primarily agrarian but depend on livestock and poultry too as secondary source of income. The productivity of local breeds of poultry is low (0.60-0.75 kg/bird) and farmers were unaware of improved poultry management practices too. To sustain the activity of backyard poultry in the tribal belt, group approach was encouraged by KVK, Nandurbar through skill-based vocational training of rural youth. They were provided skills on building poultry sheds by utilizing local material like bamboo, *kadbi*, local grass and wood; homemade feed preparation from locally available grains like maize, *jowar, bajra*, rice bran, *dal chunni*, area specific mineral mixture etc., scientific poultry rearing practices and group marketing. The three tier system comprising brooding at KVK, rearing at farmers' level and group marketing by farmers ensured sustainability of the backyard enterprise in the district and enhanced livelihood security to the tribals. At present, 247 tribal families are maintaining backyard poultry in Nandurbar district and getting benefited from this innovative group approach.

Precision farming of vegetables and cotton

Precision farming technologies for cultivation of chllies and brinjal, and drip and fertigation techniques in cotton is getting popularized in Shivagangai,Tamil Nadu. Shri G. Ganesan is its classic example who learned precision farming techniques from the KVK in the district. On receiving the technology and techniques he had set out a unit to produce 500,000 protray seedlings of chilli and brinjal in every season and supplying the same not only to the farmers of Shivagangai district, but also to the nearby districts. He is earning a net return of ₹ 2.5 lakh/ha in chillies and ₹ 2.0 lakh from cotton cultivation through drip and fertigation system. With the efforts of the KVK, precision farming has spread to about 3,600 ha in Shivagangai and farmers have collectively undertaken market linked production of various commodities.

Fair on *Pradhan Mantri Fasal Beema Yojana* at KVK, Motihari, East Champaran, Bihar and briefed about PMFBY to the farmers and also explained benefits of different government schemes of Union Government, viz. *Pradhan Mantri Krishi Sinchai Yojana, Soil Heath Card Scheme, Paraparagat Krishi Vikash Yojana* etc. During 2016-17, total 525 KVKs across the country organized this event with the participation of 34 Union Ministers; 26 Ministers of respective State Government; 288 Members of Parliament (MP); and 207 Members of Legislative Assembly (MLAs). These functions benefited more than 3.12 lakh farmers and farm women across the country.

Jai Kisan–Jai Vigyan Week

'*Jai Kisan-Jai Vigyan*' week was celebrated by each KVK between 23 and 29 December 2016 and different programmes were organized including *gosthies*, visits, exhibitions, interactions etc. Besides, pre-*kharif* and pre-*rabi kisan sammelans* were organized by 369 and 374 KVKs, respectively, for better planning and Farmers' participation ensuring timely dissemination of knowledge and information, flow of technological inputs and effective crop management strategy.

Jai Kisan–Jai Vigyan week celebration

ARYA

The Division of Agricultural Extension launched ARYA (Attracting and Retaining Youth in Agriculture) project in 25 districts of 25 states to train youth in entrepreneurial activities. In each of these districts 200-300 youth are being empowered to establish their income generating units and work as model for other youth in the villages. Under this project 5,000 youth are being empowered through KVKs.

Mera Gaon-Mera Gaurav

The scientists of NARES working with SAUs and ICAR Institutes are engaged in enhancing direct interface of scientists with farmers under *Mera Gaon– Mera Gaurav* initiative. The objective of this initiative is to provide farmers with required information, knowledge and advisories on a regular basis. It will also provide regular feedbacks to research institutions for conducting relevant researches. During the reported year, 10,712 villages were regularly visited by scientists who provided advisory to the farmers. Each group of scientists (four scientists in one group) is in contact of five villages and thus, enhancing the reach of ICAR to farmers.

KVK Portal

'Krishi Vigyan Kendras Knowledge Network' portal was launched on 8 July 2016, for regular monitoring of KVKs and to provide information and advisories to the farmers. It is a dynamic portal having read and write facility. Farmers and other stakeholders can get information related to facilities and services at KVKs, weather and market related information, past and forthcoming events and details of the programmes. ❑

15. Research for Tribal and Hill Regions

Specific technologies are required for the tribal and hill farmers of unique ecosystems of the Himalayas and Islands of Andaman and Nicobar. The research institutes located in north-west Himalayas (Vivekanand Parvatiya Krishi Anusandhan Sansthan, Almora), the north-east Himalayas (ICAR Research Complex for NEH Region, Umiam), and Andaman and Nicobar Islands and Goa (Central Island Agricultural Research Institute, Port Blair and ICAR Research Complex for Goa) are engaged in area-specific research.

NORTH-WEST HIMALAYAS

ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, caters to the agricultural research needs of the north-western Himalayan states of Uttarakhand, Himachal Pradesh and Jammu and Kashmir. The salient accomplishments during the period under report are presented hereunder.

Varieties notified

Maize: Central Maize VL Sweetcorn 1 (FSCH 18) is the first public sector bred sweetcorn single-cross hybrid recommended for North Western and North Eastern Hills, Punjab, Haryana, Delhi, Western Uttar Pradesh, Karnataka, Tamil Nadu, Telangana, Andhra Pradesh, Gujarat, Rajasthan, Chhatisgarh and Madhya Pradesh. It recorded an average green cob yield of 10,847 kg/ha across four zones when harvested between 70 -77 days depending on altitude. The hybrid possesses a TSS% range of 15.5-16.0.

Central Maize VL Sweet Corn

Rice: VL *Dhan* 156 (VL 7620, IET 20955) was released for June sown rainfed uplands of Uttarakhand hills and valleys. Average yield of the variety is 2,426 kg/ha and maturity is in the range of 115-120 days. It possesses resistance against leaf and neck blast, brown leaf spot, sheath rot, leaf scald and false smut diseases.

VL *Dhan* 156

Finger millet: VL *Mandua* 348 (average yield 1,877 kg/ha) was released for cultivation in Uttarakhand hills. The variety is tolerant to lodging and its light copper colour grains are preferred by the farmers. VL *Mandua* 348 showed resistance to both neck and finger blast.

VL *Mandua* 348

Soybean: VLS 77 variety is recommended for Uttarakhand state and average yield is 1,970 kg/ha under organic mode. Its average maturity duration is 117 days and it is moderately resistant to frog eye leaf spot and pod blight. VLB 201 high yielding *Bhat* (black soybean) genotype has an average yield of soybean 1,642 kg/ha under organic mode and is recommended for Uttarakhand state. It is highly resistant against frog eye leaf spot, target leaf spot and moderately resistant to pod blight.

VL *Bhat* 201

VLS 77

Wheat: VL *Gehun* 953 a high yielding wheat variety was released for timely sown irrigated organic conditions of Uttarakhand hills as well as timely sown irrigated conditions of Uttarakhand Plains. It has an average yield potential of 3,341 kg/ha in hills and 4,474 kg/ha in Plains. The variety possesses high degree of resistance to yellow and brown rust.

VL *Gehun* 953

Barley: VLB 94 a high yielding disease resistant barley variety having an average yield potential of 1,830 kg/ha was released for cultivation under timely sown rainfed organic condition of Uttarakhand hills. VLB 94 is resistant to yellow rust and stripe disease of barley. It has medium sized (35 g Test weight), hulled yellow color grain.

VLB 94

Biodiversity among zinc solubilizing bacteria: Bacterial isolates (83) were isolated from rhizosphere/ rhizoplane/ endorhizosphere of wheat cultivars and screened for zinc solubilization. Three isolates W5Rp75, W4Rp74 and W2Rs25 showed maximum Zn solubilization in 0.5% of ZnO, $ZnCO_3$ and $Zn_3(PO_4)_2$

amended minimal medium. In LB broth with tryptophan, 5 bacterial isolates showed IAA production in the range of 0.103-0.165 µg/ml after 42 hr of incubation at 28ºC. All the isolates were able to grow at temperatures 4, 15, and 28ºC with optimal growth at 28ºC. Three isolates (W5Rs70, W4ERs71 and W3ERs78) were able to tolerate salt concentration up to 8%. Ten isolates selected from the above experiments, were characterized on the basis of morphological, physiological and biochemical characteristics. The composite dendrogram revealed that isolate W1ERs55 and W4Rp44 showed maximum diversity among the elite PGP bacterial isolates and isolates W3ERs78, W5Rs70, W4Rp77 and W2Rs25 showed maximum diversity among the 10 elite PGP bacterial isolates.

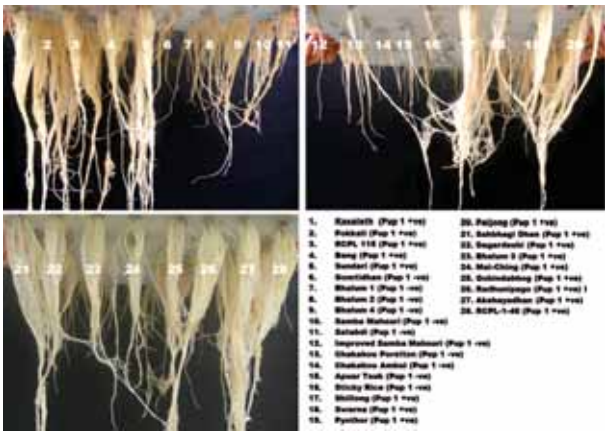
Rice variety- TRC 2013-2/IET 23947: This is found suitable for cultivation under irrigated as well as rainfed shallow lowland ecosystems of Uttarakhand.

Occupational health hazards in wheat production system: A study carried out to assess occupational health hazards and drudgery as perceived by women while carrying out different activities in a wheat production system, revealed that harvesting activity was perceived as the most hazard prone activity closely followed by threshing, manure application, winnowing, transporting. The cumulative score for perceived drudgery in wheat production system was highest for threshing followed by transporting manure/produce and harvesting. None of the respondents was using personal protective equipments (PPE) while carrying out different farm activities. Based on these findings, awareness programme for use of PPE and improved tools was initiated among the farm women. Training-based interventions on agricultural health and safety would be planned to reduce the incidence of health hazards.

Crop protection studies: Maize genotypes V433, VSL13, V25, V345 and V341 showed antibiosis mechanism of resistance to sitophilus weevil. Four lentil genotypes were found moderately resistant to pulse beetle *Callosobruchus* sp. Owing to the importance of insect pollinators of the region, a total of 22 non-apis bees were catalogued.

EASTERN HIMALAYAS

Phosphorus (P) tolerance and validation of *Pup-1* linked markers in rice genotypes: Rice varieties/ genotypes/landraces (172) grown in upland/lowland of North Eastern Region were phenotypically screened in hydroponics for identification of tolerance/sensitivity to P-deficiency at Meghalaya. Systematic molecular analysis was done for validation of *Pup1* linked markers in all rice varieties/genotypes/landraces identified to be tolerant or sensitive to low soil P. Tolerant donor lines identified are Vandana, Sahbhagi Dhan, Rasi, Akshayadhan, Bhutmuri, Gobindabhog, Radhunipagol, RCPL 1-113, Dagardeshi, Pynthor, Paijong, Bhalum - 3 etc. and the presence of *Pup1* in these lines was validated. Satabdi, Naveen, Anjali, Samba Mahsuri, Improved Samba Mahsuri, MTU 1010, NDR 359,



Root diversity of rice varieties/genotypes/Landraces with and without *Pup 1* QTL (*Pup1 + ve/Pup1–ve*)

Gomtidhan, Bhalum 1, Bhalum 2, Bhalum 4 etc., were found highly susceptible to low soil P and were also validated by markers. Interestingly, Swarna, a very popular rice of India, was found highly tolerant to P deficiency; and presence of *Pup1* QTL was also confirmed by *Pup 1* specific markers. Rice plants growing in hydroponics showed diverse root morphology directly correlated with presence of *Pup1* QTL. Based on the results obtained, Marker Assisted Backcross breeding programme can be initiated for development of phosphorus efficient rice for NEH region

Physiological aspects of phosphorus efficiency in maize: Different nutrient sources of phosphorus were evaluated in acid soil of Meghalaya. Chlorophyll increased in maize-plants provided with pig manure at 5 tonnes/ha and biochar at 10 tonnes/ha. Anthocyanin accumulation in the leaves with biochar applied at 5 tonnes/ha was significantly higher compared to other

Pest attack in indigenous orchid

A new pest was identified which attacks the indigenous orchid (*Eulophia andamanensis)* as *Lema pectoralis Baly (Coleoptera: Chrysomelidae)* and is reported for the first time in the Island. In the infested flower

Lema beetle attack in *Eulophia andamanensis*

Adult beetle of *Lema sp.*

spike, the florets dropped which reduces the market value of the flowers. The adults of *Lema* sp forms a frothy white mass in the spike in which it lays its eggs. The larval and adult stages of the insect damages the flower spikes.

nutrient sources. Root exudation showed that organic acids were synthesized and excreted more in control and in roots with pig manure at 5 tonnes/ha. Plants grown with FYM @ 10 tonnes/ha and poultry manure accumulated more nutrient uptake especially phosphorus compared to other treatments. Root size was higher in FYM than poultry manure. Maize-plants grown with poultry manure, pig manure and biochar at 10 tonnes/ha showed better growth and nutrient accumulation in acidic soils of Meghalaya.

New rice RC Maniphou 13: This variety is a derivative of cross between Leimaphou (KD-2-6-3) × *Akhanphou*. It is semi-dwarf, fertilizer-responsive high -yielding variety suitable for main *kharif* season under Manipur conditions. It is photo-insensitive with yield potential of 7-8 tonnes/ha and is tolerant to leaf and neck blast diseases.

Field view of RC Maniphou-13

Shading effect on growth and yield of turmeric: The relative shading effect of different local cucurbit landraces (bottle gourd, ridge gourd, pumpkin and bitter gourd) was assessed on turmeric yield (RCT 1) at Mizoram. Turmeric rhizome yield was significantly higher (15.2%-17.9%) with increased shading from cucurbit canopy.

Cropping system effect on system productivity and production efficiency: Study on diversification of rice through leguminous crops, tested at Sikkim, revealed that rice-fenugreek (leafy vegetable)-maize (green cobs) recorded maximum system productivity (82.2 tonnes/ha), followed by rice-vegetable pea-maize (green cob). Similarly, production efficiency (25.3 kg/ha/day) was higher in rice-fenugreek (leafy vegetable)-maize (green cobs), followed by rice-vegetable pea-maize (green cobs) and lowest was under rice-buckwheat.

Fish

Immunostimulation of *Labeo rohita* against EUS through *Withania somnifera* : Systematic survey and studies were conducted to characterize isolates of *Aphanomyces invadans* in NEH region and the efficacy of *Withania somnifera* (Indian ginseng, Ashwagandha) feed supplements as an immunostimulants in *Labeo rohita*. *W. somnifera*, enhanced immunostimulation in fish against the epizootic ulcerative syndrome (EUS). The molecular characterization of *A. invadans* from randomly collected 972 infected fish samples confirmed presence of a single isolate of the fungus in all fish species across the regions. Lab study, of six-week-old *Labeo rohita* fingerlings fed with WS supplement showed increased tolerance of *Labeo rohita* fingerling against *A. invadans*. The WS supplemented feed also significantly decreased blood glucose level and enzymatic parameters (GOT, GPT, ALP), while improved total blood protein, hemoglobin and nitroblue tetrazolium (NBT) level in fish. Further, the modeling studies suggested significant immunostimulation capability of *Withania somnifera* against EUS disease of fish.

ISLAND AND COASTAL REGION

Quality seed production and dissemination: Under the ICAR Seed Project –73 q Breeder and Truthfully Labelled Seed of improved varieties of paddy and pulses (paddy,69 q and pulses, 4 q) was produced during the reported period under farmers' participatory mode at farmers fields in Diglipur, North Andaman separately.

In addition, 120 kg breeder seed and 600 kg TFL seed of the Institute's recommended rice varieties was also given to the Department of Agriculture, Andaman and Nicobar Islands for further multiplication. Besides, about 3 kg brinjal seed of CARI Brinjal 1 (a bacterial wilt resistant brinjal) was also produced.

TFL seed field of HYV of rice

Salt-tolerant rice lines: KS 12 (IET 25055), a high-yielding salinity-tolerant rice line with medium bold grain type, was developed through pure-line selection from local salinity tolerant landrace Korgut, for coastal saline soils of Goa and adjoining regions. It is semi-tall (non-lodging) with medium bold grains with maturity duration of 130-135 days and yield of 2.0 tonnes/ha (under stress condition). The selections yielded 50-100% more compared to original Korgut. The entry was promoted to AVT-I (2016-17) in the Coastal salinity tolerant variety trial of the rice.

GRS 1 (IET 25051) (Goa Rice Selection 1) is a selection from the *saltol* introgressed rice lines received from the IRRI, Philippines. The lines were tested under natural stress (coastal salinity) during wet season along with check varieties CST7-1 and Korgut. It is a semi-tall type with maturity duration of 130-135 days. It recorded average grain yield of 3,831 kg/ha compared to national coastal salinity check CST 7-1 (1,823 kg/ha) and local check Korgut (1,233 kg/ha) in the trial conducted for the two years. The entry was promoted to AVT-I (2016-17) in the coastal salinity tolerant variety trial of the rice.

Polyembryonic mango collection: Fifteen local polyembryonic mango accessions, collected from South and North Andaman, showed polyembryony ranging from 2 to 4 seedlings per stone.

Noni (*Morinda citrifolia*): Thirty three accessions of noni were analysed using 36 morphological (12 tree and 24 flower and fruit traits) characters and based on these observations the guidelines for DUS testing of noni were developed.

Introduction of non-conventional and exotic crops: Cultivation of non-conventional and exotic crops, superior germplasm of dragon fruit (*Hylocerus* spp.), rambutan (*Nephelium lappaceum*), mangosteen (*Garcinia mangostana*), sweet carambola (*Averrhoa carambola*), *Annona* hybrid Arka Sahan and edible cactus (*Opuntia ficus-indica*) was successfully introduced in the islands.

Dragon fruit

Tuber crops: A total of 95 accessions in 14 tuber crop accessions were collected from Car Nicobar, Kamorta, Chowra, Teressa and Katchal islands and are being maintained in the field gene bank at ICAR-CIARI, Port Blair.

Plantation crops

Coconut: Twelve different dwarf coconut cross combinations were made, in which the cross, viz. AOD × AGD recorded the highest setting percentage (81.8) followed by AGD × AYD. Among the CARI coconut varieties, the cross between CARI–Annapurna × CARI–Surya recorded the highest setting percentage of 72.5. *Inter se* mating was carried out in 17 selected Pacific Ocean coconut accessions for germplasm multiplication and further conservation at ICGSA at ICAR-CPCRI.

Pulse cultivation as under storey crops: Under storey crops of coconut, pulse crops, viz. pigeonpea, mung bean and urd bean recorded seed yield of 554, 410 and 390 kg/ha, respectively. These pulse crops produced 1.5 (pigeonpea) to 2.7 tonnes/ha (mung bean and urd bean) stover that can serve as potential fodder to livestock. Introduction of pulses in coconut did not hamper the coconut productivity despite a built up of soil N by 23 kg/ha owing to biological N fixation. Based on mean price of ₹ 45,000/tonne, the gross and net income (₹/ha) of coconut plantation improved by ₹ 20,250 and ₹ 8,000 with introduction of pulse crops. Thus, the wide gap in production of pulses in the islands can be filled by their intercropping in coconut.

Production technology including protection

A new technology was standardized for production of high value flower crops. Ridges and furrows were made and covered with weed mat. Reconstituted media with soil and organic substrate were filled in the furrows. Planting was done in the furrows filled with the reconstituted media. The growth and yield performance of the flowers were better when compared with other treatments like ridges and furrow method with or without mulching.

Post-harvest technology and value-addition: Phytochemical analysis was carried out in the leaves and stems of kalmegh (*Andrographis paniculata*), which suggested that the andrographolide content was higher in leaves (3.49%) than the stems (1.60 %). The phytochemical analysis of black turmeric (*Curcuma caesia*) revealed that the rhizomes were rich in flavonoids (4371 mg/100 g) and possess antioxidant properties. Analysis of phytochemicals in spikes and roots of *Piper sarmentosum* showed that the spikes were rich in phenols and antioxidant content than the roots. Tender coconuts with Ready-–To–Serve (RTS) beverage having 12% TSS and 0.26 % TA and preservative (mainly citric acid) was found satisfactory. The beverage contains 12% pulp, 0.22% TA and 6.1 pH was found satisfactory with better organoleptic quality.

Propagation of jasmine: A new technique of propagation in jasmine was standardised using leaf as the propagule. This is a new technology standardized for the first time in *J. sambac* using root trainers and

Root and shoot formation in propagation from leaf

Propagules in *J. sambac*

modified substrate. Maximum success percentage and early sprouting were observed in the modified propagation structure than the open condition.

Animal Science

Teressa goat (Accession No : INDIA_GOAT_3300_TERESSA_06025): Nicobari tribal farmers maintained this indigenous goat breed by selective breeding. Nicobari tribal farmers of Teressa Island, Car Nicobar and Nancowrie group of islands are maintaining the pure indigenous stock of Teressa goats. Population is approximately 7,800. Teressa goats are tall, sturdy, brownish or dark tan or black or white, with white and black patches.

The animal has peculiar white patch/line starting from inner canthus of both eyes or from eye brows and extending up to nostrils or mouth; black hairs on dorsal midline up to the tail; black muzzle, eyelids and hoofs. Height ranges from 24 to 27 inches. Head length of male and female is 8.86±0.10 and 7.5±0.27 inches. The other physical features are: tail-medium to long; horn—large with flat base; and ears—erected directing downwards. Teressa goats are considered as an indigenous goat breed/germplasm belonging to this island territory. An average flock size of 6 Teressa goats are maintained by individual tribal family of Nicobar group of islands.

Nicobari pig (Accession No : INDIA_PIG_3300_NICOBARI_09005): Nicobari pigs, indigenous pigs of Nicobar Islands, are reared by Nicoabri tribes since time immemorial. Approximate population is 35,000. They are sturdy and short with long body and red-brown, black, grey, brown, blackish brown and fawn skin colour. Marked bristle crest (mane) on the back of the pig extending from mid head/shoulder to base of the tail. Facial profile varied from flat to concave. Slightly downward arch/curvature of the low back. Short neck with very large jowl. Characteristic feature is the tail having no curling. They are fast runner. Evolved and thriving under plantation based low input production system of the Nicobari tribes. They have good fostering ability and have less pre-weaning mortality.

Health management in poultry: *In ovo* dietary exposures to bioactive components present in the Kalmegh and Noni enhances the expression of TLR-3, TLR-4 and TLR-5 genes and systemic inflammatory immune response in chicks. Elevated expression indicated that supplementing Kalmegh and Noni in breeder diet induces antiviral and antibacterial responses in their progeny. Water supplement of aqueous extract of neem and *Aloe vera* @ 3 ml/bird/day has hepatoprotective, hypocholestremic and anti hyperglycemic effect in Nicobari fowl.

Herbal preparation for conjunctivitis in poultry: Conjunctivitis, usually caused by bacteria, virus and fungus, is a wide spread problem among rural poultry in A&N Islands where more than 80% of poultry population belong to backyard poultry. In clinical trials application of the *Aloe vera* based herbal eye drops (2-3 drops) reduced the microbial load, swelling and pus discharge of affected eyes. The oil based aloe herbal eye drops worked better than antibiotics and could be an effective ethno veterinary medicine and best alternative to alleviate antimicrobial resistance in the management/treatment of conjunctivitis in poultry.

Aquatic animal diseases: Infectious hypodermal and hematopoietic necrosis virus (IHHNV), a shrimp DNA virus was reported for the first time from the wild shrimps (*Penaeus monodon*) of Andaman and Nicobar Islands. White spot syndrome virus (WSSV), a shrimp DNA virus was also reported from the wild shrimps of Andaman and Nicobar Islands

New reports on fish parasites: Marine parasites *Ryukyua circularis, Norileca indica,* and *Bathynomus lowryi* were reported for the first time from Andaman and Nicobar Islands. Occurrence of branchial parasitic cymothoid, *Ryukyua circularis* from the marine finfish, *Amblygaster sirm* is reported for the first time from Andaman Islands.

Occurrence of parasitic cymothoid, *Norileca indica* from carangid fish (*Selar crumenophthalmus)* is reported for the first time from Andaman Islands.

New records of marine flora and fauna: A pantropical sea grass *Halophila decipiens* is reported

Integrated water resources management

Birjaberna village in Sundargarh district of Odisha, a tribal dominated village (77% ST farm families), was devoid of assured irrigation facility in spite of 1,400 mm annual rainfall and existence of Ghurlijore minor irrigation project. Poor canal functioning with damage of the surplus escape structure of the Ghurlijore reservoir had drastically reduced the water availability. Various water conservation and management strategies resulted in enhanced water availability by 1.2 ha-m in the pond thus increasing command area by 30%. These interventions led tribal farmers in growing three crops in a sequence of paddy in *kharif*, mustard in *rabi*, and groundnut and greengram in summer instead of rice monocrop in *kharif* in the command area. The yield of *kharif* rice also improved by 30% with supplemental irrigation provided by dug-well. Further introduction of sprinkler irrigation system during *rabi*, enhanced yield by 28% with saving of 32% irrigation water, which improved water productivity by 60% compared to traditional check-basin irrigation in groundnut. Low input based fish culture was also undertaken in the pond and after 210 days of rearing, phased harvesting of 472 kg fish, resulted in net income of ₹ 62,000/ ha, which corresponded to ₹ 6.2/ m of net consumptive water productivity. The interventions of water resource development and management in crop production and pisciculture enhanced average annual net income in the target area (2.1 ha crop area and 1.0 ha pond area) from ₹ 17,000 to ₹ 1.42 lakh during the reported period.

as new record for Andaman and Nicobar Islands. This discovery leads to increase in sea grass diversity to 11 species in the Islands. A new record of nudibranch *Halgerda dalanghita* was reported as first record for India from Andaman and Nicobar Islands collected from Havelock Islands. *Thenus unimaculatus* - a slipper Lobster was recorded for the first time in Andaman Islands. A giant marine isopod, *Bathynomus lowryi*, was reported from Andaman Islands. A giant marine isopod, Bathynomus lowryi, was reported from Andaman Islands.

Giant marine isopod, *Bathynomus lowryi*

Tribal Sub Plan

Andaman and Nicobar

Under Tribal Sub Plan (TSP) empowerment of tribal population through training cum technology dissemination was carried out. Trainings in agriculture, horticulture, animal husbandry, fisheries, field crops, land resource management, post-harvest, crop protection and value addition technologies, were conducted for the benefit of the tribals in Nicobar District and Little Andaman. From the tuber crop based farming system

Training on pulse and maize cultivation at Car Nicobar

the tribal farmers generated an amount of ₹ 9,160.00 to 18,220.00 from crop component and from pigs they generated approximately ₹ 9,000.00 to 85,000.00. With the intervention of tuber crops based farming system, at present they work 2-3 h/day and employment generation has increased to 91- 140 days/year while the farm revenue (net income) has increased to ₹ 33,225/ annum (average of 15 farm families) as compared to their traditional system.

Karnataka

In hill regions of Kodagu, an off-campus training followed by input distribution at Balegundi and Thyagathur villages of Somwarpet Taluk, Kodagu for Skill up-gradation of farmers was organized. This training on coconut and vegetable cultivation aspects benefited 90 tribal beneficiaries from both the tribal villages to whom six months old coconut seedlings of West coast tall variety and 100 vegetable seed kits were distributed.

Forty three acre area has been taken under plantation for mango and litchi at Bandel village of Rayagada district of Odisha under TSP.

Maharashtra

Ten tribal farmers from the villages of Bamani, Rangapalli, Mukalikonda, Pochanpalli and Venkatpura, Taluk Sironcha, District Gadchiroli were selected for demonstration of pomegranate cultivation in light texture soil. Each of the ten farmers was provided 325 plants of pomegranate variety Bhagwa along with inputs. Technical knowhow on cultivation of pomegranate was provided to record the performance of pomegranate in light textured soil.

Planting by Mahila Sarpancha

Uttar Pradesh

With a view to ensure livelihood and nutritional security in the tribal populated areas of Sonbhadra district of Uttar Pradesh, 1,000 tribal households from Chopan block of the district were adopted. Considering the importance of nutritional garden in tribal region 1,600 kitchen garden packets of vegetable seeds (tomato, brinjal, sponge gourd, okra, cowpea, dolicus bean and bottle gourd) were provided to these households after awareness cum training programme.

Gujarat

Promotion of medicinal plants cultivation was initiated for livelihood and health security in the tribal villages of Narmada and Jambugoda districts of Gujarat. Skill building was taken up and seed and planting material were made available.

Kerala

Demonstration of improved varieties of turmeric IISR Prathibha (300 kg), elephant foot yam Gajendra (600 kg) and ginger variety Varada (200 kg) were conducted in 14 tribal hamlets in Wayanad district, Kerala. A naturally ventilated polyhouse was provided to Attapady Tribal Farming Cooperative Society, Palakkad District, Kerala, for raising black pepper cuttings.

Rajasthan

Three exposure trips and 109 FLD's in TSP (0.2 ha area each) and 110 FLD's in NEH regions (25 m^2 area each) were conducted on seed spices. In TSP area average yield increase of FLD's over local check/ practices ranged from 20.63% to 59.11%.

Uttarakhand

Twelve village clusters in five districts of Uttarakhand, viz. Pithoragarh, Bageshwar, Chamoli, Udham Singh Nagar and Dehradun were adopted by the institute under Tribal Sub Plan with for socio-economic development of the tribal communities of Uttarakhand. Activities under the programme were: Capacity development programmes in which 981 tribal farmers benefited; distribution of seeds of improved varieties, small hand tools, VL *Syahihal* and *Krishi* calendars to all participant farmers; *Vivek Millet* thresher-1 and maize sheller were provided for community use. The power-operated maize sheller intervention reduced the drudgery of farmwomen by nearly half.

Himachal Pradesh

A spawn laboratory has been set up at KVK, Sharbo, Kinnaur (HP) under TSP. The spawn lab will cater to the demand for spawn from tribal people around Kinnaur district of Himachal Pradesh.

Training programme for tribal people of Kinnaur (Himachal Pradesh) were conducted on cultivation technology of mushrooms. The basic inputs and machinery required for crop management along with the complete set of literature were distributed to participants.

Odisha

Under the Tribal Sub-Plan for promotion of horticulture in tribal areas of Kashipur in Rayagada, pesticides, farm tools, sprayers, fertilizers, etc. were provided to 450 farmers to promote mango cultivation in the region. The concept of nutritional kitchen gardening was introduced with the participation of 250

Beneficiaries of the training programme on nutritional gardening

tribal households of seven villages of Mohana block of Gajapati district of Odisha for ensuring nutritional security at household level and to generate supplementary income for the farm women. Interventions to promote underutilized cucurbits like, teasel gourd, ivy gourd and pointed gourd were initiated with 50 farmers' households by providing seedlings to selected farmers. Farmer's self-help groups were trained to produce planting material of these crops in the polyhouse nursery.

North East Hill regions

Nagaland and Asom: Canopy management and rejuvenation of old senile litchi trees were successfully demonstrated in Nagaland and Asom under North-eastern region programme.

Mizoram: One on campus and three off campus training programmes on mushroom cultivation technology for the residents of North Eastern States were conducted at Mizoram University, Aizawl and ICAR-RC for NEH region, Imphal centre. Critical inputs for mushroom crop management along with the essential literature were distributed to 136 participants.

Manipur: Under the North Eastern Hill Regions programme a 'Village Incubation Centre for Value Addition of Tuber Crops' was established at Ukhrul, Manipur. About 100 progressive farmers/SHG members/ prospective entrepreneurs from Riha village were trained in the tuber crops snack food production.

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16. Organization and Management

DARE

The Department of Agricultural Research and Education (DARE) was established in the Ministry of Agriculture, Government of India in December 1973 to coordinate and promote agricultural research and education in the country. DARE provides the necessary government linkages for the Indian Council of Agricultural Research (ICAR), the premier research organization for coordinating, guiding and managing research in areas including crop science, natural resource management, horticultural science, fisheries science and animal science in the entire country. With 112 ICAR institutions and 73 agricultural universities spread across the country this is one of the largest national agricultural research system in the world. Apart from ICAR the Department of Agricultural Research and Education has other autonomous bodies, viz. the Central Agricultural Universities (CAU) 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.

ICAR

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. Erstwhile known as Imperial Council of Agricultural Research, it was established on 16 July 1929 as a Registered Society under the Societies Registration Act, 1860 on the recommendations of the Royal Commission of Agriculture. It has been reorganized twice, in 1965 and 1973, and is located at Krishi Bhawan, New Delhi, and its other buildings are Krishi Anusandhan Bhavan I and II, and NASC Complex, 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 acts as Secretary to the Government of India in the Department of Agricultural Research and Education. The General Body of the ICAR Society is the supreme authority of the ICAR, and the Union Minister of Agriculture and Farmers Welfare, heads it. Its members are the Ministers for Agriculture, Animal Husbandry and Fisheries, and the senior officers of the various state governments, representatives of Parliament, industry, institutes, scientific organizations and farmers (Appendix 1). The Governing Body (Appendix 2) is the chief executive and decision making authority of the ICAR which is headed by the Director General, ICAR who also acts as Secretary, DARE. It consists of eminent agricultural scientists, educationists, legislators and representatives of the farmers. It is assisted by the Accreditation Board, Regional Committee, Policy and Planning Committee, several Scientific Panels and Publications Committee. In the scientific matter, the Director General is assisted by eight Deputy Directors General, one each for (*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. The eight Deputy Directors General are responsible for the Institutes, National Research Centres, and the funding of Project Directorate in their respective fields. Besides, one ADG (NASF) looks after the Secretariat of National Agricultural Science Fund (NASF) and also assists Director General, ICAR. The ICAR recruits scientists and to such other posts and services as may be specified by the President, ICAR from time to time through competitive examination/direct recruitment by selection etc. through its independent recruitment body.

