1. Overview

Keeping pace with the changing requirements of the Country's farm sector, ICAR Institutes developed a number of cost-effective technologies, techniques and products, not only to enhance the productivity of various crops and commodities, but also the quality of produce, for enabling remunerative agriculture. The partnerships within the National Agricultural Research and Education System (NARES) as well as outside, with several organizations were the hallmark of R&D efforts during the year. An overview of the salient achievements is presented here and the detailed accounts of activities/ achievements are presented in the specific sections devoted to each thematic area. It is my pleasure to present DARE/ICAR Annual Report 2015-16, in which multiple activities of agricultural research, education and extension are highlighted.

The 87th Foundation day of ICAR function held at Patna was graced by the Hon'ble Prime Minister for the second consecutive year. On this occasion, the Hon'ble Prime Minister launched several initiatives of ICAR, viz. Farmers FIRST, Student READY, Attracting Retaining Youth in Agriculture (ARYA), Agri-Tech Foresight Centre (ATFC) and *Mera Gaon, Mera Gaurav*, for building entrepreneurship amongst the agricultural graduates and improving technology delivery as well as knowledge empowerment of farmers. Hon'ble Prime Minister also laid Foundation Stone of IARI, Hazaribagh, Jharkhand, being the first such step in the country. Hon'ble Minister of Agriculture and Farmers Welfare laid the foundation stones of the Indian Institute of Agricultural Biotechnology (IIAB), Ranchi and National Research Centre on Integrated Farming at Motihari, Bihar. The other initiatives included launching of Consortia Research Programmes and Extra Mural Funding in the Council.

The ICAR in a major exercise, formulated the Vision-2050 documents and revised the mandates of all the institutes keeping in view the changing needs of agricultural research, human resources and technology dissemination *vis-à-vis* growing population and consequent increase in food demand, changing food consumption pattern, state of natural resources, climate change, commercialization of agriculture, global trade regime and a dynamic policy environment both, domestic as well as global. The nomenclature of several ICAR institutes was also revised.

During the year, several areas in the northern states were impacted by hailstorms that caused damage to ready-to-harvest wheat crop; the monsoon was delayed and on an average remained 14% deficient resulting in loss to rainfed farming in some parts of the country. Such unforeseen natural calamities bring out the vulnerability of the agriculture and also look to the agricultural research community to be proactive for building resilience to natural exigencies. Our institutions responded to the needs from time to time. The Overview presents brief account of salient achievements.

Soil and water productivity

Land resource inventory on 1:10,000 scale was prepared taking Landscape Ecological Unit (LEU) consisting of landforms, land use and slope as the base map while bio-climatic map of India was revised. Electronic atlas of water resources, developed for Odisha and Himachal Pradesh, is a useful tool for catch assessment and developing GIS based Decision Support System. The information will help planners to concentrate efforts, allocate resources and deploy manpower according to the distribution of fishery resources.

Bamboo plantation-based bio-engineering interventions were found promising for reclamation and productive utilization of major ravines namely, Mahi ravines at Vasad (Gujarat), Chambal ravines at Kota (Rajasthan), and Yamuna ravines at Agra (Uttar Pradesh). These interventions could absorb more than 80% of rainfall and reduce the soil and nutrient losses by 90 and 70%, respectively. Foliar sprays with various chemicals were evaluated to mitigate dry spells during crop growing season across diverse rainfed agro-ecologies. Plant growth promoting *Rhizobacteria* and *Arthrobacter* were isolated, characterized and field evaluated in vertisols of Madhya Pradesh; average yield of wheat due to actinomycetes inoculation was 16% higher over control. Shortlisted *Arthrobacter* isolates effectively improved yield of maize and soybean. A soil nitrogen test based fertilizer prediction model for targeted yield in Nagpur Mandarin was developed.

Integrated farming system (1 ha) model comprising cropping systems (0.52 ha) + horticulture (0.32 ha) + dairy including bio-gas and vermicompost unit (0.08 ha) + fish cum poultry (0.1 ha) + mushroom developed in western Himalayas, provided round the year improved production (21.52 tonnes REY (rice equivalent yield)/ year), profit (₹ 3.06 lakh/year) and employment (731 man days/year).

Climate change

The Cool Farm Tool model used to estimate emission of GHGs, integrates several globally determined empirical GHG quantification models. Using the tool, GHG fluxes (carbon-dioxide and methane), moisture and heat in the soil-plant-atmosphere systems were measured in rice-wheat rotation. Among the cropping systems, maize-wheat cropping registered highest

carbon management index. The cumulative seasonal methane emission was reduced by 75% in aerobic rice as compared to continuously flooded rice and the seasonal emissions were lower in slow-release N fertilizer.

Genetic resources

Genetic resources form the basis of qualitative and quantitative improvements in agriculture. The search for new genetic resources, floral and faunal, their documentation, conservation and utilization form a continuum. In this endeavour 29 explorations were undertaken in eight states and 1,454 accessions including 500 of wild species were collected; 383 Herbarium specimens were added to the National Herbarium of Cultivated Plants. In the National Gene Bank, 7,