The Agricultural Scientists' Recruitment Board is accountable to proceeds of the ICAR Society, and receives funds 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 111 research institutes such as 68 institutes (Appendix 4), 6 National Bureaux (Appendix 5), 22 Project Directorates and Agricultural Technology Application Research Institutes (Appendix 6), 15 National Research Centres (Appendix 7), and 81 All India Coordinated Research Projects, and Network Research Projects (Appendix 8). The Directorate of Knowledge Management in Agriculture (DKMA) works 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 also CeRA. The ICAR promotes research, education and extension education in 73 Agricultural Universities such as 62 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 2016-17, the following posts were filled up under the promotion quota: two Directors, one Director (OL), three Under Secretaries, two Section Officers, three Assistants, thirty-six UDCs, two Senior Administrative Officers, nine Administrative Officers, two CFAO/Deputy Director (Finance), two Sr. Finance & Accounts Officers, two Finance & Accounts Officers, two Principal Private Secretaries. Besides twenty-four Administrative Officers, eight Finance & Account Officers, and eight Assistant Director (OL) were also appointed on direct recruitment basis.

Financial upgradation granted under MACP Scheme:

During 2016-17, (12) eligible officers and staff of ICAR (Headquarters) and Institutes were granted the benefits of financial upgradation under the Modified Assured Career Progression Scheme in accordance with the Government of India (Department of Personnel and Trainings) instruction in this regard.

E-governance in ICAR

E-governance can be defined as use of information and communication, quality of information and services provided in a cost effective manner. It is relevant for transparency, people's participation, and promotion of democratic society, managing voluminous data and information effectively, simplicity, efficiency and accountability in the Government of India. In the ICAR (Hq), the newly created e-Governance Division has been implementing and monitoring the following activities:

In ICAR, the following activities taken up under e-Governance are:

E Office: A module of NIC for File Tracking, PUC monitoring, and KMS. The ICAR (Hq) is on the way to implement complete e-Office filing system.

Vigilance Online Integrated Complaints and Enquiry (VOICE): An application exclusively for Vigilance section. It is meant for monitoring vigilance cases. It is functional at the ICAR (Hq).

Court Case Monitoring System (CCMS): It is a web-based application for monitoring i.e. starting with the entry of a new court case to recording down all proceedings and maintaining the history of each and every case.

E-procurement: The E-procurement System enables the tender bearers to download the Tender Schedule free of cost and then submit the bids online through this portal. This Division has been monitoring and coordinating with all the Units of ICAR for implementing on-line e-procurement.

Online RTI : This is a portal to file RTI applications/first appeals online along with payment gateway. Through this portal, RTI applications/first appeals can be filed by Indian citizens for ICAR and its institutes and these are viewed by delegated officers of ICAR.

Aadhaar Enabled Biometric Attendance System (AEBAS): Its purpose is to enable an employee with an Aadhaar Number, to mark his/her attendance in ICAR through Biometric Authentication device. Records of attendance in respect of ICAR (Hq) employees are generated at regular intervals and forwarded to the nodal officers for monitoring. Further, implementation of AEBAS for all the institutes of ICAR is being monitored.

ICAR web site

URL is icar.org.in and all activities of ICAR taking place in ICAR (Headquarters) and its institutions are uploaded on regular basis. The circulars, guidelines, important instructions related to all divisions can be downloaded from ICAR web site.

Facebook page of ICAR: The ICAR has maintained its FB page and URL i.e. www.facebook.com/InAgrisearch. Through this page ICAR's stories, photographs, activities, technologies, organize contests etc. are showcased.

ICAR Twitter account: The ICAR maintain its twitter account, ICAR@icarindia, to tweet comments and suggestions on it.

VC facility: For video conferencing (VC) the ICAR has its desktop VC facility to increase productivity and efficiency by reducing unproductive travel time, preventing meeting delays, creating shorter and more structured meetings and allowing for greater reach of a message.

ERP: Implementation of complete Enterprises Resource Planning (ERP) solution in respect of all the institutes of ICAR were monitored by this Division.

PERSONNEL

Several policy decisions were taken during the reported period to galvanise the human resources of the Council and streamline the operational process of the resources available at the institute in scientific category.

Important policy initiatives during the reported period are as follows:

1. *Eminent scientists:* The provision of 'Eminent Scientist' was included in the alternate qualification for all Research Management Positions via, Director of ICAR institutes, Joint Directors of National Institutes and ADGs at the ICAR (Hq) based on the recommendations of a Committee constituted with recommendations of the Governing Body for Revision of Essential Qualifications for all RMPs and Non-RMPs of the Council.

2. *Ammendment to tenure renewal committee:* The existing provisions of Tenure Renewal through a specified Tenure Renewal Committee (TRC) for RMP/some Non-RMPs were reviewed and with the approval of the competent authority it was decided that there shall be no renewal of tenure after completion of

first tenure of the incumbents holding the RMP/ Non-RMP.

3. *ICAR-NET:* The ICAR-National Eligibility Test (NET) is conducted by ASRB for determining eligibility for Lecturer/Assistant Professor in the State Agricultural Universities (SAU's)/other Agricultural Universities (AU's). After qualifying in NET, eligibility certificates is issued to the candidates by ASRB to enable them to apply against vacancies to be notified or advertised by the state agricultural universities/other agricultural universities. After thorough deliberation keeping in view the larger interest of student community, it has been decided with the approval of the competent authority to remove the restrictions on number of attempts in ICAR-NET to draw parity with the UGC-NET Examination.

4. *Rationalization of institutional transfer:* Guidelines issued for Inter-Institutional transfer for all category of scientist was revisited and reviewed to streamline the transfer guidelines. To streamline the process for transfer, it has been decided that the meeting of the Transfer Committee at ICAR (Hq) to examine the proposals for transfer of scientists will be held once in March every year and specific guidelines were formulated which indicate the period of receiving applications and that transfer to be effected based on availability of vacancy in the discipline of the applicant at the institute in which transfer is sought for; and the guidelines were communicated to all institutes for compliance.

5. *Rationalization eligibility criteria for different position for scientists:* A committee was constituted on the recommendation of the Governing Body and with the approval of competent authority to deliberate on the essential qualification of all RMPs and Non-RMPs viz. HoD, I/c of Regional Stations at ICAR, and recommend the list of relevant Doctoral Degree including the relevant basic sciences for each position considering the nature, duties and responsibilities of the position and the overall mandate of the concerned institute.

The recommendations of the committee are being implemented in phase manner with the approval of the competent authority of the Council.

6. *Rationalization of score card system:* A committee, constituted on the recommendation of the Governing Body, deliberated on issues relating to revamping of score card and issues concerning selection to senior scientific positions in ICAR by the ASRB. Further, the terms of reference of the committee include recommendation on the desirability of incentivizing the scientist to appear for direct recruitment to position of Senior Scientist and Principal Scientist instead of awaiting to be promoted to such positions under CAS. The committee commenced the deliberation on the issues in which the procedure being followed in other similar scientific organizations are also being looked into and recommendations are underway.

7. *Expediting recruitment of scientists:* It has been decided with recommendation of the Governing Body and approval of the competent authority to identify the vacancies discipline/institute-wise in consultation with all SMDs to be filled by recruitment through the ARS Examination in each year commencing from ARS Examination 2016.

7.1. In this process the identified vacancies would remain frozen from the period of conducting the ARS-examination to completion of FOCARS training, and thereafter the recruited scientists would be posted based on the merit *vis-à-vis* preferences. This would enable filling of vacancies at the desired institutes in a uniform manner irrespective of locations. An enormous effort has been made to increase the pace of recruitment and appointment to various RMP/Non-RMP and other vacant scientific positions. Further, the process for issuance of the appointment offer to selected candidates has also been streamlined.

7.2. Accordingly, the pace of recruitment to vacant positions has been enhanced with a mission to accomplish in a targeted manner.

(i) Followings have been accomplished in direct recruitment of RMP/Non-RMP and other scientific positions

Requisition to ASRB during Year-month	Advt. No	RMP	Non-RMP	PS/ Senior Scientist/ Scientist
2016- June	02/2016	08	09	-
2016- October	03/2016	-	-	51 (PS)
2016 October/ November	Yet to be advertised	-	-	75 (SS) & 2 (PS)

PS, Principal Scientist

(ii) Appointments offer issued after receipt of recommendation from ASRB

Year-month	RMP	Non-RMP	PS/Senior Scientist/SS
2016-July	9	9	-
2016-August	4	3	4 (PS)
2016-September	4	14	-

PS, Principal Scientist

8. MIS with regard to strength/in-position/vacancy in all categories of scientists: This exercise was carried out online interactive mode with each institute. After completion of the exercise the database has been uploaded on the ICAR web site. From this task emerged the distortions which have occurred due to posting of Scientist/Senior Scientist/Principal Scientist at various Institutes irrespective of sanctioned strength in a discipline at the concerned institute. These distortions were identified and a committee was constituted with the approval of the competent authority to examine the distortions and provide recommendations to harmonize the same.

INTELLECTUAL PROPERTY AND TECHNOLOGY MANAGEMENT

Patents

To protect new innovations, ICAR has filed 45 patent applications at Indian Patent Office (IPO), which were generated by its 23 national institutes. These applications were filed through SMDs include Animal Science (13), Crop Science (11), Horticultural Science (11), Agricultural Engineering (4), Natural Resource Management (4), and Fisheries Science (2). Thus the cumulative figure of patent applications has now risen to 1,025 applications from 69 ICAR institutes. These applications were pertaining to varied sectors of agriculture as given in Table 1.

Copyrights: Ten copyright applications were filed by three ICAR institutes for their research outcomes including Expert system for identification and control of diseases/ insect-pests in pulse crops; IRS-MULLaRP; and Online database for specific plant parts images of selected varieties of rice, okra, mustard and chick pea.

Copyrights were also filed for software including design of farm pond (version-1.0), design of straight drop spillway-version 1.0, analysis of performance parameters of seed metering device, economic-financial viability, nomenclature of images of specific plant parts and plant varieties; and training manual on soil conservation and watershed management. A total of 104 filed copyrights have been thus recorded from 23 ICAR institutes.

Trademarks: Twelve trademark applications were filed by the five ICAR institutes for products and processes including

- Bird species of CARI, Izatnagar: *Chitambari, Caribrovishal, Caridebendra, Carivirat, Carinirbheek, Carishyama, Upcari* and *Hitcari;*
- Expert system of IIPR, Kanpur (Pulsexpert): Diagnostic Expert System for Pulse Crops;
- Institute logo of IISR; and
- NRC on Banana, Trichy for their product Banana Shakti.

A total of 82 trademark applications were filed by the 30 ICAR institutes; out of which 21 applications have been granted registration.

Plant varieties: As the Protection of Plant Varieties and Farmers' Rights Authority notified new genera, applications for 135 varieties (107 extant; 27 new and 1 essentially derived variety) were filed at the Registry. For applications filed earlier, 56 varieties (51 extant and 5 new) were granted registration certificates during this period; raising the cumulative figure of registered varieties to 756. The cumulative total for plant variety protection applications rose to 1,186.

Capacity building and outreach activities

Programme organized: To create awareness and develop expertise in the domain area of intellectual property rights and technology management, organization of various capacity building programmes at institute/ zonal/national levels was emphasized. Accordingly, 39 ICAR institutes organized 129 Awareness Generation Programmes/ Interface/ Product-specific Meets/ Workshops/ Seminars, wherein 10,421 scientists/ researchers/ business professionals/ farmers/ social workers were benefited.

Programme attended: To expose the scientific and technical staff to specific nuances of intellectual property and technology management issues 113 personnel from different ICAR institutes were deputed to attend 52 capacity building programmes organized by 36 different national/ international organizations.

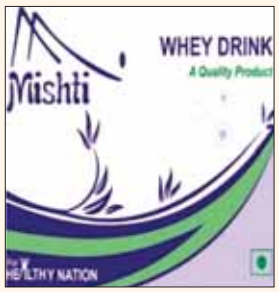
Technology Transfer/Commercialization

The period also witnessed increasing engagement of the ICAR institutes with external agencies from public and private sectors, and including regional/social organizations for partnership in research and commercialization activities. The mode of partnerships largely had been through formal Memoranda of Understandings (MoUs), Licensing Agreements, Consultancies/Contract Research/Contract Service etc. Accordingly, this year 356 such partnership agreements were firmed up with 186 public and private organizations and 73 entrepreneurs by 43 ICAR institutes in different Subject Matter Divisions. These included Agricultural Engineering (12), Animal Science (46), Crop Science (51), Fisheries Science (24), Horticultural Science (214) and Natural Research Management (9). The highest number of partnerships were developed by the IIHR, Bengaluru (103); followed by CPCRI, Kasaragod (46); and IVRI, Izatnagar (26). Out of these 356 partnerships,

Success Story

Name : Mishti Farmers Producer Co. Ltd, Nagla Rodan, Karnal

Description : BPD Unit, NDRI licensed *Bajra Lassi*, Whey Jaljeera Drink and Whey Mango technologies to *Mishti* Farmers Producer Co. Ltd. BPD Unit, NDRI and supported farmers by transferring latest available dairy technologies. Thus achieving intended solutions for social impact**.** BPD Unit, NDRI has also extended its support to continuously educate them with series



of interactions with mentors and developing business acumen to compete with intangible market forces. Company has generated asserts amounting to ₹ 25 lakh and reached a monthly turnover of ₹ 20.00 lakh within a span of 2 years. Unit has also assisted company in mobilizing the funds worth ₹ 40.00 lakh from bank.

Table 1. Important patent applications filed by the ICAR institutes in different sectors

Subject/area	Name of innovation/technology
Crop Protection Technologies	• Banana-stem weevil pheromone component. • Dorsalure-plant volatile composition to increase the trap efficiency for mango fruit flies. • Enteric methane reduction using silk worm *(Bombyx mori)* pupae oil. • Eugalure: plant volatile composition for trapping eucalyptus gall wasp, *Leptocybe invasa.* • Herbal-based repellent for termites on woody trees – REPTER. • Liquid formulation of *Beauveria bassiana*. • Method for albino free shoot regeneration in rice through anther culture. • PCR-based method and kit for simultaneous detection of four LYMVs. • Peptide elicitor of insect and pathogen defense in *brassica.* • Process for the production of alkyl coumarate concentrate. • Protocol for alcohol free plywood-laced melon fly attractant.
Food Processing Technologies	• Oil in water curcumin nano-emulsion. • Process for iron fortification of *paneer* using edible coating. • Process for preparing cashew apple crunch. • Process for preparing nutmeg taffy. • Process of extraction of virgin pomegranate seed oil.
Animal Health Practices	• Diagnosis of human brucellosis by IgG- and IgM-based combo lateral flow assay. • Genome wide QTLs for: age at first calving in buffaloes; milk fat percentage, milk protein percentage, total milk fat; milk yield in buffaloes; and somatic cell counts in buffaloes. • Peptide recombinant protein-based antigen capture immunoassay for detection of Rota virus. • Rapid spores-enzyme based miniaturized assay (s) for detection of pesticide residues. • Recombinant Hcp1 protein for detection of antibodies against *Burkoholderia mallei* in equines. • Recombinant NS1 protein-based indirect IgG ELISA for sero-diagnosis of Japanese encephalitis in swine.
Fisheries Science	• Primers for single tube reverse transcriptase-loop mediated isothermal amplification as well as a kit and method for detecting β noda virus infection. • A process and formulation to prepare vibrio antagonistic micro-feed for finfish and shell fish larvae using marine bacteria and a product thereof.
Agricultural Engineering	• *Aonla* seed removing and segmentation equipment-mechanical model. • Dipstick for estimation of glucose in potato tubers. • Double roller banana pseudo-stem fibre extractor. • Plant holding and lifting mechanism.

Further, the Indian Patent Office granted the following 11 patents, taking ICAR's cumulative number of granted patents to 181 from 25 institutes.

Institute	Technology/ Innovation
CIBA, Chennai	• Molecular tool for the detection of chemolitho autotropic bacteria (IN 275528)
CIFA, Bhubaneshwar	• A process for differential sero-diagnosis of gram-negative bacterial infections and detection of their toxins in human food in reference to fish and fish products using polyclonal antibodies to their less cross reacting and highly specific extra cellular products antigen (IN 277749)
	• A competitive ELISA for diagnosis and seromonitoring of microbial infections in cultured freshwater fishes (IN 277740)
IVRI, Izatnagar	• Oligonucleotide primer sequences for the specific and sensitive detection of *Bebesia bigemina* by polymerase chain reaction (IN 269419)
NBAIR, Bengaluru	• A simple and novel design for small-scale solid state mass production unit for antagonistic fungi (IN 275009)
NCIPM, New Delhi	• An insect rearing device for multiplication of insect larval parasitoid (IN 274901)
NDRI, Karnal	• A process for the preparation of milk-cake (IN 270312)
	• Spore germination based detection kit for β-lactam group in milk (IN 273160)
	• A kit for detection of adulteration of milk with soy-milk (IN 275521)
NIRJAFT, Kolkata	• Reuse of reactive dyes for jute dyeing following two step two bath method (IN 272713)
NRC on Cashew, Puttur	• Radial arm type cashew kernel extracting machine (IN 272371)

50 were finalized for 43 IP protected technologies (i.e. for Design/ Patents/ Trademark/Copyright/Plant Variety Protection).

The agreements were signed for 100 technologies of agricultural and its allied sciences, viz. animal food and processing technologies (3); cosmetic industry (1); crop production technologies (26); crop varieties (16); farm machines and tools (13); fish-based products and processes (4); food processing and value addition (32); and textile (5).

Incubation Fund was operationalized to address the critical gap observed for successful commercialization of technologies from ICAR institutes. It addresses the much-needed requirements of business incubation for converting agricultural technologies into an attractive commercial proposition. Accordingly, 25 Agri-business Incubation (ABI) centers are being supported/established in various institutes.

These ABIs have undertaken different activities to facilitate the business environment in the ICAR institutes, which included Business Plan Development (75); Conferences/Seminars organized (21); Consultancy (Short- and Long-term) (104); Entrepreneurs admitted for Incubation (163); Entrepreneurs graduated from the Incubator (61) and Value chain development (40).

PROGRESSIVE USE OF HINDI

DARE

DARE ensures compliance of the provisions of the Official Language Act. 1963, Official Language Rules, resolution, general orders, notification, administrative or other reports, or press communiques, issued or made by the Central Government or by a Ministry, Department or office thereof or company, company owned or controlled by the Central Government or by any office of such corporation and various orders/instructions issued by Department of Official Language from time to time on progressive use of Hindi for official purposes in the Department and Autonomous bodies coming under its purview. Efforts to make Hindi as official language in accordance with official language policy, are being made on continuous and on-going basis.

Targets and achievements, in brief, accomplished by Hindi Section of DARE with regard to progress of *Rajbhasha* and implementation of Official Language Policy are given bellow:

Policy implementation: The Official Language Division of the Department, manned by an officer of the level of Assistant Director (OL), has made continuous efforts towards implementation of the instructions issued by the Department of Official Language in this Department and Autonomous Bodies under its purview. In this regard, effective check points have been prepared for compliance of the implementation of the Official Language Policy and circulated to all officers to ensure more and more use of Hindi while disposing of their official work. Emphasis is also given to achieve the targets of correspondence in Hindi with offices located in 'A', 'B' and 'C' Regions.

Notification of Institutions/Offices under Rule 10(4) of the Official Rules 1976: Institutes/Offices of ICAR where 80% of staff have acquired working knowledge of Hindi, are notified under Rule 10 (4) of the Official Rules 1976. Overall 129 offices and attached stations with regional offices of ICAR have also been notified.

Official Language Policy related meetings: Quarterly up to 25 November 2016 Joint Meetings of Official Language Implementation Committee of DARE and ICAR are held regularly under the Chairmanship of Additional Secretary (DARE) and Secretary (ICAR) who is the nodal officer for implementation of the official language policy in DARE. Deputy Secretary/ Under Secretary/Section Officer, representing various divisions of the Ministry/Departments, are to be nominated as members of these committees while Hindi Officer, Assistant Director/ Deputy Director (OL) concerned would function as Member-Secretary of the same. Four meetings were organized and follow up action were taken in compliance with the decisions taken in these meetings.

Official Language Policy related Reports: Annual Assessment Reports and Quarterly Progress Reports regarding use of *Rajbhasha* in the Department are sent to the Department of Official Language regularly.

Official Language Policy related Inspection: During the year, two Institutes of ICAR were inspected and suggestions were given to solve practical problems being faced by the employees of these offices while working in Hindi.

Bilingual Printing of Manuals/ Rules: In pursuance of Section 3(3) of the Official Language Act 1963, all Resolutions, Notifications, Communiqués, Press release, Rules, Regulations, Administrative Reports and all Official Reports meant for laying in the Parliament are issued bilingually. Other than above, stationary items, name plates, notice boards, forms, procedural literature, rubber stamps, invitation cards etc. of all the Ministry/ Department got prepared both in English and Hindi.

Training: Apart from monitoring and implementation of the Official Language Policy and Programmes of the Government, Hindi Section arranged training of the personnel for effective use of Hindi , Hindi typing and Hindi stenography and translation. Officers have been issued instructions to make use of the services of stenographers, PAs, PSs trained in Hindi stenography for doing work in Hindi. The stenographers not knowing Hindi stenography were nominated for such training.

Translation work: Hindi Section of the Department carries out translation work under Section 3 (3) of Official Language Act. Accordingly, documents like Cabinet Notes, Resolutions, Notifications, MoU/ Agreements/Work Plans in the field of Agriculture with other Institutes were translated in Hindi within the stipulated time-frame based on their priority.

Hindi Chetna Maas: This *Maas* was observed from 15 September to 13 October 2016 in the Department

in association with ICAR. On the occasion, the message of Union Minister of Agriculture and Farmers Welfare and Secretary, DARE and DG, ICAR regarding progressive use of Hindi was circulated. In addition, various competitions were also organized on this occasion.

Use of Mechanical/Electonical Equipment: All equipments like Teleprinter/Talex /Computers etc. were allowed bilingual. Ministries/Departments are especially invited to ensure strict compliance of the orders issued from time to time by the Department of Official Language. DARE is also trying its best to ensure compliance of orders issued by the Department of Official Language.

Incentives Scheme: This scheme may be operated on financial year basis. The Officers who participate in this scheme will maintain a record of their work doing in Hindi during the reported period. One employee was awarded in this scheme.

ICAR

• In Council officers/staff having proficiency in Hindi are encouraged by the Secretary (ICAR) to do their work in Hindi and individual orders have been issued to them to do their maximum work in Hindi.

• Total 129 institutes/centres of ICAR have been notified in the Gazette under Official Language Rule 10 (4). Besides, 16 sections of ICAR (Hqrs.) were notified under rule 8(4) to do their cent per cent administrative work in Hindi.

• As per the Annual Programme, 4 meetings of the Joint O.L. Implementation Committees of DARE and ICAR were held under the chairmanship of Additional Secretary (DARE) and Secretary (ICAR).

• Official Language Implementation committees were constituted in all Institutes/centers, and their meetings were held regularly. Proceedings of these meetings were reviewed at the ICAR (Hqrs.) and appropriate suggestions and instructions were given to the concerned institutes.

• The quarterly progress reports were sent on-line to the Regional Implementation Office. The quarterly progress reports received from various institutes were reviewed and suggestions given to them for effective implementation. ICAR (Hqrs.) regularly participated in TOLIC's meeting.

• The employees were nominated regularly for Hindi language, Hindi typing and Hindi stenography training in every session. At ICAR (Hq), training in Unicode typing was also imparted by the *Hindi Anubhag*.

• During the reporting period four Hindi workshops were organized for officers/staff of various categories.

• Cash Awards were given to 10 officials for 2015-16 at ICAR (Hq) for doing their maximum official work in Hindi under the cash award scheme of Official Language Department.

• *Hindi Chetna Mass* was organized from 14 September to 13 October 2016. On this occasion an inspiring message from Union Agriculture Minister and Farmers Welfare was sent to all ICAR Institutes.

Competition organized during *Hindi Chetna Mass*

The Director General of ICAR also appealed to make progressive use of Hindi at every level. various competitions were organized during *Hindi Chetna Mass*.

• Under the Rajarshri Tandon *Rajbhasha Purskar Yojana*, 2014-15, given Institutes were awarded for doing their maximum work in Hindi.

1. Big Institutes	Award
1. Cenral Research Institute for Dryland Agricuture, Hyderabad	First
2. Central Institute of Fisheries Education, Mumbai	Second
2. Institutes/Centre of 'A' and 'B' Region	
1. Central Research Institute for Integrated Pest Management, New Delhi	First
2. Central Island Agricultural Research Institute,Andaman & Nicobar	Second
3. Institutes/Centre of 'C' Region	
1. Central Institute of Fisheries Technology, Cochin	First
2. Central Marine Fisheries Research Institute, Kochi	Second

• Under the Ganesh Shankar Vidyarthi Hindi *Patrika Purskar Yojana*, *2014-15* following magazines, published from different Institutes, were awarded:

S. No.	Magazine	Name of the Institute	Award
1.	*Akshay Kheti*	ICAR Research Complex for Eastern Region, Patna	First
2.	*Pashudhan Prakash*	National Bureau of Animal Genetic Resources, Karnal	Second
3.	*Swarnima*	Indian Institute of Wheat and Barley Research, Karnal	Third
4.	*Masalo ki Mahak*	Indian Institute of Spices Research, Calicut	First

• In accordance with the instructions of Department of Official Language, 31 Institutes were inspected by the Committee of Parliament on Official Language and senior officers of hqrs. during 2015-16 and suggestions were given for effective implementation of other languages.

Rajbhasha Alok, 2015 was released by Shri Radha Mohan Singh, Union Minister of Agriculture and Farmers Welfare

• *Krishika,* Hindi research journal was published.

• In-house magazine of ICAR (Hqrs.) *Rajbhasha Alok, 2015* depicting the Hindi activities of ICAR (Hqrs) and different Institutes was published. This magazine was released on 16 July 2016 on the occasion of 88th Foundation Day of ICAR by the Union Minister of Agriculture and Farmers Welfare, and President of the ICAR.

• The Council and its institutes are organizing *Kisan Mela* and other *Gosthies* in Hindi and other Indian Languages. Training was imparted to the farmers of different regions in their regional language and Hindi as well.

• Cabinet Notes, Audit Accounts, Annual Plan, SDG, Governing Body, Parliamentary Standing Committee on Agriculture, Annual General Meeting of ICAR Society and proceedings of many other meetings were prepared bilingually. The draft speeches of Union Agriculture Minister and Farmers Welfare and other higher officials of ICAR were prepared in Hindi.

FINANCE

DARE

The Plan and Non-Plan allocation (R.E.) to DARE/ ICAR for 2015-16 were ₹ 3,000.00 crore and ₹ 2,586.00 crore respectively. An internal resources of ₹ 227.20 crore (including interest on Loans and Advances, Income from Revolving Fund Schemes and interest on Short Term Deposits) was generated by ICAR during 2015-16. The Plan and Non-Plan allocation (B.E.) for 2016-17 are ₹ 3,700.00 crore and ₹ 2,920.00 crore respectively.

Under (*i*) Indo- Africa Forum Summit, DARE had released an amount of ₹ 22,702,375 during the financial year 2015-16 as payment of Fellowship and Institutional Economic Fee in respect of African students who were studying in M.Sc. and Ph.D. Courses in different Agricultural University, and under (*ii*) Indo-Afghanistan Forum Summit, this Department had released an amount of ₹ 28,496,206 during the financial year 2015-2016 as payment of Fellowship and Institutional Economic Fee in respect of Afghan students who were studying in B.Sc. and M.Sc. Courses in different Agricultural Universities and 101 applications of Afghan students were received by this Development from the Embassy of India in Kabul, Afghanistan and the same were processed for admission in B. Sc. and M.Sc. courses in different agricultural universities in the academic year 2016-17.

ICAR

• The *ICAR Audit Manual* was thoroughly revised, updated and published in December 2015. This handbook is a useful reference text not only for Finance and Account Officers, but for the Drawing and Disbursing Officers, Head of Office and authorities holding Research Management Position (RMP).

• An initiative was taken by the Additional Secretary (DARE) and Financial Advisor (ICAR) to hold interactive meeting with the Finance Officers of ICAR institute on zonal basis to address issues related to old audit paras, advances, items pending, the Bank reconciliation statement and review of Plan and Non-Plan Expenditure. Three rounds of such Interactive Meeting have already been conducted successfully. The first round of such meeting was conducted during September-December 2015. The second round of meeting was conducted during April-May 2016 and third round concluded during August-October 2016. The outcome of this interaction has been quite useful leading in settlement of audit paras especially old audit *paras* and advances through persistent pursuance and monitoring. Out of 992 pending audit *paras* of the Local Audit Report, 349 (35%) have been settled from September 2015 to September 2016.

- The exercise of tabling the *Annual Account of the ICAR for 2015-2016* before both the Houses of Parliament along with the Separate Audit Report was completed in a time bound manner without any delay. There have been no PAC audit paras with regard to ICAR which is an achievement.
- The Internal Inspection for 2014-2015 of 114 ICAR units of the Council was undertaken during 2015-2016 by ICAR (Hqrs) and completed successfully.

SWACHHTA PAKHWADA

DARE/ICAR

The Department of Agricultural Research and Education/Indian Council of Agricultural Research celebrated *Swachhta Pakhwada* from 16 to 31 October 2016. The ICAR (Headquarters) in New Delhi, all ICAR Research Institutes and all Krishi Vigyan Kendras took active part in *Swachhta Pakhwada* activities and conducted a wide range of activities which included, cleaning of campuses, residential areas, villages and localities in the vicinities in addition to conducting seminars, awareness camps, rallies, street plays and expert talks. Through KVKs promotion of *Swachhta* activities was done in more than 3,040 villages with the active participation of farmers and village youths. Farmers were made aware of clean farming technologies and

package of practices and make best use of the farm waste. Technology options available with the ICAR institutes for converting waste to wealth were showcased by the ICAR Institutes on this occasion. Central and local leaders, Senior Officers from the Institutes and the ICAR (Hq) participated in the events organized at various places across the country during the *Swachhta Pakhwada.*

AWARD CEREMONY, 2016

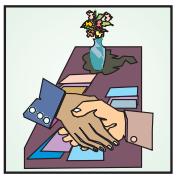
To commemorate the 88th Foundation day of ICAR, the ICAR Award, 2015 ceremony and a farmers' meet were organized at Vigyan Bhawan, New Delhi on 16 July 2016 in which 114 awardees, including 77 scientists, which also included 13 women scientists were awarded. 3 institutes, 2 AICRPs and 9 KVKs were also awarded. The awardees also included 7 journalists and 11 farmers, one among them was a woman farmer.

TECHNICAL COORDINATION

During 2016-17, the Council provided financial support to 53 societies for the publication of scientific journals. In addition, 56 societies/associations/universities were supported for holding National Seminars/Symposia/ Conferences and 27 societies/association/universities for holding International Seminars/Symposia/ Conferences. Annual Report (2015-2016) of DARE/ ICAR was laid on the table of both houses of parliament. The ICAR also supported short-term Extramural Research Projects aimed at filling the critical gaps in the scientific field or resolution of problems limiting production and value addition in various spheres of agricultural and allied sciences.

The Council provided financial support to 265 research projects under this scheme during 2016-17. The ICAR Regional Committees Meetings (7) were organized in different regions during 2016-17.

❑



17. Partnership and Linkages

DARE

The Department of Agricultural Research and Education (established in December, 1973) provides the necessary government linkages for the Indian Council of Agricultural Research (ICAR), the premier research organization for coordinating, guiding and managing research in crop science, horticulture, fisheries and animal sciences in the entire country. Apart from ICAR, the Department of Agricultural Research and Education has other autonomous bodies, viz. the Central Agricultural University (CAU), Imphal; RLBCAU, Jhansi and RPCAU, Pusa, and AgrInnovate India Limited, Delhi under its administrative control.

The Department liaises with foreign governments, United Nations, CGIAR and other multi-lateral agencies for cooperation in various areas of agricultural research. The DARE also coordinates admissions of foreign students in various Indian agriculture universities/ICAR institutions.

The AgrInnovate India Limited (incorporated on 19 October 2011) 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.

Memoranda of Understandings/MoAs

ICAR has signed Memoranda of Understandings (MoUs)/Memoranda of Agreements (MoAs) with the various CG Centres long back. Since then many instructions on the subject have changed, and new instructions have also been issued by the Cabinet Secretariat from time to time. Accordingly, a review process was undertaken in respect of all such MoUs/MoAs to bring these in accordance with the existing instruction/extant rules on the subject.

- ICAR signed MoU with Papua New Guinea – University of Technology (UNITECH) in Horticultural Science Research on 29 April 2016. ICAR has signed MoU with Horticultural Innovation, Australia on 27 May 2016.
- A Declaration of Intent was signed between the Ministry of Agriculture and Rural Development of the State of Israel and the Ministry of Agriculture of the Republic of India (in the Department of Agricultural Research and Education).
- Memorandum of Understanding between ICAR and Brazilian Agricultural Research Co-operation (ENRAPA) was signed on 17 October 2016.

Work Plans

Work Plan between Indian Council of Agricultural Research (ICAR) and International Water Management Institute (IWMI), Sri Lanka has been renewed for 2 years, i.e. 2016-18, and was signed on 7 July 2016 to develop, promote and accelerate closed collaboration in the field of Water Management Research.

Work Plans signed by ICAR with some CGIAR centres are coming to an end. Action has been initiated to revise/renew these Work Plans for further periods based on our agricultural research priorities in consultation with concerned Subject Matter Divisional Heads.

Collaborative Research Work Plans between Indian Council of Agricultural Research - International Water Management Research Institute, Sri Lanka (ICAR-IWMI); and Indian Council of Agricultural Research - Word Agro-forestry Centre, Kenya (ICAR-ICRAF) have been renewed in consultation with Subject Matter Divisional Heads and with the approval of Competent Authority.

MAJOR EVENTS

BRICS (Brazil, Russia, India, China and South Africa)

DARE organized BRICS Expert Group Meeting from 27 to 28 June 2016; BRICS Expert Group Meeting on 21 September 2016; and BRICS Agricultural Cooperation Working Group meeting on 22 September 2016.

The MoU for Establishment of BRICS Agricultural Research Platform (a virtual network) was finalized in BRICS Agricultural Cooperation Working Group Meeting held on 22 September 2016 in New Delhi (hosted by Department of Agricultural Research and Education). It was signed during the 8th BRICS Summit held on 15-16 October 2016 in Goa. Thereafter, DARE constituted a committee to finalize the location, staff structure and functions of the Coordinating Centre for establishment of BRICS Agricultural Research Platform in virtual mode.

Advance Centre for Agricultural Research and Education

A Memorandum of Agreement for—setting up of an 'Advance Centre for Agricultural Research and Education' (ACARE) at Yezin, Myanmar, to assist Government of Myanmar's efforts in capacity building of Myanmar's scientific and technical staff with support of equipment, training, research and participatory knowledge management, was signed between the Ministry of External Affairs (MEA), Government of India and Department of Agricultural Research and Education (DARE), Government of India on 21 September 2015. An amount of ₹ 32,812,128 was released by MEA to DARE as first advance release for setting up of ACARE. The funds have been released to IARI, New Delhi by DARE.

A Project Management and Co-ordination Unit (PM & CU) with Professor S.L. Mehta as Indian Resident Advisor for ACARE was established. IARI organized 21 days training programme for 15 faculty members of YAU, Myanmar from 31 May to 20 June 2016 in three different areas; Advances in molecular breeding of crop plants; Post-harvest management and value addition of agri-produce; and Agriculture knowledge management through innovative communication interventions. Dr Abhijit Kar, Project Leader, visited YAU, Myanmar to conduct an orientation programme for the research managers and identify faculty for the next training programme. Purchase of seven equipment for ACARE is under process. Two more trainings proposed to be conducted between 14 February and 7 March 2017 and between 28 March and 18 April 2017.

Afghan National Agricultural Sciences and Technology University

Afghan National Agricultural Sciences and Technology University (ANASTU) at Kandahar, Afghanistan was established with the support of the Ministry of External Affairs (MEA), Government of India, under the bilateral cooperation programme between Afghanistan and India. An MoU between ICAR and ANASTU was signed on 21 April 2016.

IARI procured laboratory instruments and farm equipment and sent to Afganistan. The second batch of M.Sc. Agronomy students (19) from ANASTU arrived at IARI, New Delhi on 21 July 2016 for eight months and had undergone 'English Language' course from 22 to 29 July 2016 at IARI, New Delhi. A course on 'Basic Statistical Methods' was conducted from 30 July to 24 August 2016 at IASRI, New Delhi (30 Lectures + 16 Practicals), followed by courses on 'Principles of Crop Production' from 26 August to 20 September 2016; 'Principles and Practices of Water Management' from 21 September to 15 October 2016; and 'Principles and Practices of Weed Management' from 17 October to 11 November 2016 at IARI, New Delhi.

A course on 'Agronomy of Vegetables and Fruit Crops' was held from 12 November to 9 December 2016 at IARI, New Delhi.

ASEAN-INDIA Cooperation

The approval for project entitled 'Genetic improvement of hybrid rice parental lines for enhancing yield heterosis' has been received from the Indian Mission ASEAN/MEA. The project is being implemented in the NRRI, Cuttack.

The comments of this department on the project proposal 'Identification and conservation of rice germplasm for nutritional and quality traits for enhancing profitability of rice production through mechanization and downstream processing' as under were forwarded to MEA for onward transmission to ASEAN Secretariat. The project will help in identifying the useful germplasm/genotypes for nutritional quality traits and stress tolerance and thus strengthen the national programmes.Through mutual exchange of identified useful germplasm under the project, the partner countries will get the opportunity to enrich their rice germplasm resources. The germplasm exchange will be done following the existing rules and guidelines of the partner countries. Sharing of knowledge and expertise through visits/review meetings and workshops will benefit the partner countries in the field of genetic resources and production technologies.

The Plan of action 2016-2020 was reviewed and necessary comments have been sent to ASEAN Secretariat for necessary action in the matter.

BIMSTEC

In the Fourth Meeting of Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) Expert Group on Agricultural Cooperation, held in Kathmandu, Nepal from 6 to 7 April 2015, it was decided that India may forward a Concept Note through the Secretariat on 'South East Asian Diagnosis Network for Ensuring Bio-security and Bio-safety' covering the area of crop/animal/fisheries. The Concept note was approved and sent to MEA for consideration of BIMSTEC Secretariat.

In the fourth meeting, it was also decided that India will submit a Concept Note on revised project as 'Human Resources Development in Agriculture' and upon receiving formal request from the Secretariat and based on requirement submitted by Member States, India would conduct training programmes for competence and capacity building. The concept note was approved and sent to MEA for consideration of BIMSTEC Secretariat.

The Fifth Meeting of BIMSTEC Expert Group on Agricultural Cooperation is scheduled to be held in Bhutan from 28 to 29 December 2016.

Indo-Africa Forum Summit

Under India Africa Forum Summit (IAFS)-III, the department has been assigned to implement Special Agricultural Scholarships (500 slots), Agricultural Training through DARE (1,200 slots), and Trainings on Food Security Programmes (30 training programmes).

Foreign Collaborative Projects with ICAR

Collaborative Projects: Total 17 collaborative projects were approved during 2016 (up to November 2016). Collaborative Research Projects (14) received in CG from various ICAR institutes to carry out the research activities with various CG Centres have been processed/approved. Activities carried out with CGIAR System and its Centres, during the reported period are given here.

Collaborative research project consisting components (a) 'Studies on certain ecosystem services in multi-varietal orchards of mango', and (b) 'Conservation and sustainable use of jack fruit diversity: sustainable livelihood, food security and ecosystem services' was approved.

Collaborative research project on 'Stress Tolerant Rice for Africa and South Asia (STRASA) Phase-III' was approved. Collaborative research project 'Development of Lentil cultivar with high concentration of Iron and Zinc' funded by ICARDA under the CGIAR Harvest Plus Challenge Programme 2015-16 (Bio-fortification programme) was approved.

Collaborative research project between ICAR and Cereal System Initiative for South Asia (CSISA) Phase-III of International Maize and Wheat Improvement Centre - CIMMYT was approved.

Collaborative research project on 'Improvement of Hulless barley for food purpose' to the Dryland Cereals Competitive Grants 2015 was approved.

Collaborative research project on 'Tropical Legumes III-Improving livelihood for small holder farmers: enhanced grain legume productivity and production in Sub-Saharan Africa and South Asia' in collaboration with ICRISAT was approved.

The IIMR and CIMMYT collaborative research project on 'Climate Resilient Maize for Asia for Ensuring Food Security and Enhancing Income for Resource-poor Farming Communities in the Tropics' (CRMA) was approved.

Collaborative research project 'Piloting and upscaling an innovative underground approach for mitigating urban floods and improving rural water security in South Asia' in collaboration with IWMI, Sri Lanka and CSSRI, Karnal was approved.

Collaborative research project on 'Improvement of banana for small holder farmers in the Great Lake Region of Africa' (Indian Component-Breeding for improved bananas with *Fusarium* wilt *(Fusarium oxysorum* fsp. *cubense)* resistance) in collaboration with National Research Centre on Banana, Trichy and Bioversity International, Rome, was approved.

ACIAR collaborative research project No. CIM/2014/081 on 'Mitigating the effects of stripe rust on wheat production in South Asia and Eastern Africa' and Memorandum of Subsidiary Arrangement for research project was approved.

UNEP/GEF Full Size Project (FSP) GEFSEC ID: 5137 'Mainstreaming agro-bioversity conservation and utilization in agricultural sector to ensure ecosystem services and reduce vulnerability, was approved.

Collaborative research project to study molecular genetics of Cotton Bollworm (CBW) entitled 'Genetics of insecticide and *Bacillus thuringiensis* toxin (Bt toxin) resistance in *Helicoverpa armigera'* was approved.

PROGRAMMES OF DARE

Foreign Deputation Cases

(*i*) Processing of applications for various training programmes abroad under various foreign governments, announced by DBT/DST etc. Government of India against open advertisements, UN/ International organizations, International agencies in various fields of agricultural research and education.

Number of finally selected/approved foreign visit cases pertaining to different fellowships/scholarships/ trainings/position of ICAR scientists

S. No.	Name of the Fellowship/ Scholarship / Position/Post	No. of cases finally approved by the competent authority
1.	Department of Biotechnology (DBT) fellowships	6
2.	DAAD, Germany	1
3.	Norman E. Borlaug Fellowship Programme	1
4.	Fulbright-Nehru Fellowship, by USIEF	2
5.	DST's Fellowship	1
6.	Ph.D-ICAR International Fellowship	8
7.	Netherlands Fellow NFP	1
8.	ICAR Lal Bahadur Shastri Award	1
9.	Other Training, Programme abroad	13
10.	Endeavour Research Fellowship in Australia	4
11.	ICRISAT Position/Post	-
12.	CSAM	3
13.	News India UK Fellowship	1
14.	Common Academic Staff Fellowship	1
	Total no. of cases	43

(*ii*) Processing of applications for various fellowships/scholarships announced by ICAR, HRD, foreign governments, etc for higher studies/research/Ph.D./Post-Doctoral Research abroad.

(*iii*) Forwarding of applications of the scientists for foreign assignments in foreign governments and International organizations.

(*iv*) Circulation of vacancies notified by the CGIAR organizations, other International organizations/ agencies such as ADB, Work Bank, Commonwealth Secretariat, United Nations etc.

Germplasm Exchange

The Department of Agricultural Research and Education (DARE) and the ICAR have a rich tradition of exchange of plant genetic resources with several countries. These resources are crucial for enhancing productivity and quality of our crops. No country is self-sufficient in these resources and the future of crop improvement programmes depends on active

international cooperation in the area of exchange of genetic resources. Essentially, the germplasm exchange programme of DARE/ICAR through bilateral MoUs with other countries has been on a *quid pro quo* basis.

The six Bureaus/Institutes under ICAR system have been designated by the Union Ministry of Environment and Forests to act as repositories under the Biological Diversity Act, 2002 for different categories of biological resources:

(*i*) NBPGR: for exchange of plant germplasm.
(*ii*) NBAGR: for exchange of animal germplasm.
(*iii*) NBFGR: for exchange of fish germplasm.
(*iv*) NBAIR: for exchange of germplasm of agriculturally important insects.
(*v*) NBAIM: for exchange of germplasm of agriculturally important micro-organism.
(*vi*) IARI: for exchange of germplasm of algae/fungi.

Cases of germplasm exchange are processed in DARE for approval of the competent authority in consultation with the Bureaus/Institute/Subject Matter Divisional Head. In the area of exchange of genetic resources, 5 cases received from friendly foreign governments/government sponsored agencies/ International Organization agencies were processed in accordance with the provisions of Biodiversity Act and further guidelines were notified in this regard. Approval of competent authority in respect of 4 cases was conveyed.

Consultative Group on International Agricultural Research

Consultative Group on International Agricultural Research (CGIAR) is an international organization having close collaboration with Department of Agricultural Research and Education (DARE), and Indian Council of Agricultural Research (ICAR). 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.

India is a funding member of the erstwhile CGIAR as a consortium and now the same consortium has been converted to a System Organization having its headquarter in Paris under the aegis of the World Bank. India is one of the founding members of the new organization representing the developing world i.e. South Asia Constituency of the CGIAR System Council along with other two alternate representatives from South Asia namely Bangladesh and Sri Lanka. Under such circumstances, India has assumed important role in CGIAR System as a permanent voting member. This responsibility requires reciprocation from India also.

CENTRAL AGRICULTURAL UNIVERSITIES

The Central Agricultural Universities are sponsored by DARE. Activities of the Universities situated in CAU Imphal (Manipur), RLBCAU Jhansi (Uttar Pradesh) and RPCAU Pusa (Bihar) are given here.

CAU, Imphal

The University research aims at developing agricultural technologies/practices which can bring about a far reaching impact on production, productivity and profitability of crops, animals and fishes through sustainable and eco-friendly scientific approaches for socio-economic upliftment of the people of NEH Region. To fulfil the research objectives of the university, a number of need based location specific internally and externally funded basic, strategic and applied research projects are being taken up in constituent colleges and the Directorate of Research. At present, there are 67 on-going internally funded research projects under the name 'Intramural Research Projects (IRP)' and 115 externally funded projects including 35 All India Co-ordinated Research Projects (AICRPs) and 4 All India Network Research Projects (AINRPs).

As an outcome of these research endeavours, the university was successful in developing location specific deliverable technologies/practices, recommendations and research findings on agriculture and allied disciplines for the farmers and agri-entrepreneurs of NEH Region.

Location specific recommendations and scientific findings in agriculture and allied sciences for NEH Region

A total of 73 location specific recommendations and scientific findings in Agriculture and Allied Sciences for NEH Region were developed by the university from 1 November 2015 to 31 October 2016.

RLBCAU, Jhansi

The Rani Lakshmi Bai Central Agricultural University (RBLCAU), Jhansi (established in 2014 as an institution of national importance) admitted students under two new degree programmes in Horticulture and Forestry [B.Sc. (Hons.) Horticulture and B.Sc. (Hons.) Forestry] from the current academic session, besides continuing its B. Sc. (Hons) Agriculture programme.

The research experiments for screening of chickpea germplasm for yield attributes and disease incidence in Bundelkhand region were also initiated. The emphasis is also being laid to disseminate production technologies of oilseeds and pulses to farmers of Bundelkhand region.

RPCAU, Pusa

The Rajendra Prasad Agricultural University, Pusa (Bihar) (established on 3 December, 1970) was upgraded as Dr Rajendra Prasad Central Agricultural University, Pusa on 7 October 2016. The University presently has six faculties, five colleges, seven research institutes/ stations and thirteen Krishi Vigyan Kendras (eleven with Dr RPCAU, Pusa and two with NGOs).

The operational area of Dr RPCAU, Pusa covers Agro-climatic Zone-I consisting of East and West Champaran, Siwan, Saran, Gopalganj, Vaishali, Muzaffarpur, Sheohar, Sitamarhi, Darbhanga, Madhubani, Begusarai and Samastipur districts. The major agricultural crops are rice, wheat, maize, sunflower, pea, potato, sugarcane and vegetables. The source of irrigation is mostly tube-well.

The Research Council of University reoriented research programme to provide research input/ technological inputs to different programmes of the Union Ministry of Agriculture and Farmers' Welfare.

Doubling farmers' income: Research projects initiated for reducing cost of production and local level processing for value addition.

Har khet ko pani: Formulated and initiated research programmes to develop technologies to provide irrigation in challenged Ecology of *Dhab, Diara, Tal* land, *Chaur* lands of Eastern India in general and Bihar in particular. The total area under this challenged ecology is about 15 lakh ha in Bihar alone.

Soil-health management: Initiated soil-health management for maize and pulse-based cropping sequence and other measures for maintaining crop production sustainability.

Enhancing pulse production: Formulated and initiated research projects for enhancing pulses production in Bihar with multi-pronged approach of breeding, seed production, intercropping and nutrient and water management.

More crop, per drop: Initiated work on formulating research projects to enhance irrigation efficiency both by redesigning surface irrigation methods as well as automation of the same. The system is collaborating with 'start ups' of IIT, Mumbai.

During 2016-17, a total of 251 students were admitted in various undergraduate (UG), postgraduate (PG) and Ph.D. programmes of the University, out of which 120 students were under UG, 115 were for M.Sc. and 16 were for Ph. D. programme.

There were 32 AICRP/AINP Projects along with 5 voluntary centres, besides many Government of India projects, State Government projects, RKVY projects, foreign aided projects and other agencies projects. Three new projects were sanctioned viz., 'Establishment of Integrated Bee Development centre/ CoE' at KVK, Piprakothi and 'Establishment of Bio-fertilizer, Bio-control production unit for increasing Pulse Production in India' at Pusa, and UNICEF project on 'Improving adolescent, maternal and infant diet diversity through local agriculture-nutrition solution-Ankuran' with a goal to reduce stunting in Bihar. In this regards, Memorandum of Understanding (MoU) has been signed between RPCAU, Pusa and UNICEF, Country Office, India.

New research projects (15) were initiated to provide technical backup to programmes of Government of India.

AGRINNOVATE INDIA LIMITED

AgrInnovate India Limited is steadily moving towards meeting its objectives and building 'A world of Innovative Partnerships'. The Vision of the company is to stimulate, foster, enhance and catalyze innovation and capacity driven agricultural development through partnerships.

The Company has fetched revenue of ₹ 16,710,043 from operations in the Financial Year 2015-16 as against ₹ 48,99,770 in Financial Year 2014-15. In the financial year 2015-16, the Company has earned net profit of ₹ 24,670,104 as against net profit of ₹ 28,921,501 in Financial Year 2014-15.

The Company undertook various proposals during the Financial Year 2015-16. The National Bureau of Plant Genetic Resources has signed a Memorandum of Agreement with M/s DSS Image Tech Private Limited, Delhi, facilitated by AgrInnovate India Limited (AgIn) for transfer of five DNA-based GMO screening technologies.

***Capacity building programmes*:** AgIn also coordinated following training and capacity building programmes.

1. A two day Training-cum-demonstration on 'Technical know-how of Aleuritic acid technology' for the two representatives of Anning Decco Fine Chemical Co., Ltd., Kunming, China during July 2016 by IINRG.
2. West Africa Agricultural Productivity Programme sponsored trainings on:
   (a) *Fish Breeding Technology* in Central Institute of Freshwater Aquaculture, Bhubaneshwar for 2 Nigerian nationals for four months.
   (b) *Food Science and Technology* in Central Institute of Agricultural Engineering, Bhopal for 2 Nigerian nationals for six months.
   (c) *Seed Technology* in Directorate of Seed Research, Mau for 8 Nigerian nationals for six months.

Company's promotional activities: AgrInnovate India Limited in partnership had participated in the drive 'Make in India' in Food processing event organized by CII, CII Agri-Technology and Mechanization Summit 2015: Strengthening Techno-Culture in Agriculture; National Seminar on 'Governance Reforms for Make-in-India' and 'Sustainable Agriculture Initiatives; Conference on 'Innovations in Agriculture mechanization- development of linkages among R&D industry–farmers' etc. wherein some of the technologies, products and solutions of ICAR Institutes were exhibited to key customers, business buyers, investors, scientific community and media at large.

Efforts for standardizing the processes: The Company has also finalized guidelines for technology commercialization and professional services for National Agricultural Research and Education System (NARES) in general and ICAR in particular.

CONSULTANCIES

- Deputation/Consultancy proposal of Dr P. Routray (Principal Scientist, CIFA, Bhubaneshwar) provided consultancy services in the field of 'Broodstock management and genetic selection of tilapia' in Food and Agriculture Organization, Namibia, as an Expert for 20 days w.e.f. 30 November 2015.
- Deputation/Consultancy proposal of Dr Kaushik Banerjee (Principal Scientist and ICAR National

Fellow, NRC on Grapes, Pune) for participation in the Programme Advisory Committee Meeting of Malaysian Palm Oil Board (MPOB) in Malaysia from 11 to 15 April 2016 as a Member of the Programme Advisory Committee - Food Nutrition and Quality Sub-Committee of the Malaysian Palm Oil Board, Ministry of Plantation Industries and Commodities, Malaysia.

- International Consultancy (short-term) proposal offered by FAO of United Nations to Dr Hukum Chandra (National Fellow, Indian Agricultural Statistics Research Institute, New Delhi) to provide consultancy for implementation of the Global Strategy to Improve Agricultural and Rural Statistics in Sri Lanka with home-based work as a sampling expert to assist with development of improved sampling design/methodology for crop yield estimation in the country at national and sub-national levels for 45 days in 03 (three) mission during 2015 and 2016 under the Food and Agriculture Organization (FAO) Consultancy project. Third mission/visit of 15 days from 25 April to 9 May 2016.
- Consultancy/Deputation proposal of Dr P. Routray (Principal Scientist, CIFA, Bhubaneshwar) to Food and Agriculture Organization, Khartoum, Sudan to provide technical consultancy services in the field of *'Tilapia* Broodstock and Seed Production (ITBS)' under FAO project (TCP/SUD/3503) to Government of Sudan as an Expert Consultant for 68 days during 2016 and 2017.
- FAO's Consultancy proposal of Dr Sushil Pandey (Senior Scientist, Germplasm Conservation Division, NBPGR, New Delhi) for Final Evaluation of the 'Second project Cycle of the Benefit-Sharing Fund of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)' against the Vacancy Announcement NO.IRC3430 [Duty station: home-based with missions to FAO Hq (Rome) and India].
- International Consultancy (short-term) proposal offered by FAO of United Nations to Dr Hukum Chandra (National Fellow, IASRI, New Delhi) for implementation of the Global Strategy to improve agricultural and rural statistics in Sri Lanka and other countries as a sampling Expert for 45 days in 03 missions during 2016-17 in Sri Lanka and other countries under the FAO project on Country Statistical Capacity Assessment and Strategic Planning in Agricultural Statistics in Sri Lanka. First mission/ visit started from 12 to 25 September 2016.
- FAO (short-term) consultancy proposal of Dr U C Sud (Director, IASRI) to Bhutan to assist with development of improved sampling design/ methodology for crop yield estimation in the country for Paddy and Maize as Sampling Expert under the FAO project of Implementation of the Global Strategy to Improve Agricultural and Rural Statistics in Bhutan from 22 August 2016 to 1 September 2016 in Bhutan and from 12 to 15 September 2016 home-based work.

INTERNATIONAL WORKSHOPS/ CONFERENCES/SYMPOSIA

• International Conference on 'Agroforestry in South Asia : The way Forward' was held between 8 and 10 October 2015 at National Agricultural Science Complex (NASC), New Delhi.

• Fifth International Symposium was held on 'Cage Aquaculture in Asia (CAA5)' between 11 and 14 November at Cochin (Kerala).

• International Rice Symposium 2015 ('Rice Science for Global Food and Nutritional Security') was held between 18 and 20 November 2015 at Hyderabad.

• Seventh Conference of the International Seabuckthorn Association (ISA - 2015) was held on 'Seabuckthorn - Emerging Technologies for Health Protection and Environmental Conservation' between 24 and 26 November 2015 at NASC Complex, New Delhi.

• Eighth International Conference was held on 'Innovative Digital Applications for Sustainable Development' from 5 to 7 January 2016 at University of Agricultural Science (UAS), GKVK, Bengaluru.

• International Extension Education Conference 2016 (IEEC BHU2016) was held on 'Education, Research and Services' from 27 to 30 January 2016 at Banaras Hindu University (BHU), Varanasi.

• Second International Symposium on 'Genomics in Aquaculture (2 ISGA)' was held between 28 and 30 January 2016 at CIFA, Bhubaneshwar.

• International Global Ravines Conference 2016 entitled 'Managing Ravines for Food and Livelihood Security' was held between 9 and 12 February 2016 at New Delhi.

• International Conference was held on 'Emerging Issues in Quality and Safety of Fish and Shellfish (EIQASFISH'16)' between 10 and 11 February 2016 at Chennai, Tamil Nadu.

• International Symposium was held on 'Microbiome in Health and Disease (MicroHD-2016)' from 23 to 25 February 2016 at National Institute of Animal Nutrition and Physiology, Adugodi, Benagaluru.

• South Asian Reactive N Assessment Workshop was held from 26 to 27 February 2016 at New Delhi.

• 'South Asia Ag-Nutrition Workshop' was held from 29 March to 2 April 2016 in New Delhi.

• Third International Conference was held on 'Agro-chemicals Protecting Crop, Health and Natural Environment - New Chemistries for Phyto-medicines and Crop Protection Chemicals' from 6 to 9 April 2016 at New Delhi.

• Global Conference was held on 'Perspective of Future Challenges and options in Agriculture' from 28 to 31 May 2016 at Jalgaon, Maharashtra.

• Regional Consultation was held on 'Enhancing Productivity and Profitability of Pulses for Addressing Food and Nutrition Security' from 7 to 9 August 2016 at M.S. Swaminathan Research Foundation, Chennai (Tamil Nadu).

• International Meet was held on 'Food, Water,

Energy nexus in arena of Climate Change' from 13 to 15 October 2016 at Anand Agriculture University, Anand (Gujarat).

• 20th International Annual Conference of Asian Science Park Association (ASPA-2016) was held from 19 to 22 October 2016 at Hyderabad International Convention Centre, Hyderabad (Telangana).

• Global Water Meet for Climate Change adaption– an agrarian perspective (GWM 2016) at University of Agricultural Sciences, Dharwad from 24 to 26 October 2016.

• First International Agro-biodiversity Congress was held from 6 to 9 November 2016 at New Delhi.

• Tenth International Conference was held on 'Controlled Atmosphere and Fumigation in Stored Products - CAF-2016' from 7 to 11 November 2016 at New Delhi.

• International Congress was held on 'Post-Harvest Technologies of Agricultural Produce for Sustainable Food and Nutritional Security' from 10 to 12 November 2016 at Integral Institute of Agricultural Sciences and Technology, Integral University, Lucknow (Uttar Pradesh).

• International Symposium was held on 'New Horizons for Augmenting Meat Production and Processing to Ensure Nutritional Security, Food Safety and Environmental Sustainability' and Seventh Conference of Indian Meat Science Association (VII-IMSACON) was held from 10 to 12 November 2016 at College of Veterinary Science, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana (Punjab).

• Fourth International Agronomy Congress was held on 'Agronomy for Sustainable Management of Natural Resources, Environment, Energy and Livelihood Security to Achieve Zero Hunger Challenge' from 22 to 26 November 2016 at New Delhi.

• International Conference was held on 'Statistics, Bioinformatics and Big Data Analytics in Agricultural Research' from 21 to 23 November 2016 at ICRISAT, Patancheru, Hyderabad (Telangana).

• Joint International Workshop between ICAR and University of Ediburgh, United Kingdom was held from 1 to 2 December 2016 at New Delhi.

• International Conference was held on 'Nutraceuticals and Functional Foods - The Challenges and Opportunities (ICNFF-16-ISAB)' from 6 to 8 December 2016 at Anand Agricultural University, Anand (Gujarat).

• Third International Symposium was held on 'Coconut Research and Development (ISOCRAD 3)' between 10 and 12 December 2016 at CPCRI, Kasaragod as part of Centenary Celebration of CPCRI.

• First Asian Conference was held on 'Water and Land Management for Food and Livelihood Security (WLMFLS-2017)' from 20 to 22 January 2017 at Raipur (Chhattisgarh).

• International Conference to be held on Drought (lnter Drought-V) from 21 to 25 February 2017 at Hyderabad International Convention Centre, Hyderabad (Telangana).

• International Seminar on 'Oilseed *Brassica* (ISOB 2017)' to be held from 23 to 26 February 2017 at State Institute of Agriculture Management, Durgapur, Government of Rajasthan, Jaipur (Rajasthan).

PROTOCOL ACTIVITIES

VVIP Delegations

• A delegation led by Union Minister for Agriculture and Farmers' Welfare, Shri Radha Mohan Singh, visited Dhaka, Bangladesh from 6 to 7 April 2016 to attend the Third SAARC Agriculture Ministers Meeting.

• Mr Wallace Cosgrow, Minister (Agriculture and Fisheries of Seychelles) visited Indian Agricultural Research Institute, New Delhi with Dr S. Ayyappan (Secretary, DARE and DG, ICAR) on 11 February 2016.

• Mr Selgo Karapentiyen, Minister (Agriculture of Armenia) visited Indian Agricultural Research Institute, New Delhi on 17 February 2016.

• Mr Amanudin Haidari, Deputy Minister for Agriculture and Livestock and Chairman of National Seed Board from International Centre for Agricultural Research in the Dry Areas (ICARDA), Afghanistan and delegation visited various ICAR Institutes from 19 to 31 March 2016.

• Mr Jean – Marie Aurand, Director General of the International Organization for Vine and Wine visited National Research Centre for Grapes on 10 March 2016.

• Mr Dasho Rinzin, former Member of National Council of Bhutan and Member of Parliament Chairperson, Environment and Natural Resources committee of Bhutan visited Indian Agricultural Research Institute, New Delhi on 29 March 2016.

• Mr Uri Ariel, Agriculture and Rural Development Minister of Israel accompanied delegation to Indian Agricultural Research Institute, New Delhi on 6 April 2016.

• Gen. Candido Pereira dos Santos Van – Dunem, Minister of former Combatants and Veterans of the Homeland, Republic of Angola accompanied delegation to Indian Agricultural Research Institute, New Delhi on 5 May 2016.

• Eng. Afonse Perdo Canga, Minister of Agriculture and Rural Development of the Republic of Angola accompanied delegation to Central Institute of Post–harvest Engineering and Technology, Ludhiana on 27 May 2016.

• Mr Mebrahtu Meles Gebru, State Minister, Ministry of Industry, Food, Dairy and Meat Development from Ethiopia accompanied delegation to National Research Centre on Meat, Hyderabad on 8 June 2016.

• Deputy Agriculture Minister, Afghanistan and accompanied delegation met with Dr T. Mohapatra [Secretary (DARE) and DG (ICAR)], on 6 June 2016.

• Dr Mohammed Hassan Dahab, Director General,

Ministry of Higher Education and Scientific Research, Government of Sudan and accompanied delegation met with Dr T. Mohapatra [Secretary (DARE) and Director General (ICAR)] on 5 September 2016.

• Mr Chris Forbes, Associate Deputy Minister, Agriculture and Agri-Food Canada accompanied by Ms. Carolina Gilberti, Executive Vice–President Canadian Food Inspection Agency, Canada and delegates met with Shri C. Roul [Additional Secretary (DARE) and Secretary (ICAR)] on 5 October 2016.

• Mr Abdullahi Adamu, Senator, Chairman Senate Committee of Agriculture and Rural Development, Federal Government Nigeria and accompanied delegation met with Shri C. Roul [Additional Secretary (DARE) and Secretary (ICAR)] on 19 October 2016.

• Mr Daniel Carmon, Ambassador of Israel in India, Embassy of State of Israel, New Delhi met with Shri C. Roul [Additional Secretary (DARE) and Secretary (ICAR)] on 11 November 2016.

• Mr Fakhri Hassan Al-Issa, the Ambassador Extraordinary and Plenipotentiary of Republic of Iraq, New India met with Dr T. Mohapatra [Secretary (DARE) and DG (ICAR)] on 1 December 2016.

• Dr T. Mohapatra [Secretary (DARE) and DG (ICAR), New Delhi] visited Colombo, Sri Lanka for participation in the IWMI-Steering Committee Meeting from 7 to 8 July 2016.

• Shri Chhabilendra Roul [Additional Secretary DARE and Secretary, ICAR, New Delhi] visited Washington DC, USA for attending Third Meeting of CGIAR Centres and Founders on the CGIAR system held from 6 to 8 June 2016 in World Bank Headquarters.

• Shri Chhabilendra Roul [Additional Secretary DARE and Secretary, ICAR, New Delhi] visited Mexico for attending Second Meeting of Consultative Group on International Agricultural Research (CGIAR) System Council from 24 to 26 September 2016.

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18.
Supporting Basic and Strategic Research

The National Agricultural Science Fund with an outlay of ₹ 500.0 crore during the XII Five-Year Plan supports basic and strategic research in agriculture with the aim to build capacity for basic, strategic and cutting edge application research in agriculture and address issues which can be solved by intensive basic and strategic research jointly by team of organizations/ institutions. Underlying this objective are the following aims: (*i*) Foster research and a research culture that will use and advance the frontiers of scientific knowledge to effectively meet the present, anticipated and unanticipated problems of agriculture through various modes and critical investments in research projects; (*ii*) Build the capability of the National Agricultural Research System through development of wide partnerships in science through projects; (*iii*) Build a storehouse of advancement of knowledge in science related to agriculture and awareness of the national importance of basic and strategic research in agriculture.; (*iv*) To provide policy support to the decision makers for use of basic and strategic research in agriculture, and; (*v*) Organizations of workshop, seminars, conferences etc. to create awareness, prioritization, scientific popularization and related issues. The scheme has already funded 112 projects, mostly in consortium mode out of which 69 are on-going projects and 60 are multi-institutional in nature. Besides supporting, reviewing, monitoring and evaluation of the on-going projects during 2016-17, the NASF initiated for funding of new projects which were in the process of evaluation. A total of 996 Concept Notes (CNs) were received against the Call VI. They were scrutinized by the corresponding Deputy Directors General and Expert Committees of the ICAR. A total of 18 projects were approved by the NASF and remaining proposals are in the process of being peer-reviewed. The 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, inviting new project proposals.

Workshop on Animal-Human conflict: A workshop on Human - Wildlife conflict in Agro-pastoral contexts, jointly organized by Indian Council of Agricultural Research and National Institute of Advanced Studies, Bengaluru, was held from 11 to 12 December 2015 at National Bureau of Agricultural Insect Resources, Bengaluru. Major thrust in the workshop was on wildlife conflict related to monkeys, wild boar, nilgai and elephant, that receive little attention in public discussions, yet cause enormous economic and human losses to small farmers. The workshop also deliberated to understand different dimension of human-wildlife conflict in agricultural ecosystem and way to mitigate the losses caused to agriculture by wildlife, with minimum losses to wild animal.

Workshop on GM Crops: The workshop on 'GM Crops in India-Way forward' was held on 17 May 2016 in New Delhi. The deliberations during the workshop included regulatory aspects, biosafety issues, transgenic research for academic purpose *vs* product oriented research, NOC from states for field trials, need of joining hands of ICAR and DBT, need of a joint taskforce, priorities of traits and crops for GM research, trait availability within germplasm and transgenic development, and pyramiding of transgenes.

Monitoring of ongoing projects: The on-going projects are being monitored at three levels. Each project has an 'Advisory Committee' which intensively reviews and monitors the projects. Besides the projects are being reviewed by the 'Experts Committees' and the 'Empowered Committee'. More than 25 advisory committee meetings were held in 2016-17 to mentor, monitor and evaluate the projects. Similarly six Annual Review meetings were held in February 2016 to review the on-going projects by the Expert Committees.

Client feedback: A survey based on a questionnaire was done among the Principal Investigators (CPIs and CCPIs) of the on-going projects to understand the scientists' perception on the processes being followed by the NASF for different activities related to award of new projects, monitoring, reviewing, release of funds and other form of supports. The results indicated satisfaction level of scientists. More than 90% of the PIs responding the questionnaire belonged to the category of more than 80% satisfaction level. This indicated that the steps and methods followed for the award of the projects and implementation are useful and efficient for the proponents. The feedback received from the stakeholders will help NASF in improving the system further.

The projects under the NASF on the whole have started giving desired results. Besides, the results in terms of high impact publications, patents and technologies, a strong and sustainable platform for developing scientific capacity and culture that encompasses the extended NARS is being established. This will ensure continuous flow of knowledge, ideas and working together among different stakeholders in the basic, strategic and frontier areas for solving problems in agriculture and also forming science policy in agriculture.

Salient achievements

During 2016-17, besides having 77 publications in reputed journal, NASF had five patents and 29

technologies. The research highlights of some selected projects are as follows:

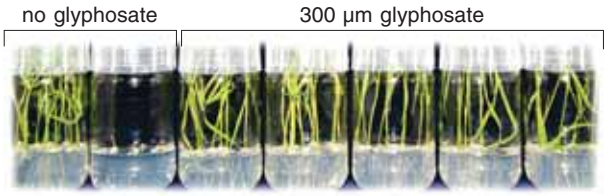
Phenomics of moisture deficit and low temperature in rice: Hyper-spectral reflectance based models which can predict relative water content with high accuracy were developed for high throughput non-destructive phenotyping drought tolerance of rice. Further, to differentiate rice genotypes, hyper spectral method based seperability index was developed. Twenty five candidate genes from rice have been cloned and functional validation is in progress. Analysis of rice F-box protein genes *OsFBX257* and *OsFBK10*, and homeodomain protein gene *OsHOX22* in *Arabidopsis* showed that these genes are negative regulators of stress tolerance. Transgenic analysis showed that ABA receptor (*OsABAR6*) gene confers enhanced drought tolerance to rice.

Plant Phenomics Facility at IARI, New Delhi

Establishment of state-of-art plant phenomics facility: A state-of-art automated high throughput plant phenomics facility for non-destructive and accurate characterization of a large number of germplasm and recombinant inbred lines under defined environmental treatment conditions was established at IARI, New Delhi. The facility consists of hi-tech climate controlled greenhouses, moving field for handling of 1,200 plants within the greenhouse and to transport them to imaging stations, different imaging platforms, viz. IR Thermal, Chlorophyll fluorescence, Visual RGB, NIR root, NIR shoot, VNIR Hyper-spectral, SWIR Hyper-spectral sensors, with computational support for image capture and analysis, and five weighing and watering stations in order to impose various drought/water-logging/ nutrient deficiency stresses, and to assess input use efficiency.

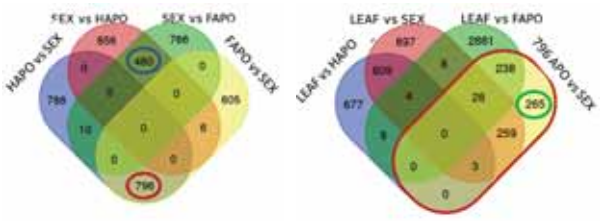
Genes for drought tolerance: RNAi silencing and overexpressing transgenic lines of ABA receptor 6 (ABAR6), MYB transcription factor (MYB TF), Protein Kinase SnRK2 and Expressed Protein (EP) genes were developed and analyzed. Transgenic rice lines overexpressing *OsABAR6* gene showed enhanced drought tolerance. Analysis of physiological basis of drought tolerance conferred by ABAR6 revealed that the transgenic plants have enhanced root growth and stomatal closure, low excised leaf water loss and reduced whole plant water use. Rice transgenics over expressing SnRK2 and EP genes also showed enhanced salt and drought tolerance, respectively at seedling stage. Analysis *Arabidopsis* transgenics over expressing rice HD-ZIP I class homeobox gene *OsHOX24* revealed that this nuclear localized HOX24 is a negative regulators of abiotic stress tolerance.

Double herbicide tolerant transgenic rice for weed management: Two broad-spectrum non-selective systemic herbicides sulfonylurea for pre-emergent application and glyphosate for post-emergent application were selected. Both mutated EPSPS and ALS were cloned to a single plant transformation vector and simultaneously transformed into rice and the transgenic lines showed significant tolerance to glyphosate and sulfonylurea but not fit enough to the recommended dose for weed management. Two multisite-compensating mutations in rice EPSP synthase were identified by substituting more amino acid (T173I, P177S or G172A, T173I and P177S) simultaneously by which these multisite-compensating mutations drastically decreased affinity for glyphosate and no hindrance for its catalytic functions as predicted by the structural docking using the bioinformatics tools. The transgenic lines expressing double amino acid (T173I, P177S) substituted mutant EPSP synthase showed very high tolerance to glyphosate without any fitness cost, whereas, the transgenic lines expressing G172A, T173I, P177S substituted mutant EPSP synthase showed significant fitness cost with moderate glyphosate tolerance. The transgenic lines expressing double amino acid substituted EPSP synthase and ALS for glyphosate and sulfonylurea are being evaluated for agronomic performances.



Transgenic rice lines expressing double amino acid (T173I, P177S) substituted mutant EPSP synthase

Development of transgenic pigeonpea and chickpea: At IIPR, Kanpur, a total of 100 putative chickpea transformants and 51 putative pigeonpea transformants were generated using *Agrobacterium tumefaciens* mediated genetic transformation. Genetic fidelity of the transgenic chickpea lines derived from DCP92-3 was assessed using SSR markers having genome wide coverage. Detached leaf bioassay was conducted in T_1 lines derived from two chickpea events using third instar larvae. Based on molecular analyses and insect bioassay data, three promising events each in chickpea and pigeonpea were identified for Event Selection Trial and application submitted to RCGM, Department of Biotechnology, New Delhi. At AAU, Jorhat, more than 200 transgenic lines have been

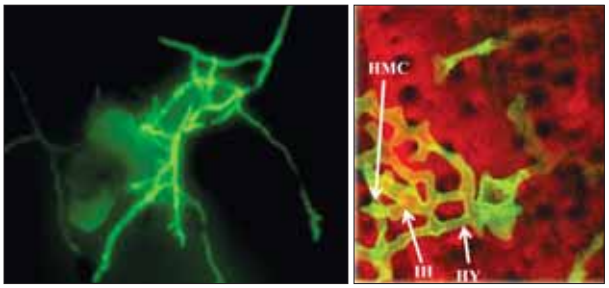


Overlap analysis of the up-regulated genes in hermaphrodite apomictic (HAPO), female apomictic (FAPO), sexual (SEX) and leaf (LEAF) tissues

generated in chickpea using different Bt-*Cry* gene constructs harbouring either a *Cry1Ac* or a *Cry2Aa* gene. Of these, 12 lines had high level of Bt toxin (>30 ng/mg FW) and in 9 of these 12 lines, transgene segregated at a ratio of 3:1. Lines with complete protection against *Helicoverpa* were obtained. At UAS, Dharwad, 202 primary transformants for *cry1Ac* and 216 primary transformants for *cry2Aa* in pigeon-pea were generated. 53 *cryAc* positive and 20 *cry2Aa* positive plants were selected and the bioassay of all 53 transformants showed a maximum mortality of about 90.0%. In two events the progenies showed 15:1 segregation. In the progenies maximum larval mortality observed was about 84.0%.

Molecular and genetic analyses of guggul for adventive embryony: The genome of guggul was sequenced, assembled and the transcriptome from different tissues both sexual and apomictic guggul *(Commiphora wightii*) plants which includes ovules, leaf and fruit wall tissue were annotated. Analysis of the assembled contigs reveals that most of the transcripts show very high similarity to apomictic genes from other species. Differentially expressed genes were identified with RSEM, abundance estimation and EDGE-R analysis. Only 265 transcripts showed expression restricted to the apomictic plants. Therefore these genes are being analyzed further to narrow down the search for the candidate gene.

Understanding the mechanisms of non-host resistance against rust and blast in rice and wheat: A total of 57 rice accessions including seven cold tolerant varities were screened against non-host pathogen, *Puccinia graminis tritici* 40A. It was observed that *Puccinia graminis tritici* 40A interacts with rice genotypes albeit without any pustule formation. Not only had the *Puccinia graminis tritici* 40A recognized rice plant, but entered the rice stomata and colonized intercellular spaces of several



Recognition and entery of *Puccinia graminis tritici* 40A into stomata of rice plant

mesophyllic cells with concomitant and spontaneous defense responses.

High oleic safflower genotypes through functional genomics: A TILLING population (M_1) of safflower variety PBNS-12 comprising 6,368 lines was developed. A germplasm comprising ~700 safflower accessions was raised and is being screened to identify high oleic accessions as well as natural variants of *FAD2* genes. Fatty acid profiling of 137 accessions by gas chromatography (GC) was performed and two varieties (IIOR-SAF-29 and IIOR-SAF-39) with 75% oleic acid and one variety (IIOR-SAF-20) with 53% oleic acid content were identified. A method based on unsaturation number with iodine value is being developed to quickly identify high oleic accessions. The *FAD2-1* gene from PBNS-12 was sequenced, which showed 99% and 98% similarity to the NCBI deposited sequences (HM165274.1 and KC257447.1) of two safflower varieties.

Molecular mechanism of induction of biotic stress tolerance by *Trichoderma* spp. in castor: Early events of colonization of castor roots by *Trichoderma* assessed through TEM and SEM studies, had established that the fungus entered roots through the intercellular spaces and colonized in the apoplastic region of the roots. By working using confocal-flourescent microscopy by specifically tagging the chitin of the fungi with the green fluorescent dye FITC, penetration was observed 72 hpi in the interstitial spaces of the cortical cells of the root. Presence of the fungus was deduced using the Z-stacking imaging. The colonization was confined to the cortical region of the *Trichoderma* treated root. The LCMS studies of the secretome of castor *Trichoderma* interaction revealed the presence of a known elicitor of biotic stress response, 1-hydroxy 3-methyl anthraquinone, in the plant + *Trichoderma* secretome fraction in independent replicates.

Infertility in crossbred bulls and early prediction of fertility: The complete protein profiling of spermatogenic cells derived from indigenous (control) and crossbred males at two age groups (6 and 24 months) were analyzed using bioinformatics and the earlier identified fertility associated proteins in crossbred bull spermatozoa were assessed for their presence in spermatogenic cells. The fertility associated proteins were validated for their efficiency in predicting bull fertility using spermatozoa from large numbers of bulls with known fertility. Four fertility associated sperm proteins (protein A, B, C and D) were identified in 6 and 24 months spermatogenic cells. Hence, the expression of these proteins in spermatogenic cells was compared between indigenous and crossbred males. The proteins A, B, C and D were observed to over-express in spermatozoa from high fertile bulls by 1.93, 2.17, 3.15 and 1.96 folds compared to low fertile bulls, respectively. The expression of these proteins in spermatogenic cells of indigenous males was 1.7, 0.8, 0.74 and 2.03 fold higher, respectively compared to crossbred bulls at 24 months of age. However at 6 months of age the differential expression

was quite impressive; the expression of these proteins in spermatogenic cells of indigenous males was 9.1, 1.8, 8.24 and 1.32 fold higher compared to crossbred bulls at 6 months of age.

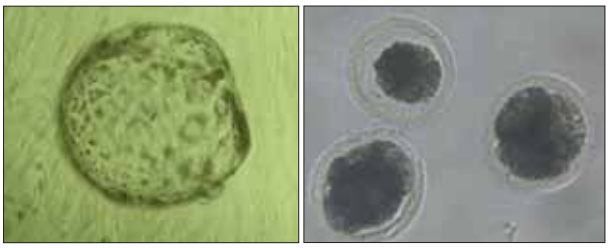
Luteinizing hormone based sensor for estrus detection in buffaloes: Putative peptide sequences from buffalo LH protein beta subunit were identified, designed and characterized by several bioinformatics analyses in order to develop luteinizing hormone based Sensor for Estrus Detection in Buffaloes. Polyclonal antibodies (Anti-LHP) against those peptides were raised in rabbit. Gold nanoparticles (AuNPs) were conjugated with most specific anti-LHP antibody. It was observed that the AuNP-anti-LHP2 conjugate was specific (antibody against LHP2; Anti-LHP2) for LH and was not found to binds with BSA and other non-specific proteins. Besides crude LH, the conjugate binds to bovine anti-rabbit IgG (secondary antibody), which was also coated on lateral flow strip. Antibody generated against the identified peptide sequence has satisfactory affinity with buffalo and bovine LH.

Mechanism of aberrant maternal recognition of pregnancy in sheep and buffalo under heat and nutritional stress: A group of 16 adult Malpura ewes were exposed to nutritional and heat stresses. Superovulation was induced by a combination of single injection of 200 IU eCG and multiple injections of Folltropin-V. Combined stress increased respiration rate and rectal temperature and blood urea, whereas decreased average daily gain. The ovarian response, ovulation rate and embryo production decreased; and number of large follicles (anovulation) increased under combined stress.

Corpus luteum on sheep endometrium

The expression of PGFS mRNA increased significantly on Day 13 of pregnancy but COX-II and PGES mRNA expression decreased significantly following combined stress. Expression of HSP 70 mRNA increased but Integrin and Galactin mRNA decreased on Day 13 of pregnancy in response to combined stress. MRP related genes, viz. COX-II, PGES, PGFS, Galactin, Integrin, Osteopontin, FGF2 and IGF2 cDNA were cloned and characterized in sheep. The nucleotide sequence of COX-II cDNA revealed 84-97% identity with the corresponding mammalian homologs, whereas deduced amino acid sequence exhibited 81-98 % homology. The gene expression study revealed that the most likely cause of oocyte deterioration as a result of heat stress is increased oxidative stress and ATP starvation leading to apoptosis. The important milestones of embryonic development like maternal to embryonic transition and morula to blastocyst transition were found to be seriously compromised as result of heat stress. Increased oxidative stress and poor mitochondrial metabolism were detected as key factors responsible for adverse effect of heat stress on oocytes and embryos.

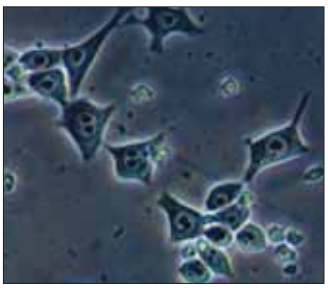
Development of parthenogenetic goat from embryonic stem cells: Parthenogenetic *caprine* embryos died after approximately 34 day of gestation, with limited development of extra-embryonic tissues. The main reason for the halted development of asexual embryos is genomic imprinting, a chromosomal modification leading to parental-origin-specific gene expression in somatic cells. Tetraploid ivf embryos and diploid parthenogenetic embryonic stem cells can be aggregated to make chimeras. A protocol was standardized to produce chimeric embryos using



Production of chimeric embryos and blastocysts from embryonic stem cells

tetraploid complementation assay. *In vitro* fertilized embryos were selected at 2 cell stage between 24 and 30 hr post insemination. The chimeric embryos were produced by parthenogenetic embryonic stem cells and fertilized tetraploid embryo complementation. Chimeric embryos produced by aggregation method, were then cultured the production of blastocyst stage embryos.

Regulation of fatty acid synthesis by RNAi in pig: Too much of fat in pork makes it 'unhealthy' for consumption. The overall objective was to generate chimeric pig, expected to have lower body fat. The project aims to produce designer pork with reduced fat using transgenic induced pluripotent stem (iPS) cells. The mesenchymal stem cell lines from porcine bone marrow were isolated. Using these cell lines, effective siRNA sequences against the target genes were identified and shRNA in appropriate delivery system was generated. Further, mesenchymal stem cell lines were used for reprogarmming and



Porcine induced pluripotent stem (iPS) cell colonies

produced putative iPS cells. These iPS cells were highly prolific, primarily grew in colony, morphologically distinct, different from mesenchymal stem cells, possessed higher volume of nuclei, compared to cytoplasmic content and expressed species specific iPS markers. The *in vitro* production of porcine embryos was standardized. The supplementation of testicular tissue lysate was found to improve developmental competence of porcine oocytes matured and fertilized *in vitro*.

Adaptive mechanisms and captive breeding in hilsa: Catch structure, growth, age, maximum sustainable yield, exploitation pattern and spawning stock biomass levels of hilsa (*Tenualosa ilisha*) from Hooghly estuary and near shore areas were worked out. Current exploitation exceeded sustainable yield levels and 75% decline occurred in standing stock biomass from virgin stock, necessitating judicious fishing and conservation measures. Existence of four distinct genetic stocks in hilsa was established. Wild collected broods of hilsa were successfully bred with 90% fertilization and 98% hatching of eggs. The artificial breeding protocol using natural brooders was standardized. After hatching, 42.5% larval survival and 30% nursery stage survival was achieved through early larval feed and management of water quality.

Hilsa grown in freshwater and brackish water pond

Hilsa cultured in freshwater pond | Hilsa cultured in brackish water pond

Hilsa fingerlings in grow out pond

Natural live food organisms of the fish were identified, isolated and mass cultured for feeding the larval stages. Milt cryopreservation trials resulted in generating viable sperms up to eight months of cryo-storage. Artificially bred hilsa spawn and fry were weaned to accept cultured natural food items and then on formulated feed in nursery and grow out stages. Hilsa seeds (81.11 ± 1.88 mm/ 5.4 ± 0.4 g) stocked @ 20,000 nos/ha in freshwater ponds grew to 259 mm/160 g in 19 months with 20% survival. The females grown in freshwater pond developed ovary up to stage IV in one year while males developed milt, indicating possibility of captive maturation. Hilsa seeds (52.97±5.50 mm/1.37±0.18 g) stocked @ 8,800 nos./ ha in brackish water ponds grew to 360g/330 mm in 21 months with 30% overall survival.

Green fishing systems for the tropical seas: The designing, fabrication and construction of the 19.75m energy efficient fishing vessel, christened as FV Sagar Harita, has been completed at the Goa Shipyard Ltd.

Designing, fabrication and launch of Sagar Harita

This new IR-Class combination fishing vessel has an array of novel features. The hull is made of marine grade steel and the cabin and wheel house is made of FRP to reduce weight, improve the carrying capacity and speed. The main engine power was finalized to 400 hp which is 20% lower than comparable size vessel. The fishing gear handling equipment such as split trawl winch, long line hauler, setter and gillnet hauler were designed with hydraulic power were installed onboard. Two RSW tanks (0°C to -10°C) of 1 tonne each capacity was installed. Solar power panel of 400 watt was designed and installed for emergency lighting. Acoustic Trawl telemetry system with under water sensor was also fitted. Bilge keels, bulbous bow, Kort nozzle propeller, fuel monitoring system are other fuel saving features of the vessel.

Diversity and synthesis of immunoglobulins in the Indian major carps: Immunoglobulin (Ig) Z and IgM expression has been analyzed in rohu and catla following argulus infection and the qRT-PCR data revealed significant induction of IgM in skin, muscle, gill and kidney of rohu. LrIgD gene expression in juveniles has been assessed by quantitative real-time PCR (qRT-PCR) showing gradual increase in IgD expression with the advancement of time. Tissue specific expression analysis of LrIgD in rohu fingerlings revealed highest expression in kidney followed by liver and spleen. B-cell activating factor (BAFF) has been cloned in rohu and catla. Rohu BAFF shared high structural similarity with human-BAFF suggesting the conservation of BAFF-signaling pathway from fish to human. BAFF is expressed in the embryonic developmental stages that may suggest its key role in immune response at the early life of fish. Both *in-vitro* and *in-vivo* treatment with toll-like

receptor (TLR)- ligand (poly I:C) or nod-like receptor (NLR)-ligands (iE-DAP and MDP) results in TLR and NLR activation and BAFF-gene expression. Involvement of MAP kinase (ERK) pathway in TLR-mediated immunoglobulin synthesis has been investigated by Western blotting and it showed expression of 44 kDa and 42 kDa of phospo-ERK (p-ERK) in TLR-ligand treated tissue protein.

Studies on micro-algal triacylglycerols (TAGs) as source of biodiesel: Five green microalgal species, viz. *Scenedesmus obliquus, Chlorella vulgaris, Chlorella minutissima, Scenedesmus accuminatus* and *Scenedesmus armatus* were selected after the screening of fifty oleaginous microalgal strains and were subjected to twelve different culture conditions. N-starved condition showed lipid accumulation by >40% of dry cell wt. in all the chosen species. A schematic model for an algal refinery was developed which demonstrated production of 0.06 g of β-carotene, 380 g (0.42 L) of biodiesel, 20 g of omega-3 fatty acids, 30 g (0.024 L) of glycerol, and 170 g (0.19 L) of bioethanol from 1 kg of *S. obliquus* dry biomass. A protein-rich algae meal with the standard (control) + whole microalgal + extracted microalgal protein diet (25:25:50) inducing significant growth stimulation in freshwater fish, was also formulated.

Decision support system for enhancing productivity of grapes: *Vitis* Mod, a grape simulation model (beta version) is developed. It is a process based model designed to run at daily step and it can simulate the growth, development and yield of grape. It has a modular structure with modules to simulate phenology, canopy, dry matter partitioning, yield, stress of water and temperature on growth and yield. As of now, the phenology module is calibrated, validated and evaluated for its simulation efficiency in farmers' fields. The phenology module is integrated into the web-based DSS. Currently, the phenology forecaster module is enabled. This DSS is available to farmers for use and validation.

Decision Support System for enhancing water productivity of irrigated rice-wheat cropping system: From the four years of experimentation, it can be concluded that the SRI and DSR methods of rice cultivation resulted in higher grain yield and saving of water as compared to puddled method. Further the crop simulation models, viz. AquaCrop and CERES-rice and wheat modules of DSSAT were calibrated and validated for all experimented rice and wheat cultivars under different rice cultivation methods and irrigation regimes and the water production functions were developed. The data acquired from field experiments were used as background data base for the development of water productivity decision support system for RWCS (WPDSS-RW).The developed DSS was operated with input data of different cultivars, cultivation methods, rainfall depths etc. for different locations to generate scenarios of grain yield under different irrigation depths, water productivity, water saving and consequent increase in the groundwater table information for enhancing water productivity of the study region.

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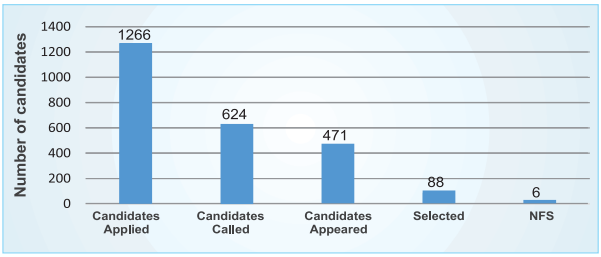
19.
Strengthening the Research System

Direct recruitment/lateral entry

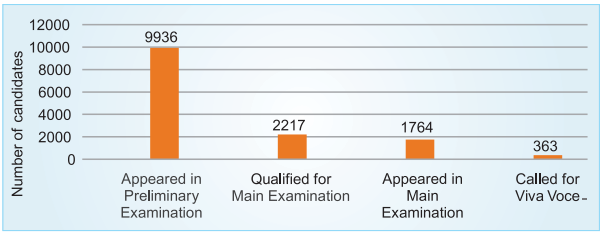
During the period, ASRB completed the recruitment process for 94 posts. Of these, 43% posts were Research Management Positions (Directors of National Institutes, Deputy Directors General, Assistant Directors General, Directors, Project Directors, Joint Directors of National Institutes and Joint Directors of other than National Institutes), 60% posts were for Head of Divisions, Project Coordinators and Principal Scientists. The Board has recommended 88 posts while only six posts could not be filled due to non-availability of suitable candidates.



Details of direct recruitment posts

ARS (Preliminary) Examination-2015

Combined examination for NET and ARS (Prelims) 2015 was conducted in online mode at 22 centres across India except Chennai centre. The examination at Chennai centre could not be held due to unforeseen rains and floods in and around Chennai. It was subsequently held during 6-12 January 2016. Out of 9,936 candidates appeared in preliminary examination, 2,217 candidates (22%) qualified for Main Examination. ARS Main Examination was conducted on 8 May 2016 at 12 centres. Out of 2,217 candidates, 1,764 (80%) appeared for 97 vacancies in 30 disciplines. The viva voce were conducted from 13 October 2016 to 29 November 2016 for 363 qualified candidates.

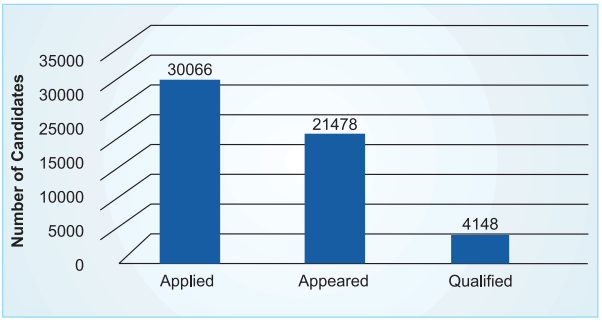


Details of ARS examination 2015

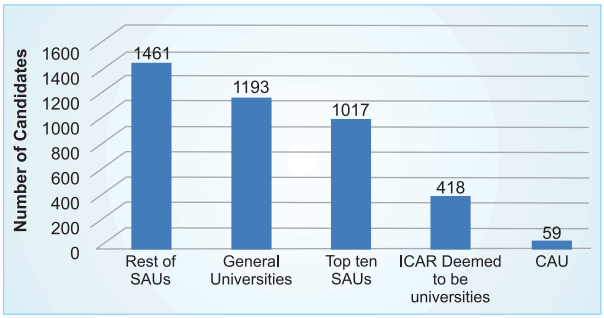
NET Examination-2015

A total of 30,066 candidates registered for the NET Examination-2015 and 21,478 candidates appeared in the examination. A total of 4,148 candidates (19%) qualified the examination.

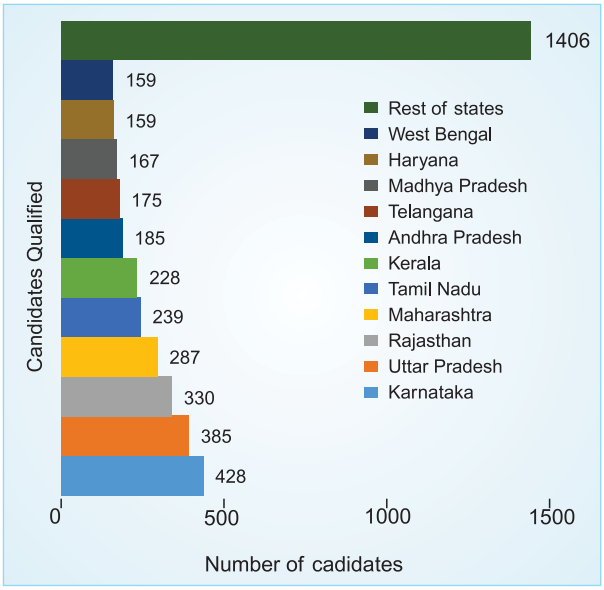
The lowest percentage of candidates qualified was in the discipline of Home Science (1.36%) and highest percentage of candidates qualified was in the discipline of Floriculture and Landscaping (65.90%), followed by Veterinary Anatomy (61.02%), Animal Reproduction and Gynaecology (52.17%), Seed Science and Technology (47.19%), Livestock Product Technology (44.32%) and Fish Nutrition (42.11%). In 10 disciplines, the success rate was less than 10%.



Details of NET examination-2015



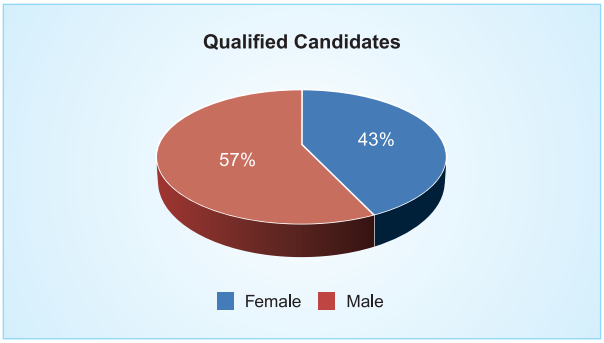
Organization wise performance in NET examination 2015



State wise details of successful candidates in NET examination 2015

Out of 4,148 qualified candidates, 1193 (28.76%) were from General Universities/International Universities with Agriculture Faculties,1017 (24.52%) from 10 State Agricultural Universities (TNAU, Coimbatore; UAS, Bangalore; GBPUA&T, Pantnagar; ANGRAU, Hyderabad; UAS, Dharwad; PAU, Ludhiana; CCSHAU, Hisar; BCKV, Nadia; Dr Yashwant Singh Parmar University of Horticulture and Forestry, Solan and UHS, Bagalkot), 418(10.08%) from Deemed-to-be Universities (IARI, New Delhi; IVRI, Izatnagar; NDRI, Karnal and CIFE, Mumbai, 1461(35.22%) from rest of SAUs and 59 (1.42%) from Central Agricultural Universities.

About 66% of successful candidates were from 11 states (Karnataka, Uttar Pradesh, Rajasthan, Maharashtra, Tamil Nadu, Kerala, Andhra Pradesh, Telangana, Madhya Pradesh, Haryana and West Bengal). States like Chhattisgarh, Andaman and Nicobar Islands, Lakshadweep, Goa, and Daman and Diu, had very little representation in the list of successful candidates. Among 4,148 qualified candidates, 43% were female candidates.



Gender wise deails of successful candidates

NET Examination-2016 (I)

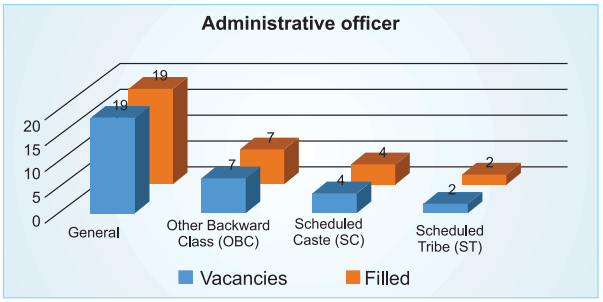
NET 2016 (I) examination was conducted from 1 to 6 August 2016 in online mode in 56 disciplines at 23 centres across India. A total of 28,558 candidates registered for the examination and 19,828 candidates appeared in the examination. A total of 3,803 candidates (19%) qualified the examination. Major discipline-wise details of candidates registered and appeared in the examination are as follows:

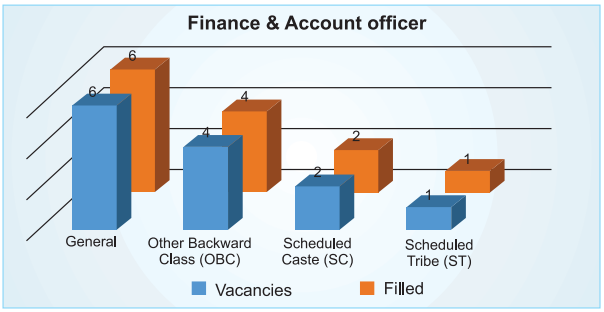
Major discipline-wise details of applicants

Discipline	Candidates registered	Candidates appeared	Candidates qualified	Qualified (%)
Crop Science	12,371	8,288	1,369	16.52
Horticulture	2,250	1,547	613	39.63
Animal Science	3,174	2,347	654	27.87
Fisheries Science	782	565	68	12.04
Natural Resource Management	4,558	3,218	523	16.25
Social Science	2,872	2,001	216	10.79
Agricultural Engineering	2,551	1,862	360	19.33
Total	28,558	19,828	3,803	19.18

Recruitment of AOs and F&AOs

Based on performance of candidates in the written examination and Structured Interview/Personality Test held in February 2016, 32 candidates were recommended for appointment to the post of Administrative Officers and 13 for Finance and Account Officers. Details are as follows:





Recruitment of Assistants

An all India Online Open Competitive Examination for recruitment of 309 Assistants (DR) was conducted from 5 January to 2 February 2015. A total of candidates 6,255 appeared in the main examination held across 12 centres in India on 18 October 2015.

The analysis further revealed that all the advertised vacancies were duly filled under various categories of candidates with maximum candidates under General Category (172 including 5 Divyang candidates), followed by Other Backward Castes (72 including 3 Divyang candidates), Scheduled Caste (40) and Scheduled Tribe (25). This year, out of 309 selected candidates, 26.5% were female.

The analysis of educational background of selected 309 candidates revealed that 129 candidates have B. Tech or BE degree. The complete analysis is given below:

Highest education qualification	Applied for preliminary examination	Qualified for main examination	Appeared in main examination	Selected
B.A.	13,670	1,055	849	42
B.Com.	6,189	506	407	11
B.Sc.	11,150	1,337	1,030	48
B. Tech./BE.	15,585	2,928	2,074	129
Other (Graduate)	3,450	379	290	8
M.A	3,920	345	272	12
M.B.A.	2,924	294	216	12
M.C.A.	1,260	147	124	2
M.Com	1,230	109	86	4
M.Tech./ ME	1,349	223	164	10
Other (post graduate)	1,586	159	117	5
Total	70,645	8,302	6,255	309

Common Written Examination 2016 for Technical Assistant (T-3)

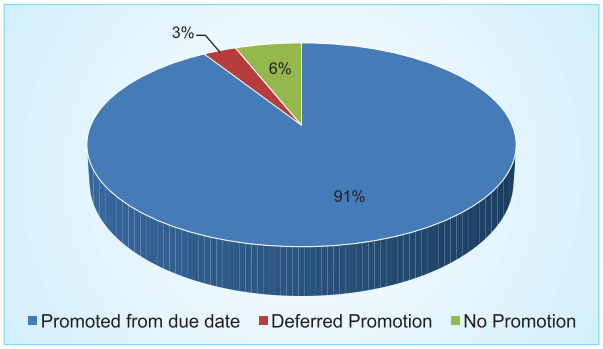
A common written examination for filling up of positions of Technical Assistant (T-3) was conducted on 17 July 2016 at 27 centers (Bangalore, Bareilly, Bhopal, Calicut, Coimbatore, Cuttack, Delhi, Dehradun, Gangtok, Hyderabad, Jaipur, Jhansi, Jodhpur, Karnal, Kasaragod, Kochi, Kolkata, Lucknow, Mumbai, Nagpur, Patna, Port Blair, Ranchi, Rajahmundry, Shimla, Thiruvananthapuram and Varanasi) across India. Further action is under progress.

Common Written Examination 2016 for Technician (T-1)

Common Written Examination 2016 for Technician (T-1) was conducted on 4 September 2016 at 27 centres (Bangalore, Bareilly, Coimbatore, Cuttack, Delhi, Dehradun, Goa, Hyderabad, Indore, Jaipur, Jodhpur, Junagadh, Kanpur, Karnal, Kasaragod, Kochi, Kolkata, Kozhikode, Medziphema, Mumbai, Nagpur, Patna, Port Blair, Ranchi, Rajahmundry, Shimla and Varanasi) across India. Further action is under progress.

Career Advancement Scheme (CAS)

A total of 253 proposals received from different ICAR institutes were assessed for placement from Senior Scientist to the grade of Principal Scientist under the revised Career Advancement Scheme (CAS) and four proposals were considered under the old Career Advancement Scheme. Major discipline- wise breakup of CAS proposals is as follows:



Major discipline-wise break-up

Major discipline	Proposals processed	
	Revised CAS	Old CAS
Crop Science	87	1
Horticulture	32	-
Natural Resource Management	35	1
Animal Science	29	-
Fisheries Science	15	
Agricultural Engineering	10	-
Social Science	45	2
Total	253	4

The outcome of this assessment indicated that 91% candidates got promotion from due date and 3% deferred promotions to the next higher grade.

Of the successful candidates, 28% secured more than 90% marks against the filed bench mark of 75 % and about 49% secured between 80-89.9% marks and only 7% candidates had secured less than 73% marks.

Out of 48 disciplines, all disciplines except eight disciplines, viz Agricultural Statistics, Biotechnology (PS), Computer Application in Agriculture, Fish and Fishery Science, Plant Pathology, Plant Physiology, Seed Technology and Soil Chemistry/Fertility/ Microbiology candidates got hundred per cent promotion.

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20. Training and Capacity Building

A systematic approach to develop and continuously improve organizational and individual competencies and capabilities is necessary for achieving organisational goals and objectives effectively. Human resource in an organization is the most crucial, vital and dynamic resource. Over the period, the Human Resource Management functions have undergone significant changes. Organizations are attaching tremendous importance to the management and development of their personnel. There is increasing recognition that the individual in an organization is a key resource and should not be simply looked upon as a cost. There is always need to improve competency in terms of skills, knowledge and attitude of the employees through appropriate training and development programmes from time to time. An employee becomes more efficient and productive if he/she is trained well as per training needs and competency gaps. To strengthen and facilitate training and capacity building of all categories of ICAR employees, the HRM Unit was established in September 2014 with the objectives: (*i*) Overall coordination, monitoring, implementation and management of training needs and HR policies for the Council. (*ii*) Evaluate and advice on all strategic HR needs and requirements of the Council.

During 2015-16, several initiatives were taken to strengthen training and capacity building of the ICAR employees and some accomplishments were attained as given below.

Nomination of HRD Nodal Officers

For effective implementation of training functions at the Institute, all 108 ICAR Institutes nominated HRD Nodal Officers for their Institute. The HRD Nodal Officers developed the Annual Training Plan (ATP) for various categories of employees-based on Training Need Assessment (TNA) along with organization of suitable trainings. They also ensured effective implementation of ATP.

Developing database of training details in ERP system

Availability of complete and comprehensive database of training details of all the employees provide a logical backup for assessing the training needs/gaps and helps in planning current and the future training programmes. Complete training details of about 2,710 (54.5%) scientists, 585 (10.5%) technical, 443 (11.5%) administrative personnel and 73 (1.3%) SSS are available in the ERP system. There would be complete database of training of all the employees in the near future.

Identification of training need/skill deficient areas

For the first time in ICAR, training need/skill deficiency of all categories of employees was undertaken at the Institutes. Almost all Institutes have identified the training areas/skill deficiency for different categories of employees and identified 128 training areas for scientists, 87 for technical, 49 for administrative personnel and 36 for skilled-supporting staff. This first time exercise has paved the way for further designing and developing the new training programmes.

Development of Annual Training Plan (ATP) based on training needs

Developing Annual Training Plan (ATP) based on training need assessment is necessary as per National Training Policy-2012 of Government of India. Systematic approach for training was implemented through development of ATPs based on identified training needs/skill deficiencies by the Institutes/ICAR

SMD-wise number of employees undergone training during 2015-16

SMDs ICAR HQs	No. of employees undergone training					% Employees undergone training				
	Scientists	Tech.	Admin	SSS	Total	Scientists	Tech.	Admin	SSS	Total
Crop Sci.	379	197	87	112	775	23.9	13.2	10.0	7.5	14.3
Hort Sci.	227	142	95	116	580	31.4	18.6	22.0	17.1	22.4
Natural Resource Management	236	158	77	93	564	30.4	18.8	15.3	11.7	19.3
Agril. Education	42	18	29	23	112	72.4	32.7	52.7	59.0	54.1
Agril. Eng.	85	53	21	32	191	34.3	13.9	9.5	13.9	17.7
Animal Sci.	232	61	98	68	459	29.9	7.2	15.9	4.3	12.0
Fisheries Sci.	172	114	64	193	543	32.3	19.9	18.6	38.1	27.7
Agril. Extn.	31	4	13	0	48	68.9	10.5	15.3	0.0	27.0
ICAR Hqs	34	16	124	0	174	42.0	18.0	22.8	0.0	22.1
Total	**1438**	**763**	**608**	**637**	**3446**	**29.8**	**15.0**	**16.6**	**11.8**	**18.1**

Number of Trainings organized by various SMDs during 2015-16

SMDs/ICAR Hq	Scientists	Technicals	Administrative	SSS	All Employees
Crop Science	81	42	18	29	170
Hort Science	25	09	08	09	51
Natural Resource Management	45	11	04	03	63
Agril. Education	42	07	02	04	55
Agril. Engineering	32	09	18	01	60
Animal Science	59	08	05	09	81
Fisheries Science	24	08	05	07	44
Agril. Extension	11	03	00	00	14
ICAR Hqs	04	04	15	00	23
Total	**323**	**101**	**75**	**62**	561

(Hqs). A total 86 Institutes/ICAR (Hqs) developed the ATP for their scientists, technical and administrative personnel for 2015-16. Such an exercise has been done for the first time in ICAR.

Leadership Workshops for Senior Personnels

The effective management of Human Resources (HR) is vital and critical for organizational excellence, more so for knowledge intensive R&D organization like ICAR. To enhance the capacity and capability of an individual for increasing the efficiency and effectiveness in discharging the responsibilities and duties, there is always need to improve the Skills, Knowledge and Attitude through participating in appropriate training and development programmes or workshops etc. Besides, such activities provide the learning opportunities for individual growth along with growth of the organisation. Therefore, 6 Leadership Workshops on Enhancing organizational productivity through management of people at work were organized in collaboration with NAARM, Hyderabad in which 95 DARE/ICAR/ASRB senior officials participated.

In-house training of employees

To enhance the knowledge and skills of administrative staff of ICAR (Hqs), for the first time weekly (one-hour one-day/week) in-house trainings were initiated without any financial liability at ICAR (Hqs) in which 107 Section Officers and Assistants participated.

Design and development of new training programmes for Technical personnel/stenographers

For the first time designing and development of new specialized training programmes (60) was initiated by 16 leading and competent institutes based on identified training need/skill deficient areas for financial personnels.

Suitable training programme exclusively for Stenographer Grade–III, PA, PS and PPS of ICAR (Hq)/institutes was developed. For the first time designing and development of a new training programme 'Enhancing efficiency and behavioural skills' was initiated by NAARM, Hyderabad.

Training and capacity building of the employees

During 2015-16, a total of 3,446 employees took various types of training and capacity development programmes, out of which Scientists, Technical, Administrative including Finance, and Skilled Supporting Staff (SSS) were 1438, 763, 608 and 637, respectively.

During 2015-16, Crop Science Division deputed highest number of Scientists (379) and Technical staff (197) while highest number of Administrative staff was deputed by ICAR Hqs (124) for various capacity building programmes. Fisheries Science Division trained highest number of SSS (193) at its various Institutes. Overall, maximum number of employees were trained in Crop Science Division (775) followed by Horticultural Science Division (580) out of 3,446 employees trained in the ICAR system.

Scientists (29.8%), Technical (15.0%), Administrative (16.6%) including Finance and Skilled Supporting Staff (11.8%) were trained in various aspects as per their training needs during 2015-16. The data revealed that 7.7 and 11.1% of Technical and Skilled Supporting Staff, respectively, had undergone more trainings during 2015-16 as compared to 2013-14.

Among the larger Divisions of ICAR, maximum percentage of employees undergone training and capacity building programmes, was in Horticultural Science (22.4) followed by NRM Division (19.3). In comparison to cadre strength, Agricultural Education Division deputed the highest number of Scientists, Technical and Administrative Staff with overall average of 54.1%.

During 2015-16, the training programmes were organized for Scientists, Technical, Administrative including Finance, and Skilled Supporting Staff were 323, 101, 75 and 62, respectively.

Crop Science Division organized maximum number of trainings for Scientists (81), Technical (42), Administrative Personnels (18) and Skilled Supporting Staff (29) with overall maximum number of trainings (170) during 2015-16 for all the categories of staff.

❑

(A) DEPARTMENT OF AGRICULTURAL RESEARCH AND EDUCATION

APPENDIX I

SUBJECTS ALLOCATED TO DEPARTMENT OF AGRICULTURAL RESEARCH AND EDUCATION (*KRISHI ANUSANDHAN AUR SHIKSHA VIBHAG*)

Part I

The following subjects which fall within List I of the Seventh Schedule to the Constitution of India:

1. International cooperation and assistance in the field of agricultural research and education including relations with foreign and international agricultural research and educational institutions and organizations.
2. Fundamental, applied and operational research and higher education including coordination of such research and higher education in agriculture, agro-forestry, animal husbandry, dairying, fisheries, agricultural engineering and horticulture including agricultural statistics, economics and marketing.
3. Coordination and determination of standards in institutions for higher education or research and scientific and technical institutions in so far as they relate to food and agriculture including animal husbandry, dairying and fisheries. Development of Human Resources in Agricultural Research/Extensions and Education.
4. Cess for financing to the Indian Council of Agricultural Research and the Commodity Research Programmes other than those relating to tea, coffee and rubber.
5. Sugarcane research.

Part II

For Union Territories the subjects mentioned in Part I above, so far as they exist in regard to these Territories and in addition the following subject which falls within List II of the Seventh Schedule to the Constitution of India:

6. Agricultural Education and Research.

Part III

General and Consequential:

7. Plant, animal and fish introduction and exploration.
8. All India Soil and Land Use Survey relating to research training, correlation, classification, soil mapping and interpretation.
9. Financial assistance to State Governments and Agricultural Universities in respect of agricultural research and educational schemes and programmes.
10. National Demonstrations.
11. Indian Council of Agricultural Research and its constituent Institutes, National Research Centres, Project Directorates, Bureaux and All India Coordinated Research Projects.
12. Research and Development on production and improvement of bio-fuels plants.

APPENDIX II

TOTAL NUMBER OF POSTS AND NAMES OF IMPORTANT FUNCTIONARIES

Group	Designation	Sanctioned strength
A	Secretary (DARE) and DG (ICAR)	1
A	Additional Secretary and Financial Advisor	1
A	Additional Secretary (DARE) and Secretary (ICAR)	1
A	Director	1
A	Deputy Secretary	1
A	Senior Principal Private Secretary/Principal Staff Officer	1
A	Joint Director	1
A	Under Secretary	7
A	Principal Private Secretary	3
B	Assistant Director (Official Language)	1
B	Private Secretary	3
B	Section Officer	4
B	Assistant Section Officer	5
B	Personal Assistant/Steno Grade 'C'	4
C	Junior Hindi Translator	1
C	Senior Secretariat Assistant (UDC)	1
C	UDC-cum-Cashier	1
C	UDC-Hindi Typist	1
C	Stenographer Grade 'D'	3
C	Staff Car Driver	1
C	Junior Secretariat Assistant (LDC)	1
D	Daftry	1
D	Peon	5
	Total	49

NAMES OF THE IMPORTANT FUNCTIONARIES

Sl.No.	Name	Designations
1.	Dr Trilochan Mohapatra	Secretary (DARE) and DG (ICAR)
2.	Shri Sunil Kumar Singh	Additional Secretary and Financial Advisor
3.	Shri Chhabilendra Roul	Additional Secretary (DARE) and Secretary (ICAR)
4.	Shri Rajan Agrawal	Director
5.	Shri Mohinder Kumar	Principal Staff Officer
6.	Shri A.R. Sengupta	Deputy Secretary
7.	Shri Jitendra Misra	Under Secretary
8.	Shri T.B. Baviskar	Under Secretary
9.	Shri P.P. Maurya	Under Secretary
10.	Shri A.G. Subramanian	Under Secretary
11.	Shri Rajesh Kumar	Under Secretary
12.	Shri R Vijayaraghavan	Under Secretary
13.	Shri U.S. Pandey	Under Secretary
14.	Shri Kurien John	Principal Private Secretary
15.	Shri Sanjeev Kumar Sharma	Principal Private Secretary
16.	Shri Ajay Wadhwa	Principal Private Secretary
17.	Dr Puran Singh	Assistant Director (Official Language)

APPENDIX III

ACTIVITY PROGRAMME CLASSIFICATION

The Budget Estimates (BE) of DARE for Plan and Non-Plan for 2015-16 is ₹ 19800.00 lakh and ₹ 1179.35 lakh respectively and Revised Estimates (RE) of DARE for Plan, and Non-Plan for 2015-16 is ₹ 18900.00 lakh and ₹ 1179.35 lakh respectively. The Budget Estimates (BE) of DARE for both Plan and Non-Plan for 2016-17 is ₹ 30000.00 lakh and ₹1311.00 lakh. The detailed break-up of these financial figures are given below in Table 1.

Table 1. Budget Estimates and Revised Estimates of DARE

(Rupees in lakh)

Budget head	Item	Budget Estimates 2015–2016		Revised Estimates 2015–2016		Budget Estimates 2016–2017	
		Plan	Non-Plan	Plan	Non-Plan	Plan	Non-Plan
Major Head '3451'							
090	Secretariat-Economic Services	–	611.00	–	611.00	–	681.00
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	150.00	–	100.00	–	200.00	–
020035	-Grants for creation of Capital Assets	700.00	–	825.00	–	6,700.00	–
020036	-Grants in Aid Salaries	150.00	–	75.00	–	100.00	–
03	-Grant-in-Aid Central Agricultural University Bihar						
030031	-Grants in Aid General	200.00	–	200.00	–	1,000.00	–
030035	-Grants for creation of Capital Assets	150.00	–	150.00	–	1,700.00	–
030036	-Grants in Aid Salaries	650.00	–	650.00	–	3,000.00	–
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	250.00	–	200.00	–	150.00	–
050035	-Grants for creation of Capital Assets	250.00	–	50.00	–	30.00	–
050036	-Grants in Aid Salaries	100.00	–	50.00	–	120.00	–
80.798	-International Co-operation (Minor Head)						
01	-India's membership Contribution to Commonwealth Agricultural Bureau						
010032	-Contribution	–	25.00	–	25.00	–	25.00
02	-India's Membership Contribution to Consultative Group on International Agricultural Research						
020032	-Contribution	–	487.50	–	487.50	–	549.05
03	-Other Programmes						
030012	-Foreign Travel Expenses	–	–	–	–	–	–
030020	-Other Administrative Expenses	–	–	–	–	–	–
030032	-Contribution	–	–	–	–	–	–
04	-Asia Pacific Association of Agricultural Institutions						
040032	-Contribution	–	7.30	–	7.30	–	7.30
05	-N.A.C.A.						
050032	-Contribution	–	44.00	–	44.00	–	44.00

Budget head	Item	Budget Estimates 2015–2016		Revised Estimates 2015–2016		Budget Estimates 2016–2017	
		Plan	Non-Plan	Plan	Non-Plan	Plan	Non-Plan
06	-Regional Coordination Centre for Research and Development of Coarse Grains, Pulses, Roots and Tuber Crops (CGPRT) in the Humid Tropics of Asia and the Pacific						
060032	-Contribution	–	–	–	–	–	–
07	-International Seed Testing Association, Zurich, Switzerland						
070032	-Contribtion	–	4.25	–	4.25	–	4.25
08	-International Society for Horticulture Science, Belgium						
080032	-Contribution	–	0.30	–	0.30	–	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	2,000.00	–	2,899.00	–	2,900.00	–
010035	-Grants for creation of Capital Assets	7,600.00	–	7,000.00	–	7,000.00	–
010036	-Grants in Aid Salaries	7,000.00	–	6,700.00	–	7,000.00	–
02	-Grant-in-Aid-General to Central Agricultural University, Barapani						
020031	-Grants in Aid General	50.00	–	0.34	–	34.00	–
020035	-Grants for creation of Capital Assets	500.00	–	0.33	–	33.00	–
020036	-Grants in Aid Salaries	50.00	–	0.33	–	33.00	–
	Total	**19,800.00**	**1,179.35**	**18,900.00**	**1,179.35**	**30,000.00**	**1,311.00**

Table 2. Details of Financial Outlay
Department of Agricultural Research and Education

The gross provision for Demand No. 2 - DARE, excluding recoveries is as under: *(Rupees In crore)*

Particulars	Actual 2014-15			Budget 2015-2016			Revised 2015-2016			Budget 2016-2017		
	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
Revenue	2336.82	2377.85	4714.67	3301.00	2623.32	5924.32	2680.00	2580.32	5260.32	3700.00	2920.00	6620.00
Capital	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Total	**2336.82**	**2377.85**	**4714.67**	**3301.00**	**2623.32**	**5924.32**	**2680.00**	**2580.32**	**5260.32**	**3700.00**	**2920.00**	**6620.00**

A. The Budget allocations, net of recoveries and receipts, are given below:

Sl. No.	Group/Sub Group/Sub Sub Group/Scheme/Sub Scheme/ Programme/Sub Programme	Major Head	Actual 2014-2015			Budget 2015-2016			Revised 2015-2016			Budget 2016-2017		
			Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
	Revenue		2456.82	2383.19	4840.01	3691.00	2629.00	6320.00	3000.00	2586.00	5586.00	3700.00	2920.00	6620.00
	Capital		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
	Total		**2456.82**	**2383.19**	**4840.01**	**3691.00**	**2629.00**	**6320.00**	**3000.00**	**2586.00**	**5586.00**	**3700.00**	**2920.00**	**6620.00**
	B.E. 2016-2017													
1.	Secretariat-Economic Services													
1.01	Secretariat-Economic Services	3451	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.81	6.81
1.02	Contributions to Commonwealth Agricultural Bureau, Consultative Group on International Agricultural Research and Association of Asia Pacific Agricultural Research Institute	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.30	6.30
	Total-Secretariat-Economic Services		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.11	13.11
2.	Natural Resource Management and Climate Resilient Agriculture													
2.01	Natural Resource Management Institutes including Agro-Forestry Research	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	220.00	406.37	626.37
		2552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00	0.00	40.00
	Total		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**260.00**	**406.37**	**666.37**
2.02	Climate Resilient Agriculture Initiative	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	103.00	0.00	103.00
		2552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	0.00	7.00
	Total		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*110.00*	*0.00*	*110.00*
	Total-Natural Resource Management and Climate Resilient Agriculture		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	370.00	406.37	776.37

(Table 2 continued)

	Particulars	Major Head	Actual 2014-15			Budget 2015-2016			Revised 2015-2016			Budget 2016-2017		
			Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
3.	Crop Sciences													
3.01	Crop Science	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	506.00	865.48	1371.48
		2552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.00	0.00	14.00
	Total		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*520.00*	*865.48*	*1385.48*
3.02	Horticultural Science	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	189.00	360.71	549.71
		2552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.00	0.00	11.00
	Total		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*200.00*	*360.71*	*560.71*
3.03	National Fund for Basic, Strategic and Frontier Application Research in Agriculture	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	70.00	0.00	70.00
3.04	Indian Council of Agricultural Research(ICAR) Headquarters Administration	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	400.00	145.21	545.21
	Total-Crop Sciences		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1190.00	1371.40	2561.40
4.	Animal Sciences													
4.01	Animal Science	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	243.00	582.68	825.68
		2552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.00	0.00	17.00
	Total		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*260.00*	*582.68*	*842.68*
4.02	Fisheries Science	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	97.00	304.70	401.70
		2552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	3.00
	Total		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*100.00*	*304.70*	*404.70*
	Total-Animal Sciences		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	360.00	887.38	1247.38
5.	Agricultural Education													
5.01	Agricultural Education	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	575.00	74.75	649.75
		2552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.00	0.00	25.00
	Total		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*600.00*	*74.75*	*674.75*
5.02	Economic Statistics and Management	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.00	39.44	69.44
5.03	Agriculture University, Andhra Pradesh	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.04	Agriculture University, Rajasthan	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.05	Horticulture University, Telangana	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.06	Horticulture University, Haryana	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total-Agricultural Education		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*630.00*	*114.19*	*744.19*
6.	Agricultural Engineering and Extension													
6.01	Agricultural Extension	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	670.00	5.99	675.99
		2552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	80.00	0.00	80.00
	Total		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*750.00*	*5.99*	*755.99*
6.02	Agricultural Engineering	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	97.00	121.31	218.31
		2552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	3.00
	Total		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	121.31	221.31
	Total-Agricultural Engineering and Extension		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	850.00	127.30	977.30

(Table 2 continued) *(Rupees In crore)*

	Particulars	Major Head	Actual 2014-15			Budget 2015-2016			Revised 2015-2016			Budget 2016-2017		
			Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
7.	**Payment of Net Proceeds of Cess under Agricultural Produce Cess Act, 1940**													
7.01	Payment of Net Proceeds of Cess under Agricultural Produce Cess Act, 1940	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.25
8.	Central Agriculture Universities and Other Institutions												8.01	
8.01	Central Agriculture University, Imphal	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	170.00	0.00	170.00
	Total		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	170.00	0.00	170.00
8.02	Central Agriculture University, Bihar	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	57.00	0.00	57.00
8.03	Central Agriculture University, Bundelkhand	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	70.00	0.00	70.00
8.04	National Academy of Agricultural Sciences and Indian Agriculture Universities Association	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	3.00
	Total-Central Agriculture Universities and Other Institutions R.E. 2015-2016		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	300.00	0.00	*300.00*
9.	Secretariat - Economic Services	3451	0.00	4.24	4.24	0.00	6.11	6.11	0.00	6.11	6.11	0.00	0.00	0.00
	Agricultural Research and Education													
	Payments to Indian Council of Agricultural Research (ICAR)													
10.	**Crop Husbandry**													
10.01	Payments of net proceeds of cess under Agricultural Produce Cess Act, 1940	2415	0.00	0.25	0.25	0.00	0.25	0.25	0.00	0.25	0.25	0.00	0.00	0.00
10.02	Other Programmes of Crop Husbandry													
10.02.01	Crop Science	2415	380.10	712.11	1092.21	556.00	778.59	1334.59	485.00	778.05	1263.05	0.00	0.00	0.00
10.02.02	Horticulture	2415	144.35	287.48	431.83	214.00	324.80	538.80	175.00	320.88	495.88	0.00	0.00	0.00
10.02.03	Agricultural Extension	2415	535.00	3.76	538.76	570.00	3.91	573.91	595.00	3.89	598.89	0.00	0.00	0.00
10.02.04	Agricultural Education	2415	400.00	48.39	448.39	557.00	50.81	607.81	395.00	49.75	444.75	0.00	0.00	0.00
10.02.05	Economic Statistics and Management	2415	15.50	35.03	50.53	20.00	37.68	57.68	14.00	35.17	49.17	0.00	0.00	0.00
10.02.06	Agricultural Engineering	2415	65.00	95.36	160.36	87.00	109.57	196.57	80.00	104.00	184.00	0.00	0.00	0.00
10.02.07	ICAR Headquarter Administration	2415	161.00	123.11	284.11	308.00	144.27	452.27	150.00	135.65	285.65	0.00	0.00	0.00
10.02.08	National Fund for Basic, Strategic and Frontier Application Research in Agriculture	2415	60.00	0.00	60.00	130.00	0.00	130.00	45.00	0.00	45.00	0.00	0.00	0.00

(Table 2 continued) *(Rupees In crore)*

	Particulars	Major Head	Actual 2014-15			Budget 2015-2016			Revised 2015-2016			Budget 2016-2017		
			Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
10.02.09	National Agricultural Innovation Project/Externally Aided Project	2415	94.65	0.00	94.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.02.10	Agriculture University, Andhra Pradesh	2415	10.00	0.00	10.00	75.00	0.00	75.00	75.00	0.00	75.00	0.00	0.00	0.00
10.02.11	Horticulture University, Telangana	2415	10.00	0.00	10.00	75.00	0.00	75.00	75.00	0.00	75.00	0.00	0.00	0.00
10.02.12	Agriculture University, Rajasthan	2415	0.00	0.00	0.00	25.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00
10.02.13	Horticulture University, Haryana	2415	0.00	0.00	0.00	25.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00
10.02.14	IARI type Deemed University, Asom	2415	0.10	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.02.15	IARI type Deemed University, Jharkhand	2415	0.10	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total-Other Programmes of Crop Husbandry		1875.80	1305.24	3181.04	2642.00	1449.63	4091.63	2089.00	1427.39	3516.39	0.00	0.00	0.00
	Total-Crop Husbandry		1875.80	1305.49	3181.29	2642.00	1449.88	4091.88	2089.00	1427.64	3516.64	0.00	0.00	0.00
11.	Soil and Water Conservation													
11.01	Natural Resource Management Institutes including Agro-Forestry Research	2415	0.00	0.00	0.00	220.00	383.83	603.83	206.00	373.80	579.80	0.00	0.00	0.00
11.02	Climate Resilient Agriculture Initiative	2415	170.00	346.57	516.57	103.00	0.00	103.00	90.00	0.00	90.00	0.00	0.00	0.00
11.03	National Adaptation Fund	2415	65.00	0.00	65.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total-Soil and Water Conservation		*235.00*	*346.57*	*581.57*	*323.00*	*383.83*	*706.83*	*296.00*	*373.80*	*669.80*	*0.00*	*0.00*	*0.00*
12.	Animal Husbandry	2415	160.00	482.41	642.41	233.00	515.50	748.50	216.00	507.37	723.37	0.00	0.00	0.00
13.	Fisheries	2415	65.00	239.14	304.14	97.00	268.00	365.00	76.00	265.40	341.40	0.00	0.00	0.00
	Total-Payments to Indian Council of Agricultural Research (ICAR)		**2335.80**	**2373.61**	**4709.41**	**3295.00**	**2617.21**	**5912.21**	**2677.00**	**2574.21**	**5251.21**	**0.00**	**0.00**	**0.00**
14.	Grant in Aid to National Academy of Agricultural Sciences and Indian Agricultural Universities Association	2415	1.02	0.00	1.02	6.00	0.00	6.00	3.00	0.00	3.00	0.00	0.00	0.00
15.	Contributions to Commonwealth Agricultural Bureau, Consultative Group on International Agricultural Research and Association of Asia Pacific Agricultural Research Institute	2415	0.00	0.00	0.00	0.00	5.68	5.68	0.00	5.68	5.68	0.00	0.00	0.00
16.	Central Agricultural University, Bundelkhand	2415	119.00	5.36	124.36	10.00	0.00	10.00	10.00	0.00	10.00	0.00	0.00	0.00
17.	Central Agricultural University, Bihar	2415	1.00	0.00	1.00	10.00	0.00	10.00	10.00	0.00	10.00	0.00	0.00	0.00

(Table 2 concluded) *(Rupees In crore)*

	Particulars	Major Head	Actual 2014-15			Budget 2015-2016			Revised 2015-2016			Budget 2016-2017		
			Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
18.	Lumpsum provision for projects/ schemes for the benefit of North Eastern Region and Sikkim	2552	0.00	0.00	0.00	370.00	0.00	370.00	300.00	0.00	300.00	0.00	0.00	0.00
	Total-Agricultural Research and Education		**2456.82**	**2378.97**	**4835.79**	**3691.00**	**2622.89**	**6313.89**	**3000.00**	**2579.89**	**5579.89**	**0.00**	**0.00**	**0.00**
19.	Actual Recoveries	2415	0.00	-0.02	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Grand Total		**2456.82**	**2383.19**	**4840.01**	**3691.00**	**2629.00**	**6320.00**	**3000.00**	**2586.00**	**5586.00**	**3700.00**	**2920.00**	**6620.00**

	C.Plan Outlay	Major Head	Budget Support	IEBR	Total	Budget Support	IEBR	Total	Budget Support	IEBR	Total	Budget Support	IEBR	Total
1	Agricultural Research and Education	12415	2456.82	0.00	2456.82	3321.00	0.00	3321.00	2700.00	0.00	2700.00	2930.00	0.00	2930.00
2	North Eastern Areas	22552	0.00	0.00	0.00	370.00	0.00	370.00	300.00	0.00	300.00	370.00	0.00	370.00
	Total		2456.82	0.00	2456.82	3691.00	0.00	3691.00	3000.00	0.00	3000.00	3300.00	0.00	3300.00

Ending - SBE

E. State and UT Plan Schemes

	Actual 2014-2015			Budget 2015-2016			Revised 2015-2016			Budget 2016-2017		
	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
	Revenue	Cap./Loan	Total	Revenue	Cap./Loan	Total	Revenue	Cap./Loan	Total	Revenue	Cap./Loan	Total
No State/UT Plan Schemes in Demand No 2												

Ending - Part E (State and UT Plan Schemes)

	Major Head	Actual 2014-2015			Budget 2015-2016			Revised 2015-2016			Budget 2016-2017		
		Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
Starting - Part D (Major Head-wise Totals)													
	2415	2456.82	2378.95	4835.77	3321.00	2622.89	5943.89	2700.00	2579.89	5279.89	3330.00	2913.19	6243.19
	2552	0.00	0.00	0.00	370.00	0.00	370.00	300.00	0.00	300.00	370.00	0.00	370.00
	3451	0.00	4.24	4.24	0.00	6.11	6.11	0.00	6.11	6.11	0.00	6.81	6.81
	Total	**2456.82**	**2383.19**	**4840.01**	**3691.00**	**2629.00**	**6320.00**	**3000.00**	**2586.00**	**5586.00**	**3700.00**	**2920.00**	**6620.00**

(B) INDIAN COUNCIL OF AGRICULTURAL RESEARCH

APPENDIX 1

INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

(i) *Minister-in-charge of the portfolio of Agriculture in the Union Cabinet- President of the Society*

1. Shri Radha Mohan Singh — *Ex-officio*
   Minister of Agriculture and Farmers Welfare
   Government of India
   Krishi Bhavan
   New Delhi-110 001

(ii) *Minister of State in the Union Ministry of Agriculture and Farmers Welfare dealing with ICAR*

2. Shri Sudarshan Bhagat — *Ex-officio*
   Minister of State for Agriculture and Farmers Welfare
   Krishi Bhavan
   New Delhi-110 001
3. Shri S.S. Ahluwalia — *Ex-officio*
   Minister of State for Agriculture and Farmers Welfare
   Krishi Bhavan
   New Delhi-110 001

(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)*

4. Shri Arun Jaitley — *Ex-officio*
   Minister of Finance
   Government of India
   North Block, New Delhi-110 001
5. Shri Rao Inderjit Singh — *Ex-officio*
   Minister of State for Planning
   Government of India
   Room No.132, NITI Aayog,
   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. Dr Harsh Vardhan — *Ex-officio*
   Minister of Science and Technology
   Government of India, CSIR Building
   2 Rafi Marg, New Delhi-110 001
8. Smt. Nirmala Sitharaman — *Ex-officio*
   Minister of State for Commerce and Industry
   Government of India
   Udyog Bhavan, New Delhi-110 001

(iv) *Other Ministers in the Union Ministry of Agriculture and Farmers Welfare*

9. Shri Parshottam Rupala — *Ex-officio*
   Minister of State for Agriculture and Farmers' Welfare,
   Krishi Bhavan, New Delhi-110 001

(v) *Ministers in the States in-charge of Agriculture/Horticulture/ Animal Husbandry/ Fisheries*

ANDHRA PRADESH

10. Shri Prathipati Pulla Rao — *Ex-officio*
    Minister for Agriculture and Animal Husbandry and Fisheries
    Government of Andhra Pradesh
    A.P. Secretariat, Hyderabad
    Andhra Pradesh-500 022

ARUNACHAL PRADESH

11. Shri Wangki Lowang — *Ex-officio*
    Minister for Agriculture
    Government of Arunachal Pradesh
    CM Secretariat, Itanagar
    Arunachal Pradesh-791 111
12. Shri Pema Khandu — *Ex-officio*
    Chief Minister and holding the charge of Minister for Animal Husbandry and Fisheries
    Government of Arunachal Pradesh
    CM Secretariat, Itanagar
    Arunachal Pradesh-791 111

ASOM

13. Shri Atul Bora — *Ex-officio*
    Minister for Agriculture and Horticulture and Animal Husbandry
    Government of Asom
    Assam Secretariat, Dispur
    Guwahati -781006, Asom
14. Shri Parimal Suklabaidya — *Ex-officio*
    Minister of Fisheries
    Government of Asom
    Asom Secretariat, Dispur
    Guwahati -781006, Asom

BIHAR

15. Shri Awdhesh Kumar Singh — *Ex-officio*
    Minister for Animal Husbandry and Fisheries Resources
    Government of Bihar
    Vikas Bhavan, New Secretariat
    Bailey Road, Patna, Bihar-800 015
16. Shri Ramvichar Rai — *Ex-officio*
    Minister for Agriculture
    Government of Bihar
    Vikas Bhavan, New Secretariat
    Bailey Road, Patna, Bihar-800 015

CHHATISGARH

17. Shri Brijmohan Agarwal — *Ex-officio*
    Minister of Agriculture, Animal Husbandry and Fisheries
    Government of Chhattisgarh
    Mahanadi Bhawan, Mantralaya
    Naya Raipur - 492002, Chattisgarh

DELHI

18. Shri Gopal Rai — *Ex-officio*
    Minister for Development
    Delhi Secretariat, I.P. Estate
    New Delhi-110 002

GOA

19. Shri Ramesh Tawadkar — *Ex-officio*
    Minister of Agriculture and Animal Husbandry
    Government of Goa
    Secretariat,
    Panaji, Goa-403 001
20. Shri Avertano Furtado — *Ex-officio*
    Minister for Fisheries
    Government of Goa
    Secretariat
    Panaji, Goa-403 001

GUJARAT

21. Shri Chimanbhai Dharamshibhai Sapariya — *Ex-officio*
Minister for Agriculture
Government of Gujarat
1st Floor, Swarnim Sankul-I
New Sachivalaya, Gandhinagar
Gujarat-382 010

22. Shri Babubhai B. Bokhiriya — *Ex-officio*
Minister for Animal Husbandry and Fisheries
Government of Gujarat
1st Floor, Swarnim Sankul-I, New Sachivalaya
Gandhinagar, Gujarat-382 010

HARYANA

23. Shri Om Prakash Dhankar — *Ex-officio*
Minister for Agriculture, Dairying
Fisheries and Animal Husbandary
Government of Haryana, Haryana Civil Secretariat
Chandigarh, Haryana

HIMACHAL PRADESH

24. Shri Anil Sharma — *Ex-officio*
Minister of Animal Husbandry
Government of Himachal Pradesh
H.P. Secretariat, Shimla
Himachal Pradesh-171 002

25. Shri Sujan Singh Pathani — *Ex-officio*
Minister for Agriculture
Government of Himachal Pradesh
H.P. Secretariat, Shimla
Himachal Pradesh-171 002

26. Smt. Vidya Stokes — *Ex-officio*
Minister for Horticulture
Government of Himachal Pradesh
H.P. Secretariat, Shimla
Himachal Pradesh-171 002

27. Shri Thakur Singh Bharmouri — *Ex-officio*
Minister for Fisheries
Government of Himachal Pradesh
H.P. Secretariat, Shimla
Himachal Pradesh-171 002

JAMMU and KASHMIR

28. Mr Ghulam Nabi Lone — *Ex-officio*
Minister for Agriculture Production
Government of Jammu and Kashmir
Civil Secretariat, Jammu-180 001
Jammu and Kashmir

29. Mr Abdul Ghani Kohli — *Ex-officio*
Minister for Animal Husbandry and Fisheries
Government of Jammu and Kashmir
Civil Secretariat, Jammu-180 001
Jammu and Kashmir

30. Smt. Priya Sethi — *Ex-officio*
Minister of State for Horticulture
Government of Jammu and Kashmir
Civil Secretariat, Jammu-180 001
Jammu and Kashmir

JHARKHAND

31. 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

32. Shri S.S. Mallikarjuna Davangere — *Ex-officio*
Minister of Horticulture
Government of Karnataka
Vidhan Soudha, Bengaluru
Karnataka-560 001

33. Shri Pramod Madvaraj — *Ex-officio*
Minister of State for Fisheries
Government of Karnataka
Vidhan Soudha, Bengaluru
Karnataka-560 001

34. Shri A. Manju — *Ex-officio*
Minister of Animal Husbandry
Government of Karnataka
Vidhan Soudha, Bengaluru
Karnataka-560 001

35. Shri Krishna Byre Gowda — *Ex-officio*
Minister of Agriculture
Government of Karnataka
Vidhan Soudha, Bengaluru
Karnataka-560 001

KERALA

36. Shri V.S. Sunil Kumar — *Ex-officio*
Minister for Agriculture
Government of Kerala
Secretariat Annexe
Thiruvananthapuram, Kerala-695 001

37. Shri K. Raju — *Ex-officio*
Minister for Animal Husbandry
Government of Kerala
Secretariat Annexe
Thiruvananthapuram, Kerala-695 001

38. Smt. J. Mercykutty Amma — *Ex-officio*
Minister for Fisheries
Government of Kerala
Secretariat Annexe
Thiruvananthapuram, Kerala-695 001

MADHYA PRADESH

39. Shri Gaurishankar Chaturbhuj Bisen — *Ex-officio*
Minister of Agriculture Development
Government of Madhya Pradesh
Vallabh Bhavan
Bhopal, Madhya Pradesh-423 006

40. Shri Surya Prakash Meena — *Ex-officio*
Minister of State for Horticulture
Government of Madhya Pradesh
Vallabh Bhavan
Bhopal, Madhya Pradesh-423 006

41. Shri Antar Singh Arya — *Ex-officio*
Minister of Animal Husbandry and Fisheries
Government of Madhya Pradesh
Vallabh Bhavan
Bhopal, Madhya Pradesh -423 006

MAHARASHTRA

42. Shri Pandurang Fundkar — *Ex-officio*
Minister for Agriculture and Horticulture
Government of Maharashtra
Mantralaya, Mumbai
Maharashtra-400 032

43. Shri Mahadev Jankar — *Ex-officio*
Minister for Animal Husbandry and
Fisheries Development
Government of Maharashtra
Mantralaya, Mumbai
Maharashtra-400 032

MANIPUR

44. Shri Gaikhangam, Dy. CM — *Ex-officio*
Minister for Horticulture
Government of Manipur
Secretariat
Imphal, Manipur-795 001

45. Shri Mohammed Abdul Nasir — *Ex-officio*
Minister for Agriculture and Fisheries
Government of Manipur
Secretariat
Imphal, Manipur-795 001

46. Shri Govindas Konthoujam — *Ex-officio*
Minister for Animal Husbandry
Government of Manipur, Secretariat
Imphal, Manipur-795 001

MEGHALAYA

47. Dr Mukul Sangma — *Ex-officio*
Chief Minister holding the Charge of Agriculture
Government of Meghalaya
Meghalaya Secretariat (C)
Shillong, Meghalaya-793 001

48. Smt. H. Donkupar R. Lyngdoh — *Ex-officio*
Minister for Animal Husbandry
Government of Meghalaya
Meghalaya Secretariat (C)
Shillong, Meghalaya-793 001

MIZORAM

49. Shri R. Lalzirliana — *Ex-officio*
Minister for Agriculture
Government of Mizoram
Aizwal, Mizoram - 796 001

50. Shri P.C. Lalthanliana — *Ex-officio*
Minister for Horticulture
Government of Mizoram
Aizwal, Mizoram - 796 001

51. Shri C. Ngunlianchunga — *Ex-officio*
Minister of State for Animal Husbandry
Government of Mizoram
Aizwal, Mizoram - 796 001

52. Shri B.D. Chakma — *Ex-officio*
Minister of State for Fisheries
Government of Mizoram
Aizwal, Mizoram - 796 001

NAGALAND

53. Dr Benjongliba — *Ex-officio*
Minister of State for Agriculture
Government of Nagaland
Civil Secretariat Complex
Kohima, Nagaland-797 004

54. Shri Kejong Chang — *Ex-officio*
Minister of State for Horticulture
Government of Nagaland
Civil Secretariat Complex
Kohima, Nagaland-797 004

55. Shri S. Chuba Longkumer — *Ex-officio*
Minister of State for Animal Husbandry
Government of Nagaland
Civil Secretariat Complex
Kohima, Nagaland-797 004

56. Shri Shetoyi — *Ex-officio*
Minister of State for Fisheries
Government of Nagaland
Civil Secretariat Complex
Kohima, Nagaland-797 004

ODISHA

57. Shri Pradeep Maharathy — *Ex-officio*
Minister for Agriculture Fisheries and
Animal Resource Development
Government of Odisha
Odisha Secretariat
Bhubaneswar, Odisha-751 001

PUNJAB

58. Sardar Tota Singh — *Ex-officio*
Minister of Agriculture
Government of Punjab
Punjab Civil Secretariat
Chandigarh, Punjab

59. Sardar Gulzar Singh Ranike — *Ex-officio*
Minister for AH and Fisheries
Government of Punjab
Punjab Civil Secretariat, Chandigarh, Punjab

PUDUCHERRY

60. Shri R. Kamalakannan — *Ex-officio*
Minister for Agriculture
Government of Puducherry
Puducherry-605 001

61. Shri A. Namassivayam — *Ex-officio*
Minister for Animal Husbandry
Government of Puducherry
Puducherry-605 001

62. Shri Malladi Krishna Rao — *Ex-officio*
Minister for Fisheries
Government of Puducherry
Puducherry-605 001

RAJASTHAN

63. Shri Prabhu Lal Saini — *Ex-officio*
Minister for Agriculture, Horticulture,
Animal Husbandry and Fisheries
Government of Rajasthan
Rajasthan Secretariat,
Mantralaya Bhawan
Jaipur, Rajasthan - 302 005.

SIKKIM

64. Shri Somnath Poudyal — *Ex-officio*
Minister for Agriculture Development
and Horticulture
Government of Sikkim
New Secretariat,
Development Area
Gangtok, Sikkim-737 101

65. Shri Arjun Kumar Ghatani — *Ex-officio*
Minister for Animal Husbandry
and Fisheries
Government of Sikkim
New Secretariat,
Development Area
Gangtok, Sikkim-737 101

TAMIL NADU

66. Thiru R. Doraikkannu — *Ex-officio*
Minister for Agriculture and Horticulture
Government of Tamil Nadu
Chennai, Tamil Nadu-600 009

67. Thiru D. Jayakumar — *Ex-officio*
Minister for Fisheries
Government of Tamil Nadu
Chennai, Tamil Nadu-600 009

68. Thiru P. Balakrishna Reddy — *Ex-officio*
Minister for Animal Husbandry
Government of Tamil Nadu
Chennai, Tamil Nadu-600 009

TELANGANA

69. Shri Pocharam Srinivas Reddy — *Ex-officio*
Minister of Agriculture, Horticulture
Animal Husbandry and Fisheries
Room No. 261,D-Block
Government of Telangana
Telangana Secretariat
Hyderabad - 500 022,
Telangana

TRIPURA

70. Shri Aghore Debbarma — *Ex-officio*
Minister for Agriculture
and Animal Resource Development
Government of Tripura
Civil Secretariat
Agartala, Tripura-799 001

71. Shri Khagendra Jamatia — *Ex-officio*
Minister for Fisheries
Government of Tripura
Civil Secretariat,
Agartala, Tripura-799 001

UTTARAKHAND

72. Shri Rajendra Singh Bhandari — *Ex-officio*
Minister for Agriculture and Horticulture
Government of Uttarakhand
Uttarakhand Vidhan Sabha Bhawan
Dehradun, Uttarakhand

73. Shri Pritam Singh Panwar — *Ex-officio*
Minister for Animal Husbandry and Fisheries
Government of Uttarakhand
Uttarakhand Vidhan Sabha Bhawan
Dehradun, Uttarakhand

UTTAR PRADESH

74. Shri Vinod Kumar Urf 'Pandit Singh' — *Ex-officio*
Minister of Agriculture
Government of Uttar Pradesh
UP Civil Secretariat
Lucknow, Uttar Pradesh

75. Shri Riyaz Ahmad — *Ex-officio*
Minister of Fisheries
Government of Uttar Pradesh
UP Civil Secretariat
Lucknow, Uttar Pradesh

76. Sh. Jiyauddin Rizvi — *Ex-officio*
Minister of Animal Husbandry
Government of Uttar Pradesh
UP Civil Secretariat
Lucknow, Uttar Pradesh

WEST BENGAL

77. Sri Purnendu Basu — *Ex-officio*
Minister for Agriculture
Government of West Bengal
"NABANNA", HRBC Building
Sarat Chatterjee Road
Shibpur, Howrah - 711102
Kolkata, (West Bengal)

78. Sri Swapan Debnath — *Ex-officio*
Minister of State for Animal Resources
(Independent Charge)
Government of West Bengal
Prabi Sampad Bhavan
LB2, Sector-III, Salt Lake City
Kolkata-700106 (West Bengal)

79. Sri Chandranath Sinha — *Ex-officio*
Minister for Fisheries Development Department
Government of West Bengal
Benfish, I.T. Tower, G.N. Block
Sector – V, Salt Lake City
Kolkata – 700106 (West Bengal)

80. Sri Janab Abdur Rezzak Mollah — *Ex-officio*
Minister for Horticulture
Government of West Bengal
Mayukh Bhavan, Salt Lake
Kolkata -700 091 (West Bengal)

(vi) *Member, NITI Ayog, In-charge of Agriculture*

81. Dr Ramesh Chand — *Ex-officio*
Member (Agriculture)
NITI Ayog
Yojana Bhawan, New Delhi-110 001

(vii) *Six members of Parliament—four elected by Lok Sabha and two elected by Rajya Sabha*

82. Smt. Renuka Chowdhury — 2 April, 2018
Member of Parliament (RS)
H.No.8-1-116, Khanapuram (V)
Khammam Urban (M), Khammam District
Andhra Pradesh-507 002

Smt. Renuka Chowdhury
Member of Parliament (RS)
76, Lodhi Estate
New Delhi-110 003

83. Shri D. Bandyopadhyay — 18 August, 2017
Member of Parliament (RS)
C-202, Swarna Jayanti Apartments
Dr. B.D. Marg
New Delhi - 110 001

Shri D. Bandyopadhyay
Member of Parliament (RS)
GD - 89, Sector - III,
Salt Lake, Kolkota
West Bengal - 700 106

84. Shri Dushyant Chautala — Till the expiry of term in Lok Sabha
Member of Parliament (LS)
18, Janpath
New Delhi - 110001

85. Shri Sanjay Dhotre — Till the expiry of term in Lok Sabha
Member of Parliament (LS)
AB-95, Shahjahan Road
New Delhi - 110013

86. Shri Raju Shetti — Till the expiry of term in Lok Sabha
Member of Parliament (LS)
226, North Avenue
New Delhi - 110001

87. Shri Ravneet Singh — Till the expiry of term in Lok Sabha
Member of Parliament (LS)
28, Dr. Rajendra Prasad Road
New Delhi – 110001

(viii) *Director-General, Indian Council of Agricultural Research*

88. Dr T. Mohapatra — *Ex-officio*
Director-General
ICAR, Krishi Bhavan
New Delhi-110 001

(ix) *All Secretaries in the Ministry of Agriculture and Farmers Welfare*

89. Shri S. K. Pattanayak — *Ex-officio*
Secretary, Deptt. of Agriculture,
Cooperation and Farmers Welfare
Ministry of Agriculture and Farmers Welfare
Krishi Bhavan
New Delhi-110 001

90. Shri Devendra Chaudhary — *Ex-officio*
Secretary, Deptt. of Animal Husbandry,
Dairying & Fisheries
Ministry of Agriculture and Farmers Welfare
Krishi Bhavan
New Delhi-110 001

(x) *CEO, NITI Ayog*

91. Shri Amitabh Kant — *Ex-officio*
CEO, Niti Ayog
Yojana Bhavan, Sansad Marg
New Delhi-110 001

(xi) *Secretary, Department of Bio-technology*

92. Prof. K. Vijay Raghavan — *Ex-officio*
Secretary
Department of Biotechnology
Block 2, 7th Floor, CGO Complex
Lodhi Road, New Delhi-110 003

(xii) *Director-General, Council of Scientific and Industrial Research*

93. Dr Girish Sahni — *Ex-officio*
Director General
Council of Scientific and Industrial Research
Anusandhan Bhavan
2-Rafi Ahmed Kidwai Marg
New Delhi-110 001

(xiii) *Chairman, University Grants Commission*

94. Prof. Ved Prakash — *Ex-officio*
Chairman
University Grants Commission
Bahadur Shah Zafar Marg
New Delhi-110 002

(xiv) *Chairman, Atomic Energy Commission (or Director, Bhabha Atomic Research Centre, if nominated by the Chairman, Atomic Energy Commission)*

95. Dr Sekhar Basu — *Ex-officio*
Chairman, Atomic Energy Commission
Department of Atomic Energy
Anushakti Bhavan
Chhatrapati Shivaji Maharaj Marg
Mumbai-400 001

(xv) *Member, Finance (Secretary/ Additional Secretary) in the Ministry of Finance, Government of India*

96. Shri Pramod Kumar Das — *Ex-officio*
Additional Secretary (Expenditure)
Department of Expenditure
Ministry of Finance, North Block
New Delhi-110 001

(xvi) *Four Vice-Chancellors of Agricultural Universities, nominated by the President*

97. Dr Anil Kumar Singh — 18 October, 2017
Vice Chancellor
Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
Race Course Road, Gwalior
Madhya Pradesh-474002

98. Dr Madan Gopal Varshneya — 18 August 2017
Vice Chancellor
Kamdhenu University
Gandhinagar, Gujarat

99. Dr A. K. Singh — 23 May, 2019
Vice Chancellor
Bihar Agricultural University, Sabour
Bhagalpur

100. Dr A. R. Pathak — 28 December, 2018
Vice Chancellor, Junagadh Agricultural University,
Junagadh – 362001, Gujarat

(xvii) *Five Technical Representatives, namely Agricultural Commissioner, Horticultural Commissioner, Animal Husbandry Commissioner, Fisheries Development Commissioner, from the Union Ministry of Agriculture and Inspector-General of Forests, Government of India*

101. Dr S.K. Malhotra — *Ex-officio*
Agriculture Commissioner
Dept. of Agriculture and Co-operation
Ministry of Agriculture and Farmers Welfare
Krishi Bhavan, New Delhi-110 001

102. Dr S.K. Malhotra — *Ex-officio*
Horticulture Commissioner
Dept. of Agriculture and Co-operation
Ministry of Agriculture and Farmers Welfare
Krishi Bhavan, New Delhi-110 001

103. Dr Suresh S. Honnappagol — *Ex-officio*
Animal Husbandry Commissioner
Dept. of Animal Husbandry, Dairying and Fisheries
Ministry of Agriculture and Farmers Welfare
Krishi Bhavan, New Delhi-110 001

104. Dr P. Paul Pandian — *Ex-officio*
Fisheries Development Commissioner
Dept. of Animal Husbandry, Dairying and Fisheries
Ministry of Agriculture and Farmers Welfare
Krishi Bhavan, New Delhi-110 001

105. Dr Anoop Badhwa — *Ex-officio*
Inspector General of Forests (NAEB)
Ministry of Environment and Forests
Paryavaran Bhawan, B-Block
CGO Complex, Lodi Road, New Delhi-110 003

(xviii) *Fifteen scientists from within and outside the Council including one representative from the Indian Council of Medical Research*

106. Dr A. Gopalakrishnan — 9 January, 2018
Director
Central Marine Fisheries Research Institute
Post Box No. 1603, Ernakulam North
P.O., Kochi-682 018

107. Dr D.P. Singh — 9 January, 2018
(Former VC, JNKVV, Jabalpur)
House No. 800, Sector-15 A
Hisar- 125 001, Haryana

108. Dr G. Trivedi — 9 January, 2018
(Former VC, RAU, Pusa, Samastipur)
Matlupur, Via-Piar, Muzaffarpur
Bihar-843 115

109. Dr Kamala Kanta Saharia — 9 January, 2018
Professor (Extension Education)
Department of Extension Education
College of Veterinary Science, AAU
Khanpara, Guwahati, Asom-781 022

110 Dr N.C. Gautam — 9 January, 2018
Vice-Chancellor
Mahatma Gandhi Chitrakoot
Gramodaya vishwavidhyalaya
Chitrakoot, Satna,-485334, Madhya Pradesh

111. Dr Vijay Singh Tomar — 9 January, 2018
Vice Chancellor
Jawaharlal Nehru Krishi Viswa Vidyalaya
Krishi Nagar, Adhartal
Jabalpur-482004, Madhya Pradesh

112. Dr K. R. Kranthi — 9 January, 2018
Director
Central Institute for Cotton Research
P.B.No.2, Shankarnagar P.O.
Nagpur-440010, Maharashtra

113. Dr Umesh Chandra Sharma — 9 January, 2018
President, Veterinary Council of India
A-Wing, 2nd Floor, August Kranti Bhawan
Bhikaji Cama Place, New Delhi-110 066

114. Dr A. K. Singh — 9 January, 2018
Managing Director
National Horticulture Board
Ministry of Agriculture and Farmers Welfare
85, Institutional Area, Sector -18
Gurgaon-122 015

115. Dr Bhagwati Prasad Bhatt — 9 January, 2018
Director
ICAR Research Complex for Eastern Region
ICAR Parisar,
P.O. Bihar Veterinary College
Patna-800014, Bihar

116. Dr Jitendra Chauhan — 9 January, 2018
Professor and Chairman, School of Social Science
College of Post Graduate Studies
Barapani (Umiam)
Shilong – Meghalaya- 793103

117. Dr S.S. Sengar — 9 January, 2018
Dean, College of Agriculture
Korea, Chattisgarh-497 335

118. Dr Prakash Shastri — 9 January, 2018
Professor (Plant Pathology)
College of Agriculture (RVSKVV)
Khandwa-450 001 (MP)

119. VACANT

Representative from the Indian Council of Medical Research

120. Dr Rashmi Arora — 18 November, 2018
Scientist G, and Head (ECD)
ICMR Hqrs., P.O. Box No. 4911
Ansari Nagar, New Delhi - 110029

(xix) *Three representatives of commerce and industry, nominated by the President*

121. Vacant
122. Vacant
123. Vacant

(xx) *One farmer from each region of the country as mentioned in Rule 60(a) and four representatives of rural interests, nominated by the President*

124. Sh. Bhuvan Chander Dabral — 8 December, 2019
Bhawanpura, Post – Rajawala
Distt.-Dehradun, Uttarakhand

125. Sh. Shay Reddy 8 December, 2019
H. No. – 11/1815, Maruti Nagar
Nizamabad, Telengana - 503002
126. Sh. Huraizeliyande 8 December, 2019
Ekranipathar, Block – 15,
House No. – 144, Dimapur – 3
Dimapur – 797112, Nagaland
127. Sh. Sarvajeet Singh 8 December, 2019
Village – Baranti
Post – Bidupur R.S.,
Thana – Rajapakar
District – Vaishali – 844502, Bihar
128. Sh. Ashok Parashar 8 December, 2019
Kailash Nagar, Sujapur
District – Pathankot - 145023
129. Sh. Rantanlal Daka 8 December, 2019
(Organic Farmer)
5, Radhika, LIC Colony,
Ummed Club Road
Jodhpur, Rajasthan
130. Sh. Rashid Mohan Gavit 8 December, 2019
At – Dhanrat Village, Tehsil – Navapur
District – Nandurbar, Maharashtra
131. Sh. B. K. Ramesh Bembila 8 December, 2019
Paltadi, Putter Taluk
Dakshin Kanada
Karnataka - 574210

Representatives of Rural Interests

132. Shri Sudhir Kumar Bhargava 8 June, 2017
Director, Agroman Systems Pvt. Ltd.
25/2, Tardeo AC Market,Tardeo
Mumbai, Maharashtra–400 034
133. Shri Ratneshwari Prasad Singh 8 April,2018
Village - Ratanpur
Post - Badahrwa
Distt. Sitamadi - 843315, Bihar
134. Shri Suresh Chandel 8 April,2018
Ex-Member of Parliament,Village - Beri
Post - Ropa,Distt.-Bilaspur-174001
Himachal Pradesh
135. Shri Ram Krishna Kusmaria 8 April,2018
Ex- Agriculture Minister
Government of Madhya Pradesh
Village - Sakora, Post - Hinota
Tehsil-Hata, Distt. - Damoh – 470661
Madhya Pradesh.

(xxi) *Four Directors of the Indian Council of Agricultural Research Institutes, nominated by the President*

136. Dr A.D. Pathak 24 May, 2019
Director
Indian Institute of Sugarcane Research
Lucknow, Uttar Pradesh
137. Dr K.K. Singh 24 May, 2019
Director, Central Institute of Agricultural
Engineering, Nabi Bagh
Berasia Road, Bhopal-462038
Madhya Pradesh
138. Dr P.C. Sharma 24 May, 2019
Director, Central Soil Salinity Research Institute
Zarifa Farm, Kachhwa Road
Karnal 132001, Haryana
139. Dr P.K. Mishra 24 May, 2019
Director, Indian Institute of Soil and Water
Conservation, Kaulagarh Road, Dehradun,
Uttarakhand 248001

(xxii) *Secretary, Indian Council of Agricultural Research-Member Secretary*

140. Shri Chhabilendra Roul *Ex-Officio*
Addl. Secretary (DARE) and Secretary
Indian Council of Agricultural Research
Krishi Bhavan, New Delhi-110 001

❑

APPENDIX 2

MEMBERS OF THE GOVERNING BODY OF THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

Rule 35(i)
Chairman

1. Dr Trilochan Mohapatra — *Ex-Officio*
   Director-General,
   Indian Council of Agricultural
   Research, Krishi Bhawan,
   New Delhi-110001

Rule 35(ii)
***Ex-Officio* Members**
Member, Finance

2. Shri Pramod Kumar Das — *Ex-Officio*
   Additional Secretary (Expenditure)
   Department of Expenditure,
   Ministry of Finance, North Block
   New Delhi - 110 001

Rule 35(iii)
Secretary, *NITI Ayog*

3. Shri Amitabh Kant — *Ex-Officio*
   CEO, NITI Ayog, Yojana Bhavan
   Sansad Marg, New Delhi - 110 001

Rule 35(iv)
Secretary, Agriculture

4. Shri S. K. Pattanayak — *Ex-Officio*
   Secretary (Agriculture, Cooperation and Farmers Welfare)
   Dept. of Agriculture, Cooperation and Farmers Welfare
   Ministry of Agriculture and Farmers Welfare
   Krishi Bhavan, New Delhi - 110 001

Rule 35(v)
Secretary, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture

5. Shri Devendra Chaudhary — *Ex-Officio*
   Secretary (ADF),
   Dept. of Animal Husbandry,
   Dairying, Fisheries and Farmers Welfare
   Ministry of Agriculture, Krishi Bhavan,
   New Delhi - 110 001

Rule35(vi)
Three Scientists (including one management expert who are not employees of ICAR-nominated by the President)

6. Dr A.K. Singh — 09.01.2018
   (Management Expert)
   Managing Director
   National Horticulture Board
   Ministry of Agriculture and Farmers
   Welfare, 85, Institutional Area,
   Sector -18, Gurgaon-122 015
7. Dr Kamala Kanta Saharia — 09.01.2018
   Professor (Extension Education.)
   Department of Extension Education,
   College of Veterinary Science, AAU,
   Khanpara, Guwahati, Asom-781 022
8. Dr Prakash Shastri — 09.01.2018
   Professor (Plant Pathology),
   College of Agriculture, Rajmata Vijayaraje
   Scindia Krishi Vishwavidyalaya (RVSKVV),
   Khandwa, Madhya Pradesh-450 001

Rule 35 (vii)
Five Vice-Chancellors of Agricultural Universities-nominated by the President)

9. Dr Anil Kumar Singh — 18.10.2017
   Vice Chancellor,
   Rajmata Vijayaraje Scindia Krishi Vishwa
   Vidyalaya, Race Course Road, Gwalior
   Madhya Pradesh 474 002
10. Dr Madangopal C Varshneya — 18.08.2017
    Vice Chancellor,
    Kamdhenu University,
    Gandhinagar, Gujarat 382 010
11. Dr Arvind R. Pathak — 28.12.2018
    Vice Chancellor,
    Junagadh Agricultural University,
    Junagadh, Gujarat- 362 001
12. Prof. Aditya Kumar Misra — 28.12.2018
    Vice Chancellor,
    Maharashtra Animal and Fishery
    Sciences University, Futala Lake Road,
    Nagpur, Maharashtra-440 001,
13. Dr Ajoy Kumar Singh — 23.05.2019
    Vice Chancellor,
    Bihar Agricultural University, Sabour
    Bhagalpur, Bihar-813 210

Rule 35(viii)
Three Members of Parliament nominated by the President-(Two from Lok Sabha and one from Rajya Sabha)

14. Smt. Renuka Chowdhury — 02.04.2018
    Member of Parliament (RS)
    76, Lodhi Estate
    New Delhi-110 003

    Smt. Renuka Chowdhury
    Member of Parliament (RS)
    H.No.8-1-116 Khanapuram(V)
    Khammam Urban(M), Khammam District
    Andhra Pradesh-507 002
15. Shri Sanjay Dhotre — 11.02.2018
    Member of Parliament (LS)
    Ranpise Nagar,
    Distt. Akola (Maharashtra) 444 005

    Shri Sanjay Dhotre
    Member of Parliament (LS)
    AB-95, Shahjahan Road,
    New Delhi 110 003
16. Shri Ravneet Singh — 11.02.2018
    Member of Parliament (LS)
    Village – Kotla Afghana,
    District Ludhiana- 141 416

    Shri Ravneet Singh
    Member of Parliament (LS)
    H.No. 28, Dr Rajendra Prasad Road,
    New Delhi - 110 001

Rule 35(ix)
Four Farmers/Representatives of Rural Areas nominated by the President

17. Shri Sudhir Kumar Bhargava, — 08.06.2017
    Director, Agroman Systems
    Pvt. Ltd.
    25/2, Tardeo AC Market,
    Tardeo, Mumbai (Maharashtra) 400 034
18. Shri Ratneshwari Prasad Singh — 08.04.2018
    Village- Ratanpur
    Post- Badahrwa
    Distt. Sitamarhi, Bihar – 843 315
19. Shri Suresh Chandel — 08.04.2018
    Ex- Member of Parliament
    Village- Gandhi Ropa
    P.O. Beri,
    Tehsil and District Bilaspur,
    Himachal Pradesh

F Preferred Contact Address:

20. Shri Suresh Chandel
    Ex- Member of Parliament
    House No. 70/5, Roura, Sector-3
    Bilaspur, Himachal Pradesh
21. Dr Ram Krishna Kusmaria 08.04.2018
    Ex- Agriculture Minister
    Government of Madhya Pradesh
    Village- Sakora, Post- Hinota
    Tehsil- Hata, Distt. Damoh, Madhya Pradesh

Rule 35(x)
Three Directors of Research Institutes of the Council nominated by the President

22. Dr Ashwini Dutt Pathak 24.5.2019
    Director, Indian Institute of
    Sugarcane Research, Raebarieli Road
    P.O. Dilkusha, Lucknow, Uttar Pradesh-226 002
23. Dr K.K. Singh 24.5.2019
    Director, Central Institute of Agricultural
    Engineering, Nabi Bagh, Berasia Road,
    Bhopal, Madhya Pradesh 462 038
24. Dr P.C. Sharma 24.5.2019
    Director, Central Soil Salinity
    Research Institute, Zarifa Farm,
    Kachhwa Road, Karnal, Haryana 132 001

Rule 35(xi)
Four representatives of State Governments to be nominated zone-wise on a rotational basis by Director General, ICAR

25. Shri M. Maheshwar Rao 15.6.2017
    Secretary to Government Agriculture
    Department, Government of Karnataka
    Room No. 411, 4th Floor, M.S. Building,
    Bengaluru, Karnataka-560 001
26. Shri Manoj Ahuja 15.6.2017
    Principal Secretary (Agriculture),
    Department of Agriculture, Government of Odisha,
    Odisha Secretariat, Rajeev Bhavan,
    Bhubaneswar, Odisha-751 001
27. Shri Sanjay Prasad 15.6.2017
    Principal Secretary(Agri.),
    Department of Agriculture and Co-operation,
    Government of Gujarat,
    Block No. 5/1, First Floor,
    New Sachivalaya,
    Gandhinagar, Gujarat-382010
28. Shri Rajnish Gupta, 15.6.2017
    Principal Secretary (Agri.)
    Department of Agriculture,
    Government of Uttar Pradesh,
    UP Civil Secretariat,
    Lucknow, Uttar Pradesh-226 001

Rule 35(xii)
One representative of Agro and Agro-Processing Industries to be nominated by President .

29. Vacant

Rule 35(xiii)
One representative from a distinguished *Non-Governmental Organization dealing with Agriculture/Extension nominated by President*

30. Sh. Alok Kumar Gupta 07.12.2019
    Chairman/President,
    Surabhi Foundation,
    UGF 118, World Trade Center,
    Barakhamba Avenue,
    Connaught Place
    New Delhi-110 001

Rule 35(xiv)
Secretary, ICAR- Member Secretary

31. Shri Chhabilendra Roul
    Additional Secretary(DARE) and Secretary, ICAR,
    Krishi Bhawan,
    New Delhi- 110 001

❑

APPENDIX 3

SENIOR OFFICERS AT THE HEADQUARTERS OF THE ICAR

SENIOR OFFICERS AT THE HEADQUARTERS OF THE ICAR

1. **Dr Trilochan Mohapatra**
   Director General, ICAR and Secretary to the Government of India, Department of Agricultural Research and Education

2. **Shri Chhabilendra Roul**
   Secretary, ICAR and Additional Secretary to Government of India, Department of Agricultural Research and Education

Deputy Directors General
1. Dr J.S. Sandhu (Crop Science)
2. Dr K. Alagusundaram(Agricultural Engineering)
3. Dr A.K. Singh(Agricultural Extension)
4. Dr Habibar Rahman(Animal Sciences)
5. Dr Joykrushna Jena(Fisheries Science)
6. Dr N.S. Rathore(Agricultural Education)
7. Dr K. Alagusundaram (Acting) (NRM)
8. Dr A.K. Singh (Acting) (Horticultural Science)

Assistant Directors General

Crop Science
1. Dr J.S. Chauhan (Seed)
2. Dr P.K. Chakrabarty (PP&B)
3. Dr B.B. Singh (OP)
4. Dr I.S. Solanki (F&FC)
5. Dr R.K. Singh (CC)

Horticultural Science
1. Dr T. Janakiram (Hort.Sci.-I)
2. Dr W.S. Dhillon (Hort.Sci.-II)

Natural Resource Management
1. Dr S.K. Chaudhari (S&WM)
2. Dr S. Bhaskar (AAF&CC)

Agricultural Engineering
1. Dr Kanchan Kumar Singh (FE)
2. Dr S.N. Jha (PE)

Animal Sciences
1. Dr R.S. Gandhi (AP&B)
2. Dr B.S. Prakash (AN&P)
3. Dr Ashok Kumar (AH)

Fisheries Science
1. Dr P. Pravin (MF)
2. Dr Sudhir Raizada (IF)

Agricultural Extension
1. Dr V.P. Chahal
2. Dr Randhir Singh

Agricultural Education
1. Dr G. Venkateshwarlu (EQA&R)
2. Dr M.B. Chetti (HRD)
3. Dr P.S. Pandey (EP&HS)

Others
1. Dr A.K. Vasisht (PIM)
2. Dr Shiv Prasad Kimothi (Cdn.)
3. Dr A.K. Vyas (HRM)
4. Dr Sanjeev Saxena (IPTM&PME)

National Agricultural Science Fund (NASF)
1. Dr P.K. Agrawal, ADG

Directorate of Knowledge Management in Agriculture (DKMA)
1. Dr Rameshwar Singh

OSD
1. Dr R.K. Mittal (IR)
2. Dr K.C. Bansal (NAHEP)

Principal Scientists

Crop Science
1. Dr Rajan
2. Dr S.K. Jha
3. Dr Dinesh Kumar
4. Dr Y.P. Singh
5. Dr P.R. Chaudhary

Horticultural Science
1. Dr Ranvir Singh
2. Dr Manish Das
3. Dr Vikramaditya Pandey
4. Dr B.K. Pandey

Natural Resource Management
1. Dr P.P. Biswas
2. Dr S.K. Dhyani
3. Dr Adlul Islam

Agricultural Education
1. Dr M.K. Agnihotri
2. Dr (Mrs.) Vanita Jain
3. Dr K.L. Khurana
4. Dr K.P. Tripathi
5. Dr Neeraj Rana
6. Dr (Mrs.) Nidhi Verma

Fisheries Science
1. Sh. Anil Agarwal
2. Dr (Mrs.) Yasmeen Basade

Agricultural Engineering
1. Dr Devinder Dhingra
2. Dr Panna Lal Singh

Animal Sciences
1. Dr Rajan Gupta
2. Dr Vineet Bhasin
3. Dr (Mrs.) Jyoti Misri
4. Dr (Mrs.) Neelam Gupta

Agri. Extension
1. Dr (Mrs.) Harjit Kaur
2. Dr P. Adhiguru
3. Dr Keshava

Others
1. Dr A.K. Bawa
2. Dr A. Arunachalam
3 Dr N.K. Jain (HRM)
4. Dr M. K. Tripathi (PIM)
5. Dr P.K. Katiha (PIM)
6. Dr A.S. Mishra (Tech. Cdn.)

7. Dr S. Mauria (IPTM)
8. Dr Shiv Datt (IPTM)
9. Dr R.K. Tomar (RFD & IR)
10. Dr S.K. Singh
11. Dr Ashok Kumar (NASF)

National Agricultural Higher Education Project (NAHEP)
1. Dr P. Ramasundaram, PS & NC
2. Dr R.B. Sharma, PS & NC

Agricultural Scientists' Recruitment Board
1. Dr Gurbachan Singh, Chairman
2. Dr V.N. Sharda, Member
3. Sh. J. Ravi, Secretary
4. Sh. Rajiv Mangotra, Deputy Secretary
5. Sh. S.P. Sanwal, Controller of Examination
6. Sh. K.N. Choudhary, Deputy Secretary

Directorate of Knowledge Management in Agriculture
1. Dr Rameshwar Singh, Project Director
2. Dr. V.K. Bharti, Chief Production Officer and I/c Under Secretary
3. Dr (Mrs.) N. Kanaka Durga, Principal Scientist
4. Dr R.S. Rana, Senior Scientist
5. Sh. Himanshu, Scientist SS, AKMU
6. Dr Aruna T Kumar, Incharge, English Editorial Unit
7. Shri Ashok Singh, Incharge, Hindi Editorial Unit
8. Sh. S.K. Joshi, Business Manager
9. Sh. Anil Sharma, Public Relations Officer
10. Sh. Vijender Singh, Incharge, ARIC
11. Sh. Narendra Bahadur, Chief Technical Officer, Art Unit
12. Smt. Mitali Ghosh Roy, Incharge, Social Media and Website Management Cell
13. Sh. Inderjit Singh, Chief Technical Officer, ICAR Library

Administration

Sr. Director
1. Sh. G.R. Desh Bandhu (Crop Sc.)

Directors
1. Sh. Sanjay Kant, Director (Extn.)
2. Sh. S.K. Mitra, Director (Pers.)
3. Sh. Devender Kumar, Director (F)
4. Sh. V.P. Kothiyal, Director (Works)
5. Sh. Kanhaiya Chaudhary, Director (GAC)
6. Mrs. Seema Chopra, Director (OL)

Deputy Secretaries
1. Sh. Rajiv Maheshwari
2. Sh. P. Sakthivel
3. Ms. Namrta Sharma
4. Sh. P.K. Bage
5. Sh. S.K. Behera
6. Sh. V.K. Sharma
7. Ms. Roja Sethumadhavan
8. Sh. K.K. Kulshreshtha
9. Sh. N.K. Jindal
10. Ms. Sunita Sharma
11. Ms. Kamla Bisht
12. Sh. P.K. Jain

❑

APPENDIX 4

ICAR INSTITUTES AND THEIR DIRECTORS

National Institutes

1. Dr (Mrs.) Ravinder Kaur (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 A.K. Srivastava
   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 (Mrs.) R. Kalpana Sastry (Acting)
   National Academy of Agricultural Research
   Management, Rajendranagar,
   Hyderabad – 500030, Andhra Pradesh
6. Dr N.P. Singh
   National Institute of Abiotic Stress Management
   Malegaon, Baramati, Pune-413 115, Maharashtra
7. Dr T.R. Sharma, OSD
   Indian Institute of Agricultural
   Biotechnology, Ranchi, Jharkhand
8. Dr Jagdish Kumar (Acting)
   National Institute of Biotic Stress
   Management, Raipur, Chhattisgarh
9. Dr D. Maity, OSD, IARI, Jharkhand

Agricultural Sciences

10. Dr S.D. Roy
    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 K.R. Kranthi
    Central Institute for Cotton Research
    Post Bag No. 2, Shankar Nagar
    P.O. Nagpur – 440 010, Maharashtra
15. Dr Shailendra Rajan
    Central Institute for Sub-tropical Horticulture
    Rehmankhera, PO Kakori
    Lucknow – 227 107, Uttar Pradesh
16. Dr Desh Beer Singh
    Central Institute of Temperate Horticulture
    Old Air Field, Rangreth – 190 007,
    Jammu and Kashmir
17. Dr R.K. Gupta
    Central Institute of Post Harvest Engineering
    and Technology
    P.O. PAU Campus
    Ludhiana – 141 004, Punjab
18. Dr P.K.G. Patil
    Central Institute for Research on Cotton Technology
    Adenwala Road, Matunga
    Mumbai – 400 019, Maharashtra
19. Dr P. Chowdappa
    Central Plantation Crops Research Institute
    Kasaragod – 671 124, Kerala
20. Dr S.K. Chakrabarty
    Central Potato Research Institute
    Shimla – 171 001, Himachal Pradesh
21. Dr Ch. Srinivasarao
    Central Research Institute for Dryland Agriculture
    Santoshnagar, Saidabad
    P.O.,Hyderabad – 500 059, Andhra Pradesh
22. Dr Gautam Roy (Acting)
    National Institute of Research on Jute and
    Allied Fibre Technology, 12, Regent Park,
    Kolkata – 700 040,West Bengal
23. Dr Himanshu Pathak
    National Rice Research Institute,
    Cuttack – 753 006, Odisha.
24. Dr Parbodh Chander
    Central Soil Salinity Research Institute
    Zarifa Farm, Kachhwa Road
    Karnal – 132 001, Haryana
25. Dr P.K. Mishra
    Indian Institute of Soil and Water Conservation
    218, Kaulagarh Road
    Dehradun – 248 195, Uttarakhand
26. Dr D. Damodar Reddy
    Central Tobacco Research Institute
    Rajahmundry – 533 105, Andhra Pradesh
27. Dr James George (Acting)
    Central Tuber Crops Research Institute, Sreekariyam
    Thiruvananthapuram – 695 017, Kerala
28. Dr E.B. Chakurkar (Acting)
    Central Coastal Agricultural Research Institute
    Ela, Old Goa, North Goa – 403 402, Goa
29. Dr B.P. Bhatt, ICAR Research Complex for Eastern
    Region, ICAR Parisar, P.O. Bihar Veterinary
    College, Patna – 800 014, Bihar
30. Dr S.V. Ngachan
    ICAR Research Complex for NEH Region
    Umroi Road, Umiam, Ri-Bhoi,
    Meghalaya – 793 103
31. Dr U.C. Sud, Indian
    Agricultural Statistics Research Institute
    Library Avenue, Pusa Campus
    New Delhi – 110 0012
32. Dr P.K. Ghosh, Indian Grassland and
    Fodder Research Institute, Pahuj Dam, Gwalior
    Road, Jhansi – 284 003, Uttar Pradesh
33. Dr M.R. Dinesh
    Indian Institute of Horticulture Research
    Hessaraghatta Lake Post
    Bengaluru – 560 089, Karnataka
34. Dr Narendra Pratap Singh, Indian Institute of Pulses
    Research, Kanpur – 208 024, Uttar Pradesh
35. Dr Ashok Kumar Patra, Indian Institute of Soil
    Sciences, Nabi Bagh, Berasia Road,
    Bhopal – 462 038, Madhya Pradesh
36. Dr K. Nirmal Babu
    Indian Institute of Spices Research
    Marikunnu P.O., Calicut – 673 012, Kerala
37. Dr A.D. Pathak
    Indian Institute of Sugarcane Research
    Rai Bareilly Road, P.O. Dilkusha
    Lucknow – 226 002, Uttar Pradesh
38. Dr K.K. Sharma, Indian
    Institute of Natural Resins and Gums
    Namkum, Ranchi – 834 010, Jharkhand
39. Dr Bijendra Singh
    Indian Institute of Vegetable Research
    PB No. 01, PO Jakhini, Shahanshapur
    Varanasi – 221 005, Uttar Pradesh
40. Dr Bakshi Ram
    Sugarcane Breeding Institute
    Coimbatore – 641 007, Tamil Nadu

41. Dr A. Pattanayak
Vivekanand Parvatiya Krishi Anusandhan Sansthan
Almora – 263 601, Uttrakhand
42. Dr P.G. Karmakar
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 Vinay Mahajan (Acting)
Indian Institute of Maize Research, PAU Campus
Ludhiana – 141 004, Punjab
45. Dr Ravi Kumar Mathur
Indian Institute of Oil Palm Research
Pedavegi– 534 450, West Godavari
Andhra Pradesh
46. Dr A.V. Reddy
Indian Institute of Oilseeds Research
Rajendranagar, Hyderabad – 500 030,
Andhra Pradesh
47. Dr V. Ravindra Babu
Indian Institute of Rice Research, Rajendranagar
Hyderabad-500 030, Andhra Pradesh
48. Dr G.P. Singh
Indian Institute for Wheat and Barley Research
P. Box No. 158, Agrasain Marg
Karnal – 132 001, Haryana
49. Dr S.K. Ambast
Indian Institute of Water Management
Opposite Rail Vihar, Chandersekharpur
Bhubaneshwar – 751 023, Odisha
50. Dr (Mrs.) Jitender Kishtwaria
Central Institute for Women in Agriculture
Plot No.50, Mauza-Jokalandi,
P.O. Baramunda, Bhubaneswar – 751 003, Odisha
51. Dr O.P. Chaturvedi
Central Agro-Forestry Research Institute
Near Pahuj Dam, Jhansi – 284 003, Uttar Pradesh
52. Dr M.S. Ladaniya
Central Citrus Research Institute
P.B. No. 464, Shankar Nagar P.O.,
Amravati Road, Nagpur – 440 010, Maharashtra
53. Dr Suresh Pal
National Institute of Agricultural Economics
and Policy Research, P.B. No. 11305, DPS Marg,
Pusa, New Delhi – 110 012
54. Dr Dinesh Kumar Agarwal (Acting)
Indian Institute of Seed Science
P.B. No. 11, Kusmaur, P.O. Kaithauli
Mau Nath Bhanjan – 275 101, Uttar Pradesh
55. Dr Vilas A. Tonapi
Indian Institute of Millets Research
Rajendranagar, Hyderabad – 500 030,
Andhra Pradesh
56. Dr V.S. Bhatia
Indian Institute of Soybean Research
Khandwa Road, Indore – 452 017, Madhya Pradesh

Animal Sciences and Fisheries

57. Dr Jag Mohan Kataria
Central Avian Research Institute
Izatnagar, Bareilly – 243 122, Uttar Pradesh
58. Dr Inderjeet Singh
Central Institute for Research on Buffaloes
Sirsa Road, Hisar – 125 001, Haryana
59. Dr Manmohan Singh Chauhan
Central Institute of Research on Goats
Makhdoom, Mathura – 281 122, Uttar Pradesh
60. Dr Basant Kumar Das
Central Inland Fisheries Research Institute
Barrackpore – 700 120, West Bengal
61. Dr K.K. Vijayan
Central Institute of Brackishwater Aquaculture
75, Santhome High Road, Raja Annamalai Puram
Chennai – 600 028, Tamil Nadu
62. Dr Ravishankar C.N.
Central Institute of Fisheries Technology
Willingdon Island, Matsyapuri
P.O.,Cochin – 682 029, Kerala
63. Dr P. Jayasankar
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 S.M.K. Naqvi
Central Sheep and Wool Research Institute
Avikanagar – 304 501, Distt. Tonk, Rajasthan
66. Dr Raghevendra Bhatta
National Institute of Animal Nutrition and Physiology
Adugodi, Bengaluru – 560 030, Karnataka
67. Dr Vijendra Pal Singh
National Institute of High Security Animal Diseases
Anand Nagar, Bhopal-462021, Madhya Pradesh
68. Dr Birham Prakash
Central Institute for Research on Cattle,
P.B. No. 17, Grass Farm Road,
Meerut Cantt. – 250 001, Uttar Pradesh

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APPENDIX 5

NATIONAL BUREAUX AND THEIR DIRECTORS

Agricultural Sciences

1. Dr (Mrs.) C.R. Ballal
   National Bureau of Agricultural Insect Resources
   P.B. No. 2491, H.A. Farm Post
   Bengaluru – 560 024, Karnataka
2. Dr Anil Kumar Saxena
   National Bureau of Agriculturally
   Important Micro-organisms
   P.B. No. 6, Kusmaur, Maunath
   Bhanjan – 275 101, Uttar Pradesh
3. Dr Kuldeep Singh (Acting)
   National Bureau of Plant Genetic Resources
   Pusa Campus, New Delhi-110 012
4. Dr Surendra Kumar Singh
   National Bureau of Soil Survey and Land Use
   Planning, Shankar Nagar P.O., Amravati Road
   Nagpur – 440 010, Maharashtra

Animal Sciences

5. Dr Arjava Sharma
   National Bureau of Animal Genetic Resources
   P.B. No. 129, G.T. Road Bye Pass
   Karnal – 132 001, Haryana
6. Dr Kuldeep Kumar Lal
   National Bureau of Fish Genetic Resources
   Canal Ring Road,P.O. Dilkusha
   Lucknow – 226 002, Uttar Pradesh

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APPENDIX 6

PROJECT DIRECTORATES, ATARI AND THEIR DIRECTORS

Agricultural Sciences

1. Dr Radhakrishnan T.
   Directorate of Groundnut Research
   Post Box No. 5, Ivnagar Road
   Junagadh – 362 001, Gujarat
2. Dr Dhiraj Singh
   Directorate of Rape seed - Mustard Research
   Sewar, Bharatpur – 321 303, Rajasthan
3. Dr A.R. Sharma
   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 Jitendra Kumar
   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 Vijay Mahajan (Acting)
   Directorate on Onion and Garlic Research
   Rajgurunagar, Pune– 410 505, Maharashtra

Animal Sciences

9. Dr Parimal Roy
   National Institute of Veterinary Epidemiology
   and Disease Informatics, H.A. Farm Post
   Hebbal, Bengaluru-560 024, Karnataka
10. Dr B. Pattnaik (Acting)
    Directorate of Foot and Mouth Disease
    IVRI Campus, Mukteshwar – 263 138, Uttarakhand
11. Dr R. N. Chatterjee
    Directorate of Poultry Research
    Rajendranagar, Hyderabad – 500 030,
    Andhra Pradesh
12. Dr Atul Kumar Singh
    Directorate of Coldwater Fisheries Research
    Anusandhan Bhawan, Industrial Area
    Bhimtal – 263 136, Uttarakhand

Others

13. Dr (Mrs.) Ravinder Kaur
    Water Technology Centre, IARI
    New Delhi-110012
14. Dr. Rameshwar Singh
    Directorate of Knowledge
    Management in Agriculture
    New Delhi 110 012

Agricultural Technology Application Research Institutes

15. Dr Rajbir Singh
    Agricultural Technology Application Research
    Institute, Zone-I, PAU Campus
    Ludhiana – 141 004, Punjab
16. Dr Subrata Kumar Roy (Acting)
    Agricultural Technology Application Research Institute
    Zone-II, Bhumi Vihar, Block-GB, Sector-III
    Salt Lake, Kolkata – 700 097, West Bengal
17. Dr B.C. Deka
    Agricultural Technology Application Research Institute
    Zone-III, TOP, Umroi Road
    Barapani – 793 103, Meghalaya
18. Dr U.S. Gautam
    Agricultural Technology Application Research Institute
    Zone-IV, G.T. Road, Rawatpura, Near Vikas Bhawan
    Kanpur – 208 002, Uttar Pradesh
19. Dr Y.G. Prasad
    Agricultural Technology Application Research Institute
    Zone-V, CRIDA Complex, Santoshnagar
    Hyderabad – 500 059, Andhra Pradesh
20. Dr S.K. Singh
    Agricultural Technology Application Research Institute
    Zone-VI, CAZRI Campus, Jodhpur – 342 003,
    Rajasthan
21. Dr Anupam Mishra
    Agricultural Technology Application Research Institute
    Zone-VII, JNKVV Campus, Jabalpur – 484 002,
    Madhya Pradesh
22. Dr Sreenath Dixit
    Agricultural Technology Application Research Institute
    Zone-VIII, ICAR Transfer of Technology Project
    MRS HA Farm Post, Hebbal
    Bengaluru – 560 030, Karnataka

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APPENDIX 7

NATIONAL RESEARCH CENTRES AND THEIR DIRECTORS

Agricultural Sciences

1. Dr (Mrs.) S. Uma
   National Research Centre for Banana
   Thogamalai Road, Thayanur Post
   Thiruchirapalli – 620 102, Tamil Nadu
2. Dr S.D. Sawant
   National Research Centre for Grapes
   P.B. No. 3, Manjri Farm Post
   Solapur Road, Pune - 412 307, Maharashtra
3. Dr B. Ahuja (Acting)
   National Research Centre for Integrated
   Pest Management, LBS Building
   Pusa Campus, New Delhi – 110 012
4. Dr Vishal Nath
   National Research Centre for Litchi
   Mushahari Farm, Mushahari
   Muzaffarpur – 842 002, Bihar
5. Dr D. R. Singh
   National Research Centre for Orchids
   Pakyong, Gangtok – 737 106, Sikkim
6. Dr T.R. Sharma
   National Research Centre on Plant Biotechnology
   L.B.S. Building, Pusa, New Delhi – 110 012
7. Dr R.K. Pal
   National Research Centre on Pomegranate
   NH-9, Byepass Road, Shelgi
   Sholapur – 413 006, Maharashtra
8. Dr Gopal Lal (Acting)
   National Research Centre on Seed Spices
   Tabiji – 305 206, Ajmer, Rajasthan
9. NRC Biotechnology Centre for Crop Science
   New Delhi

Animal Sciences and Fisheries

10. Dr N.V. Patil
    National Research Centre on Camel, Jorbeer
    P.B. No. 07, Bikaner – 334 001, Rajasthan
11. Dr B.N. Tripathi
    National Research Centre for Equines
    Hisar – 125 001, Haryana
12. Dr V.V. Kulkarni
    National Research Centre on Meat
    Chengicherla, P.B. No. 19, Uppal PO
    Hyderabad – 500 039, Andhra Pradesh
13. Dr Abhijit Mitra
    National Research Centre for Mithun
    Jharnapani, P.O. Medziphema– 797 106
    Nagaland
14. Dr D.K. Sarma
    National Research Centre on Pig
    Rani, Guwahati – 781 131, Asom
15. Dr S.M. Deb
    National Research Centre on Yak
    Dirang, West Kameng– 790 101,
    Arunachal Pradesh

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APPENDIX 8

ALL INDIA CO-ORDINATED RESEARCH PROJECTS AND NETWORK PROGRAMMES

1. AICRP on Maize, New Delhi
2. AICRP on Nematodes in Cropping System, New Delhi
3. All India Coordinated Rice Improvement Project, Hyderabad
4. AICRP on Chickpea, Kanpur
5. AICRP on MULLaRP, Kanpur
6. AICRP on Pigeon Pea, Kanpur
7. AICRP on Wheat and Barley, Karnal
8. AICRP on Forage Crops and Utilization, Jhansi
9. AICRP Sorgum , Hyderabad
10. AICRP on Pearl Millets, Jodhpur
11. AICRP on Small Millets, Bangalore
12. AICRP on Sugarcane, Lucknow
13. AICRP on Cotton, Coimbatore
14. AICRP on Groundnut, Junagarh
15. AICRP on Soybean, Indore
16. AICRP on Rapeseed and Mustard, Bharatpur
17. AICRP on Oilseed, Hyderabad
18. AICRP on Linseed, Kanpur
19. AICRP on Sesame and Niger, Jabalpur
20. AICRP on Biocontrol of Crop Pests, Bengaluru
21. AICRP - Honeybees and Pollinators, New Delhi
22. AICRP NSP(Crops), Mau
23. AICRP Fruits (Tropical and Sub Tropical), Bengaluru
24. AICRP Arid Zone Fruits, Bikaner
25. AICRP Mushroom, Solan
26. AICRP Vegetables, Varanasi
27. AICRP Potato, Shimla
28. AICRP Tuber Crops, Tiruvanthapuram
29. AICRP Palms, Kasargod
30. AICRP on Cashew, Puttur
31. AICRP Spices, Calicut
32. AICRP Floriculture, Pune
33. AICRP on Micro Secondary and Pollutant Elements in Soils and Plants, Bhopal
34. AICRP on Soil Test Crop Response, Bhopal
35. AICRP on Long Term Fertilizer Experiments, Bhopal
36. AICRP on Salt Affected Soils and use of Saline Water, Karnal
37. AICRP on Irrigation Water Management Research, Bhubaneshwar
38. AICRP Dryland Agriculture, Hyderabad
39. AICRP on Agrometeorology, Hyderabad
40. AICRP on Integrated Farming System, Modipuram
41. AICRP on Agroforestry, Jhansi
42. AICRP on Weed Management, Jabalpur
43. AICRP on Farm Implements and Machinery, Bhopal
44. AICRP on Ergonomics and Safety in Agriculture, Bhopal
45. AICRP on Energy in Agriculture and Agro based Industries, Bhopal
46. AICRP on Utilization Animal Energy, Bhopal
47. AICRP on Plasticulture Engineering and Technology, Ludhiana
48. AICRP on Post Harvest Engineering and Technology, Ludhiana
49. AICRP on Goat Improvement, Mathura
50. AICRP on Improvement of Feed Sources and Nutrient Utilisation, Bengaluru
51. AICRP on Cattle Research, Meerut
52. AICRP Foot and Mouth, Mukteshwar
53. AICRP on Poultry, Hyderabad
54. AICRP ADMAS, Bengaluru
55. AICRP on Pig, Guwahati
56. AICRP Home Science

NETWORK PROGRAMMES

1. AIC Research Network on Potential Crops, New Delhi
2. Network Progject on Transgenics
3. AINP on Soil Arthropod Pests, Durgapura, Rajasthan
4. AINP on Agricultural Acarology
5. AINP on Pesticides Residues, New Delhi
6. AINP on Arid Legumes, Kanpur
7. All India Network Research Project on Tobacco, Rajamundry
8. AINP on Jute and Allied Fibres, Barrackpore
9. AINP on Vertebrate Pest Management, Jodhpur
10. Network on Insect Biosystematics, New Delhi/ Bengaluru
11. Application of Micro-organisms in Agriculture and Allied Sectors(AMAAS) +Microbial Genomic Resources repository network, Mau
12. Network O and G (included in Directorate)
13. Network on Medicinal and Aromatic Plants, Anand
14. AINP on Biofertilizer, Bhopal
15. Network Programme on Organic Farming, Modipuram
16. Network project on Harvesting, Processing and Value Addition of Natural Resins & Gums, Ranchi
17. Network Project on Conservation of Lac Insect Genetic Resources, Ranchi
18. Network project on Animal Genetic Resources, Karnal
19. Network on Sheep Improvement, Avikanagar
20. Network Project on Buffalo Improvement, Hissar
21. Network on Gastro Intestinal Parasitism, Izatnagar
22. Network on Haemorrhagic Septcamia, Izatnagar
23. Network Programme on Blue Tongue Disease, Izatnagar
24. All India Network Program on Neonatal Mortality in Farm Animal(NNM), Izatnagar
25. All India Network Program on Diagnostic Imaging and Management of Surgical Condition in Animals, Izatnagar

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APPENDIX 9

AGRICULTURAL UNIVERSITIES

State Agricultural Universities

1. Acharya N.G. Ranga Agricultural University, Lam, Guntur (Andhra Pradesh) 522 509
2. Agriculture University, Jodhpur (Rajasthan) 342 304
3. Agriculture University Kota (Rajasthan) 324 001
4. Anand Agricultural University Anand (Gujarat) 388 110
5. Asom Agricultural University Jorhat (Asom) 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. Birsa Agricultural University Ranchi (Jharkhand) 834 006
10. Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana) 125 004
11. Ch. Sarwan Kumar Krishi Vishvavidyalaya Palampur (Himachal Pradesh) 176 062
12. Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh) 208 002
13. Chhattisgarh Kamdhenu Vishvavidyalaya Durg (Chhattisgarh) 491 001
14. Dr Panjabrao Deshmukh Krishi Vidyapeeth Akola (Maharashtra) 444 104
15. Dr Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli (Maharashtra) 415 712
16. Dr Y.S. Parmar University of Horticulture and Forestry Nauni- Solan (Himachal Pradesh) 173 230
17. Dr Y.S.R. Horticultural University Venkataramannagudem (Andhra Pradesh) 534 101
18. G.B. Pant University of Agriculture and Technology Pantnagar (Uttarakhand) 263 145
19. Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana (Punjab) 141 004
20. Indira Gandhi Krishi Vishwavidyalaya Raipur (Chhattisgarh) 492 006
21. Jawaharlal Nehru Krishi Viswavidyalaya Jabalpur (Madhya Pradesh) 482 004
22. Junagadh Agricultural University Junagarh (Gujarat) 362 001
23. Kamdhenu University Amreli (Gujarat) 382 010
24. Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar (Karnataka) 585 401
25. Kerala Agricultural University Thrissur (Kerala) 680 656
26. Kerala University of Fisheries and Ocean Studies Panangad (Kerala) 682 506
27. Kerala Veterinary and Animal Sciences University Wayanad (Kerala) 673 576
28. Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar (Haryana) 125 001
29. Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan) 313 001
30. Maharashtra Animal and Fishery Sciences University Nagpur (Maharashtra) 440 001
31. Mahatma Phule Krishi Vidyapeeth Rahuri (Maharashtra) 413 722
32. Nanaji Deshmukh University of Veterinary Science Jabalpur (Madhya Pradesh) 482 001
33. Narendra Dev University of Agriculture and Technology, Faizabad (Uttar Pradesh) 224 229
34. Navsari Agricultural University Navsari (Gujarat) 396 450
35. Orissa University of Agriculture and Technology Bhubaneswar (Odisha) 751 003
36. Professor Jayashankar Telangana State Agricultural University, Hyderabad (Telangana) 500 030
37. Punjab Agricultural University Ludhiana (Punjab) 141 004
38. Rajasthan University of Veterinary and Animal Sciences Bikaner (Rajasthan) 334 001
39. Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya Gwalior (Madhya Pradesh) 474 002
40. Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (Uttar Pradesh) 250 110
41. Sardarkrushinagar Dantiwada Agricultural University Sardarkrushinagar (Gujarat) 385 506
42. Sher-e-Kashmir University of Agricultural Science and Technology of Jammu, Jammu, Jammu and Kashmir 180 009
43. Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar (Jammu and Kashmir) 190 025
44. Sri Karan Narendra Agriculture University Jobner (Rajasthan) 303 329
45. Sri Konda Laxman Telangana State Horticultural University, Rajendra Nagar Campus Hyderabad, Telangana 500 030
46. P.V. Narsimha Rao Telangana Veterinary University Rajendranagar, Hyderabad, Telangana 500 030
47. Sri Venkateswara Veterinary University Tirupati (Andhra Pradesh) 517 502
48. Swami Keshwanand Rajasthan Agricultural University Bikaner (Rajasthan) 334 006
49. Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu) 641 003
50. Tamil Nadu Veterinary and Animal Sciences University, Chennai (Tamil Nadu) 600 051
51. Tamil Nadu Fisheries University, Nagapattinam (Tamil Nadu) 611 001
52. U.P. Pt. Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwa Vidhyalaya Evem Go Anusandhan Sansthan, Mathura (Uttar Pradesh) 281 001
53. University of Agricultural and Horticultural Sciences Shimoga (Karnataka) 577 204
54. University of Agricultural Sciences Bengaluru (Karnataka) 560 065
55. University of Agricultural Sciences Dharwad (Karnataka) 580 005
56. University of Agricultural Sciences Raichur (Karnataka) 584 102
57. University of Horticultural Sciences Bagalkot (Karnataka) 587 103
58. Uttar Banga Krishi Viswavidyalaya Coochbehar (West Bengal) 736 165
59. V.C.S.G. Uttarakhand University of Horticulture and Forestry Bharsar, Pauri Garhwal (Uttarakhand) 246 123
60. Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani (Maharashtra) 431 402
61. West Bengal University of Animal and Fishery Sciences, Kolkata (West Bengal) 700 037
62. Sam Higginbottom University of Agriculture, Technology and Science, Allahabad (Uttar Pradesh) 211 007

Deemed Universities

1. ICAR-Indian Agricultural Research Institute New Delhi- 110 012

2. ICAR-National Dairy Research Institute
   Karnal (Haryana) 132 001
3. ICAR-Indian Veterinary Research Institute
   Izatnagar, Barielly (Uttar Pradesh) 243 122
4. ICAR-Central Institute of Fisheries Education
   Mumbai (Maharashtra) 400 061

Central Agricultural Universities

1. Central Agricultural University
   Imphal (Manipur) 795 004
2. Rani Laxami Bai Central Agricultural University
   Jhansi (Uttar Pradesh) 284 003
3. Dr Rajendra Prasad Central Agricultural University
   Pusa, Samastipur (Bihar) 848 125

Central Universities with Agriculture Faculty

1. Aligarh Muslim University
   Aligarh (Uttar Pradesh) 202 002
2. Banaras Hindu University
   Varanasi (Uttar Pradesh) 221 005
3. Nagaland University
   Lumani (Nagaland) 798 620
4. Visva Bharti University,
   Shanti Niketan, Birbhum (West Bengal) 731 235

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APPENDIX 10

Total number of employees in the ICAR and its research institutes and number of 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	4397	3690	406	11.00	158	4.28	484	13.12
	b Senior Scientist	1304	849	79	9.30	23	2.71	102	12.01
	c Pr. Scientist	776	576	49	8.51	3	0.52	36	6.25
	d RMP	175	138	8	5.80	5	3.62	17	12.32
	Total	**6652**	**5253**	**542**	**10.32**	**189**	**3.60**	**639**	**12.16**
2	**Technical Posts**								
	a Category I	3993	2870	508	17.70	281	9.79	360	12.54
	b Category II	2650	2205	271	12.29	109	4.94	293	13.29
	c Category III	514	479	81	16.91	49	10.22	90	18.79
	Total	**7157**	**5554**	**860**	**15.48**	**439**	**7.90**	**743**	**13.38**
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)/	332	306	41	13.39	24	7.84	17	5.56
	b Category 'B' posts :- AF&AO/AAO/PS/SO/ALA/ Assistant/PA/JAO	2835	2144	407	18.98	171	7.97	268	12.5
	c Category 'C' posts :- UDC/Steno/LDC	1710	1140	190	16.67	85	7.45	122	10.70
	Total	**4877**	**3590**	**638**	**17.77**	**280**	**7.79**	**407**	**11.34**
4	**Skilled Supporting Staff**								
	Total	**8364**	**5266**	**1512**	**28.72**	**492**	**9.34**	**825**	**15.6**

APPENDIX 11

ICAR AWARDS

AWARDS	AWARDEES
Sardar Patel Outstanding ICAR Institution Award 2015	**Large Institutes** Indian Institute of Rice Research, Rajendranagar Hyderabad, Telangana Indian Grassland and Fodder Research Institute Near Pahuj Dam, Gwalior Road, Jhansi, Uttar Pradesh **Small Institutes** National Bureau of Agricultural Insect Resources, Bellary Road, Bengaluru, Karnataka **Universities** University of Agricultural Sciences, Dharwad, Karnataka
Chaudhary Devi Lal Outstanding All India Coordinated Research Project Award 2015	All India Coordinated Research Project on Micro-and Secondary-Nutrients and Pollutant Elements in Soils and Plants, Indian Institute of Soil Science, Bhopal All India Coordinated Research Project on Post-Harvest Engineering and Technology, CIPHET, PAU, Ludhiana
Rafi Ahmed Kidwai Award for Outstanding Research in Agricultural Sciences 2015	**Crop and Horticultural Sciences** **Dr Gyanendra Pratap Singh** Principal Scientist, IARI, New Delhi-110 012 **Natural Resource Management and Agricultural Engineering** **Dr S.K. Chaudhari** ADG (S&W Mgt), KAB-II, New Delhi **Animal and Fisheries Sciences** **Dr M.S.Chauhan** Principal Scientist, Animal Biotechnology Centre, NDRI, Karnal
Lal Bahadur Shastri Outstanding Young Scientist Award 2015	**Crop and Horticultural Sciences** **Dr S. Gopalakrishnan** Senior Scientist (Plant Breeding), IARI, New Delhi **Natural Resource Management and Agricultural Engineering** **Dr A. K. Bhardwaj** Senior Scientist, CSSRI, Karnal, Haryana **Animal and Fisheries Sciences** **Dr N.H. Mohan** Senior Scientist, NRC on Pig, Guwahati, Asom **Social Sciences** **Dr Subhasis Mandal** Senior Scientist (Agricultural Economics), CSSRI R.S., Canning Town, South 24 Parganas, West Bengal
Panjabrao Deshmukh Outstanding Woman Scientist Award 2015	**Dr (Ms.) Neelam Patel** Principal Scientist, Water Technology Centre, Indian Agricultural Research Institute, New Delhi **Dr (Mrs.) Chandish R. Ballal** Principal Scientist and Head, Division of Insect Ecology, National Bureau of Agricultural Insect Resources, Bengaluru
Bharat Ratna Dr C. Subramaniam Award for Outstanding Teachers 2015	**Crop and Horticultural Sciences** **Dr Anil Kumar** Prof. and Head, GBPUAT, Pantnagar Natural Resource Management and Agricultural Engineering

AWARDS	AWARDEES
	Dr A.K. Singh Principal Scientist, Department of Dairy Technology, NDRI, Karnal **Animal and Fisheries Sciences** **Dr G. Taru Sharma** Head, Division of P and C, IVRI, Izatnagar **Social Sciences** **Dr Hema Tripathi** Pri. Sci. TT and EU, CIRB, Hisar
Fakhruddin Ali Ahmed Award for Outstanding Research in Tribal Farming Systems 2015	**Dr Bidyut C. Deka** ICAR R.C. for NEH Region, Nagaland Centre, Jharnapani, Nagaland **Dr Manas Kumar Patra** (Associate), Scientist (Animal Reproduction), IVRI, Izatnagar, Bareilly, Uttar Pradesh 243 122 **Dr Rakesh Kumar** (Associate), Scientist (Agronomy), ICAR RC for Eastern Region, Patna, Bihar 800 014 **Dr S.V.Ngachan** (Associate), Director, ICAR Research Complex for NEH Region, Umroi Road, Umiam, Meghalaya 793 103 **Dr G.P.Pali** Dean, College of Agriculture, Kanker, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh 492 012 **Dr S.K.Patil** (Associate), Vice-Chancellor, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh 492 012 **Dr Birbal Sahu** (Associate), Programme Coordinator, Krishi Vigyan Kendra, Kanker, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh 492 012 **Dr Rama Mohan Savu** (Associate), Scientist (Agronomy), Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh 492 012
Jawaharlal Nehru Award for P.G. Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences 2015	**Crop Sciences** **Dr Manpreet Singh** New Suraj Nagri, Street No.7, Chowk No.12, Backside DAV College, Abohar, Punjab 152 116 **Dr Banisetti Kalyana Babu,** IIOPR,7th Mile Road,Pedavegi-534450 West Godavari Distt., Andhra Pradesh **Biotechnology (Animal/Plant)** **Dr Monika Saini, D/o Mangeram Saini** Lane No.3, Railpar Shamli, UP 247 776 **Dr Devanna** #38, LBS Buld., NRCPB, New Delhi 110 012 **Crop Protection** **Dr Rimaljeet Kaur** H.No.157/8, Gurbax Nagar, near Mohan Plaza, D.B.N.Rd. Gurdaspur, Punjab

AWARDS	AWARDEES
	Dr Chinnaraja Chinnadurai C/o Dr R.Viswanathan, Head I/c Div. of C.P., SBI, Coimbatore
	Natural Resource Management **Dr Ajay Gajanan Bhave** 63,Cardinal Place, Woking, Surrey GU227LR, United Kingdom
	Dr Saurav Saha ICAR-Res. Complex for NEH Region, Mizoram Centre Kolasib 796 081
	Agriculture Engineering **Dr Parmanand Kumar** Type-III/81, Forest Res. Instt., Dehradun
	Animal Sciences **Dr Selokar Naresh Lalaji** Division of Animal Physiology and Reproduction, CIRB, Hisar
	Dr Jonathan Lalsiamthara Post-Doctoral Researcher, Department of Bioactive Material Sciences and Department of Veterinary Public Health, College of Veterinary Medicine, Chonbuk National University, Iksan Campus, 570 752, Republic of Korea
	Social Sciences **Dr Jaya Kumaravaradan R.** 13,1 Block, Housing Board Apartments, Kavikuil Street, Ashok Nagar, Lawspet, Puducherry 605 008
	Dr Sujit Sarkar Scienctist,IARI, Regional Station, Kalimpong, Darjeeling, West Bengal
Jagjivan Ram Abhinav Kisan Puruskar 2015/ Jagjivan Ram Innovative Farmer Award (National/ Zonal)	**National** **Sh Bodavula Lakshminarayana** Thimidithapadu, Karamchedu Mandal, Prakasam District, Andhra Pradesh 523 170
Zone 1	**Zone 1** **Smt Gurdeep Kaur** Vill. Alhoran Kalan, PO-Lobana Khas, The-Nabha, Distt.-Patiala, Punjab 147 201
Zone 2	**Zone 2** **Sh Jitendra Kumar Singh** Vill.-Namidih, Post-Ghatrao, Distt.-Vaishali, Bihar 844 119
Zone 3	**Zone 3** **Sh Dhruba Jyoti Barua** Vill.-North Kachakhana, P.O.-Paglahat, Distt.-Dhubri, Asom 783 334
Zone 4	**Zone 4** **Sh Manoj Kumar Tyagi** Vill. and Post-Rohana Kala, Distt.-Muzaffarnagar, Uttar Pradesh 251 202
Zone 5	**Zone 5** **Sh B.V. Ramanamurthy** Akkivalasa village, Amadalavalasa Mandal, Srikakulam Distt., Andhra Pradesh 532 185
Zone 6	**Zone 6** **Sh Shree Kishan Suman** Ward No.2, Gram and Post-Girdharpura First, Theh.-Ladpura, Kota

AWARDS	AWARDEES
Zone 8	**Zone 8** **Sh S.N. Shankara Murthy S/o Nandyappa** Lingadahalli, Channagiri (Taluk), Davanagere Distt., Karnataka 577 221
Dr Rajendra Prasad Puruskar for technical books in Hindi in Agricultural and Allied Sciences 2015	**Crop and Horticultural Sciences** **Dr Devina Vaidya** Pri. Sci, Department of Food Science and Technology, Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh 173 230 **Dr Manisha Kaushal (Associate)** Scientist, Department of Food Science and Technology, Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh 173 230 **Dr Anil Kumar Verma (Associate)** T-6, Department of Food Science and Technology, Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh 173 230 **Dr Anil Gupta (Associate)** T-3, Department of Food Science and Technology, Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh 173 230 **Dr Anil Dixit (Associate)** Sr. Sci, Department of Food Science and Technology, Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh 173 230 **Natural Resource Management and Agricultural Engineering** **Dr S.K. Ambast** Director, IIWM, Bhubaneswar **Dr A. Velmurugan (Associate)** Sr. Sci. (Soil Sc.) CIARI, Port Blair, Andaman and Nicobar 744 105 **Dr T.P. Swarnam (Associate)** Sr. Sci. (Soil Sc.) CIARI, Port Blair, Andaman and Nicobar 744 105 **Dr B. Gangwar (Associate)** Ex-Director, PDFSR, Meerut
Vasant Rao Naik Award for Research Application in Agriculture 2015	**Dr Sunil Kumar** Principal Scientist, IGFRI, Jhansi, U.P. **Dr A.K. Dixit (Associate)** Senior Scientist (Agronomy), IGFRI, Jhansi, U.P. **Dr Kiran Kumar Tirumala (Associate)** Scientist (Agronomy), IGFRI, Jhansi, U.P. **Dr S.K. Rai (Associate)** Principal Scientist (Agro-Meteorology), IGFRI, Jhansi **Dr Rajiv Kumar Agrawal (Associate)** Principal Scientist (Agronomy), IGFRI, Jhansi, U.P. **Dr Probir Kumar Ghosh (Associate)** Director, IGFRI, Jhansi, U.P.
Swami Sahajanand Saraswati Outstanding Extension Scientist Award 2015	**Dr Dheeraj Singh** Programme Coordinator KVK CAZRI, Pali, Rajasthan **Dr P. Susheela, Associate** Professor and Principal Investigator Kerala Agricultural University, Kerala

AWARDS	AWARDEES
NASI-ICAR Award for Innovation and Research on Farm Implements 2015	**Dr Adurthi Mrunalini** Unit Coordinator (Research and Management Position), PJTSAU, Hyderabad, Telangana
ICAR Award for Outstanding Interdisciplinary Team Research in Agricultural and Allied Sciences 2013-14	**Crop and Horticultural Sciences** **Dr A.T. Sadashiva,** Principal Scientist and Head Division of Vegetable Crops IIHR, Bengaluru-560 089, Karnataka **Dr Peter Hanson (Associate)** IIHR, Bengaluru, Karnataka 560 089 **Dr M. Krishna Reddy (Associate)** IIHR, Bengaluru, Karnataka 560 089 **Dr Girija Ganeshan (Associate)** IIHR, Bengaluru, Karnataka 560 089 **Dr C. Gopalakrishnan (Associate)** IIHR, Bengaluru, Karnataka 560 089 **Dr K. Madhavi Reddy (Associate)** IIHR, Bengaluru, Karnataka 560 089 **Dr S. Shankara Hebbar(Associate)** IIHR, Bengaluru, Karnataka 560 089 **Dr T.H. Singh (Associate)** IIHR, Bengaluru, Karnataka 560 089 **Dr K.V. Ravi Shankar (Associate)** IIHR, Bengaluru, Karnataka 560 089 **Natural Resource Management and Agricultural Engineering** **Dr Susanta Kumar Jena** Indian Institute of Water Management, Bhubaneswar **Sh Prabir Roy Choudhury (Associate)** Ex-Director, IRMRA **Dr Mrinal Kanti Talukdar (Associate)** KPCL, Mumbai **Dr Pothula Srinivasa Brahmanand (Associate)** IIWM, Bhubaneswar **Dr Kasilingam Rajkumar (Associate)** IRMRA **Dr Narayan Sahoo (Associate)** IIWM, Bhubaneswar **Dr S.K.Chakraborty (Associate)** IRMRA **Dr Ashwani Kumar (Associate)** IIWM, Bhubaneswar **Er. Ashok Kumar Bharimalla (Associate)** CIRCOT, Mumbai **Dr Atmaram Mishra (Associate)** IIWM, Bhubaneswar **Er. D.U. Patil (Associate)** IIWM, Bhubaneswar **Animal and Fisheries Sciences** **Dr S.K. Singla** Principal Scientist, Livestock Production and Management, National Dairy Research Institute, Karnal

AWARDS	AWARDEES
	Dr M.S. Chauhan (Associate) National Dairy Research Institute, Karnal
	Dr R.S. Manik (Associate) National Dairy Research Institute, Karnal
	Dr Shiv Prasad Kimothi (Associate) National Dairy Research Institute, Karnal
	Dr P. Palta (Associate) National Dairy Research Institute, Karnal
Chaudhary Charan Singh Award for Excellence in Journalism in Agricultural Research and Development 2015	**Print Media** **Sh Vishwa Mohan** Editor-Environment-The Times of India (English)
	Sh Skand Vivek Dhar Principal Correspondent, Rajasthan Patrika (Hindi)
	Sh Sanjay Mishra Special Correspondent, Amar Ujala (Hindi)
	Sh Dhirendra Kumar Dhirendra Kumar, Millennium Post Newspaper (English)
	Electronic Media **Sh Manoj Kumar Patairiya** Channel Head-DD Kisan, Central Production Centre, Doordarshan, Khel Gaon, Siri Fort, New Delhi 110 049
	Sh Amit Kumar Special Correspondent, ANI
	Sh Virendra Parihar Programme Producer, Krishi Darshan, Jaipur
ICAR Cash Award Scheme 2015	**Administrative** **Sh Anil Kumar Verma** ICAR, Krishi Bhawan, New Delhi
	Ms. Chitra-Anagha U. Joshi, Asstt., CIFE, Mumbai
	Technical **Sh. R. Sudhakar** CTO (Rural crafts), CTRI, Rajahmundry
	Sh. Sandeep Kumar Technical Assistant, NDRI, Karnal
	Supporting **Sh. Ram Pal Saini** SSS, NDRI, Karnal
Haldhar Organic Farmer Award 2015	**Sh Rajesh Kheri** Vill.-Kheri Sikandar, PO-Pundri, Distt-Kaithal, Haryana 136 026
	Sh Shyam Bihari Gupt Krishak Bhawan, Near Rajghat Colony, Nandanpura, Jhansi, Uttar Pradesh 284 003
N.G. Ranga Farmer Award for Diversified Agriculture 2015	**Sh Kunal Gahlot** House No. 176, Village-Tigipur, P.O.-Bakhtawarpur, Delhi 110 036
Best Krishi Vigyan Kendra Awards (National and Zonal) 2015	**National** Krishi Vigyan Kendra, Dantewada, Chhattisgarh
	Zone I Krishi Vigyan Kendra, Bathinda, Punjab

AWARDS	AWARDEES
	Zone II Krishi Vigyan Kendra, Harnaut, Nalanda, Bihar **Zone III** Krishi Vigyan Kendra-Lunglei, Hnahthial, Mizoram 796 571 **Zone IV** Krishi Vigyan Kendra, Pratapgarh, Uttar Pradesh **Zone V** Krishi Vigyan Kendra, Amadalavalasa-532 185, Srikakulam District, Andhra Pradesh **Zone VI** Krishi Vigyan Kendra, Navsari, Gujarat **Zone VII** Krishi Vigyan Kendra, Dhar, Gwalior, Madhya Pradesh **Zone VIII** Krishi Vigyan Kendra, Malappuram, Kerala
Pt. Deen Dayal Upadhyay Antyodaya Krishi Puruskar 2015	**ATARI Kanpur** Smt. Krishna Yadav (National) Village-Dinapur, Najafgarh **ATARI Ludhiana** Shri Jitender Singh (Zone-I) Roopnagar, Punjab **ATARI Jodhpur** Smt. Pooja Sharma (Zone-II) Village-Chandu, Distt. Gurgaon (Haryana) **ATARI Kanpur** Shri Moti S/o Shri Shyama, Saidasounkh, Mathura (Zone III) **ATARI Kolkata** Shri Deepak Kumar Singh (Zone-IV) Village-Bishanpur, Banka, Bihar **ATARI Kolkata** Shri Ashok Kumar Sarkar (Zone-V) Village-Govindpur, Nimbudera, A & M Andaman Andaman and Nicobar Island **ATARI Barapani** Smt. Anuradha Chetri (Zone-VI) Village-Uppar, Pakyong, East Sikkim, Sikkim **ATARI Barapani** Shri Biswajit Majumder (Zone-VII) Village-Ramendranagar, Sabroom, Tripura **ATARI Hyderabad** Shri Hasan Bhai Jumabhai Musangara (Zone-VIII) Gir-Somnath (Gujarat) **ATARI Jabalpur** Shri Balaram Patidar (Zone-IX) Village-Sarangi, Petlawad, Jhabua, Madhya Pradesh **ATARI Hyderabad** Shri Alluri Suryanarayana Murthy (Zone-X) East Godavari, Andhra Pradesh **ATARI Bengaluru** Shri A. Baburaj (Zone-XI) Ambali House, Kozhikode (Kerala)

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Acronyms

ABST	: Antibiotic Sensitivity Test
AcMNPV	: Autographa Californica Multiple Nucleopoly-hedrovirus
AES	: Agriculture Expert System
AFC	: Age at First Calving
AFLP	: Amplified Fragment Length Polymorphism
AGID	: Agar Gel Immunodiffusion
AI	: Artificial Insemination
AICRP	: All India Coordinated Research Project
AINP	: All India Network Project
ALV	: Avian Leukosis Virus
ASAM	: Alkaline Sulfite Anthraquinone Methanol
ASEAN	: Association of South-East Asian Nations
ASRB	: Agricultural Scientists' Recruitment Board
ATIC	: Agricultural Technology Information Centre
AUTM	: Association of Universities for Technology Management
BAIF	: Bhartiya Agro-Industrial Foundation
BCM	: Billion Cubic Metres
BFF	: Buffalo Fetal Fibroblasts
BHU	: Banaras Hindu University
BIMSTEC	: Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Co-operation
BOD	: Biochemical Oxygen Demand
BRICS	: Brazil, Russia, India, China and South Africa
BTV	: Blue Tongue Virus
BVDV	: Bovine Viral Diarrhoea Virus
BVS	: Bovine Vaccinate Serum
CAFT	: Centres of Advanced Faculty Training
CAU	: Central Agricultural University
CAZRI	: Central Arid Zone Research Institute
CCHF	: Crimean Congo Hemorrhagic Fever
CeRA	: Consortium for e-Resources in Agriculture
CFL	: Current Fallow Land
CFT	: Complement Fixation Text
CGIAR	: Consultative Group on International Agricultural Research
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
CMS	: Cytoplasmic Male Sterility
CP	: Crude Protein
CPC	: Corn Protein Concentrate
CPE	: Cumulative Pan Evaporation
CRRI	: Central Rice Research Institute
CSEV	: Classical Swine Fever Virus
CSFL	: Coloured Synthetic Female Line
CSML	: Coloured Synthetic Male Line
CWM	: Chicken Waste Meal
DAS	: Days After Sowing
DAT	: Days After Transplanting
DG	: Distillers' Grains
DRWA	: Directorate of Research on Women in Agriculture
EEE	: Eastern Equine Encephalitis
EHV	: Equine Herpes Virus
EIA	: Enzyme Immuno Assay
EIV	: Equine Influenza Virus
ELISA	: Enzyme-linked Immunosorbent Assay
EPN	: Entomopathogenic Nematode
ETL	: Economic Threshold Level
EXPSS	: Expert System on Seed Spices
FAD	: Fatty Acid Desaturase
FAO	: Food and Agriculture Organization
FCR	: Feed Conversion Rate
FEC	: Faecal Egg Count
FMD	: Foot-and-Mouth Disease
FPPS	: Farnesyl Pyrophosphate Synthase
FPT	: Field Progeny Testing Project
FSH	: Follicle-stimulating Hormone
FYM	: Farmyard Manure
GADVASU	: Guru Angad Dev Veterinary and Animal Sciences University
GBNV	: Groundnut Bud Necrosis Virus
GBPUAT	: Govind Ballabh Pant University of Agriculture and Technology
GDP	: Gross Domestic Production
GEF	: Global Environmental Facility
GHG	: Greenhouse Gases
GIS	: Geographical Information System
GML	: Gramapriya Male Line
GPA	: Global Plan of Action
GPS	: Global Positioning System
HAPA	: Hybridization-supplemented Apomixis Components Partitioning Approach
HDPE	: High Density Polyethylene
HF	: Holstein Friesian
HPAI	: Highly Pathogenic Avian Influenza
HPNA	: Highly Pathogenic Notifiable Avian Influenza
HPTLC	: High Performance Thin Layer Chromatography
HRR	: Head Rice Recovery
HS	: Haemorrhagic Septicaemia
HSP	: Heat Shock Protein
IAA	: Integrated Agri-aquaculture
IBR	: Infectious Bovine Rhinotracheitis
ICARDA	: International Centre for Agricultural Research in Dry Areas
ICMV	: Indian Cassava Mosaic Virus
ICRISAT	: International Crops Research Institute for Semi-Arid Tropics
ICT	: Information and Communication Technologies
IDS	: Integrated Drying System
IFS	: Integrated Farming System
IHC	: Immuno-histochemistry
IPM	: Integrated Pest Management
IPNS	: Integrated Plant Nutrient System
IPR	: Intellectual Property Rights
ITK	: Indigenous Technical Knowledge
IWMI	: International Water Management Institute
JE	: Japanese Encephalitis
JNKVV	: Jawaharlal Nehru Krishi Vishwa Vidyalaya
KVAFSU	: Kerala Veterinary, Animal Sciences and Fisheries University

KVK : Krishi Vigyan Kendra
LDPE : Low Density Polyethylene
LLO : Listeriolysin-O
LPNA : Low Pathogenic Notifiable Avian
LRI : Land Resource Inventory
MAb : Monoclonal Antibody
MAFSU : Maharashtra Animal and Fishery Sciences University
MAS : Molecular Marker-assisted Selection
MAT : Macroscopic Agglutination Test
MoU : Memorandum of Understanding
MPP : Methane Production Potential
MPUAT : Maharana Pratap University of Agriculture and Technology
MRSA : Methicillin Resistant *Staphylococcus aureus*
MS : Mass Spectrometry
MSCs : Mesenchymal Stem Cells
MW : Molecular Weight
NABG : National Agricultural Bioinformatics Grid
NADRES : National Animal Disease Referral Expert System
NAE : Niche Area of Excellence
NARD : National Agricultural Research Database
NASF : National Agricultural Science Fund
NBSS&LUP : National Bureau of Soil Survey and Land Use Planning
NDF : Non-detergent Fibre
NDRI : National Dairy Research Institute
NDVSU : Nanaji Deshmukh Veterinary Science University
NEH : North-Eastern Hills
NET : National Eligibility Test
NGOs : Non-Government Organizations
NIABI : Network of Indian Agri-business Incubators
NICRA : National Initiative on Climate Resilient Agriculture
NISAGENET : National Information System on Agricultural Education Network
NRC : National Research Centre
NRCC : National Research Centre on Citrus
NSP-Ab : Non Structural Protein Antibody
NTM : Non-tuberculous *Mycobacterium*
NTS : National Talent Scholarship
NUE : Nitrogen Uptake
NWPSI : Network Project on Sheep Improvement
OBCs : Other Backward Classes
PCR : Polymerase Chain Reaction
PDDUUKSY : Pandit Deen Dayal Upadhyay Unnat Krishi Shiksha Yojana
PG : Post-graduate
PIADC : Plum Island Animal Disease Center
PME : Priority Setting, Monitoring and Evaluation
PPGSE : Plausible Potato Growing Seasons Estimator
PPR : *Peste des Petitis Ruminants*
PRRSV : Porcine Reproductive and Respiratory Syndrome Virus
QTL : Quantitative Trait Loci
RAWE : Rural Agricultural Work Experience
RCCARI : Research Centre of Central Avian Research Institute
RDF : Recommended Dose of Fertilizers
RE : Revised Estimate
RFD : Results-Framework Document
RFLP : Restricted Fragment Length Polymorphism
RH : Relative Humidity
Risk MAP : Risk Mapping, Assessment and Planning
RMP : Research Management Positions
RNFE : Rural Non-farm Employment
RVF : Rift Valley Fever
SAARC : South Asian Association for Regional Co-operation
SAUs : State Agricultural Universities
SCSMV : Sugarcane Streak Mosaic Virus
ShRNA : Small hairpin RNA
SiRNA : Small interferring RNA
SNP : Single Nucleotide Polymorphism
SOD : Super Oxide Dismutase
SPR : Surface Plasmon Resonance
SRF : Senior Research Fellowship
SRI : System of Rice Intensification
SSB : Spawning Stock Biomass
SSD : Surface and Subsurface Drainage
SSLUP : Small Scale Lac Processing Units
SWYMOD : Surface-Water Yield Model
TANUVAS : Tamil Nadu University of Veterinary and Animal Sciences
TDN : Total Digestible Nutrient
TFP : Total Factor Productivity
TLCV : Tomato Leaf Curl Virus
TLR-1 : Toll Like Receptor-1
TMU : Total Milk Yield
TNFU : Tamil Nadu Fisheries University
TOT : Transfer of Technology
TSP : Tribal Sub-Plan
TSS : Total Soluble Solids/Sugars
TTV : Transfusion Transmitted Virus
UG : Under-graduate
UGC : University Grants Commission
UNITECH : University of Technology
UV : Ultra Violet
VACV : Vaccinia Virus
VNTR : Variable Number Tandem Repeats
VPKAS : Vivekananda Parvatiya Krishi Anusandhan Sansthan
VRFA : Variable Rate Granular Fertilizer Applicator
VS : Vesicular Stomatitis
VTCC : Veterinary Type Culture Centre
WB : Western Blot
WBUFAS : West Bengal University of Fisheries and Animal Sciences
WCL : Whole Cell Lysate
WNF : West Nile Fever
WNV : West Nile Virus
WUE : Water Use Efficiency

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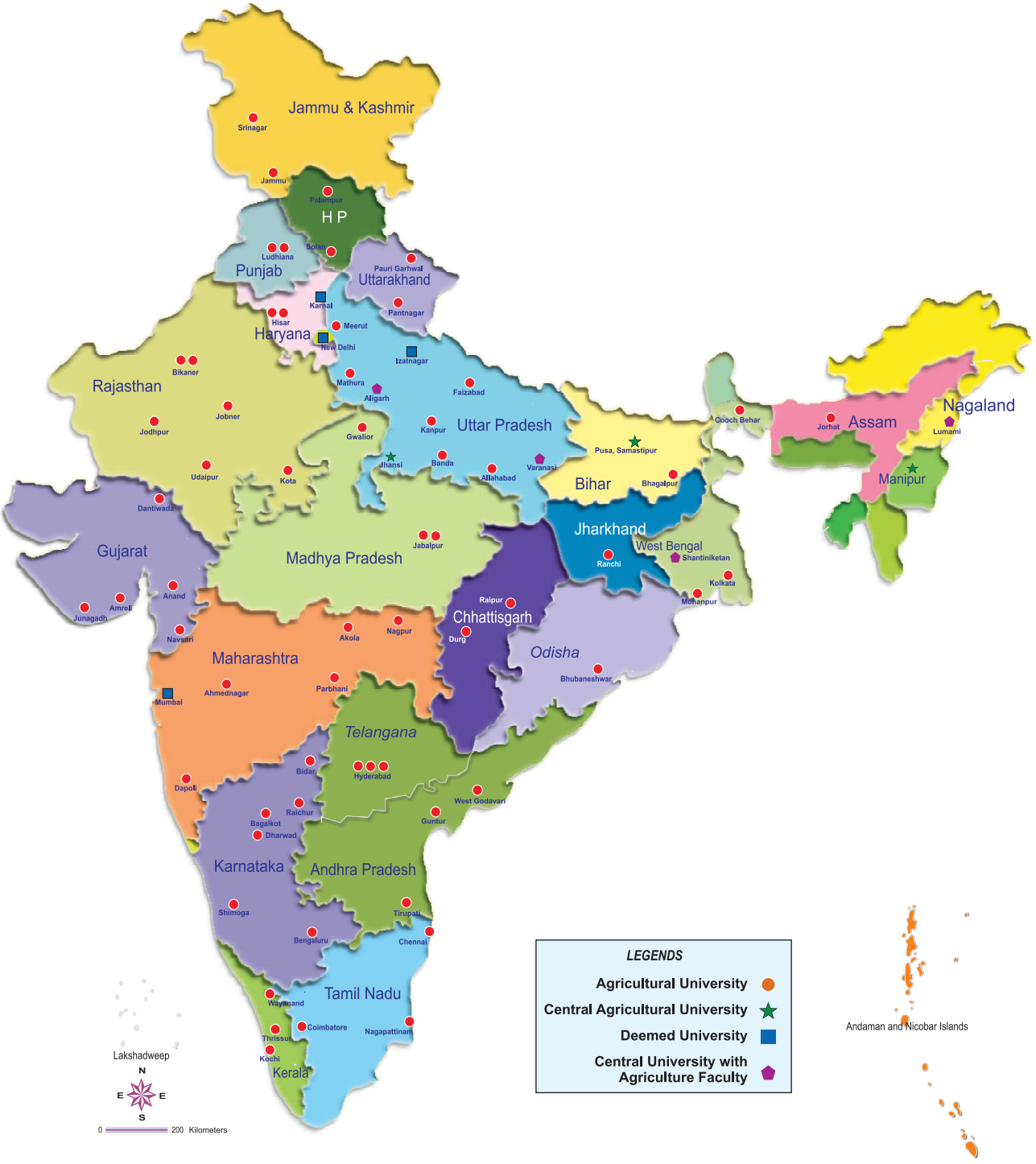
INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Agricultural Universities



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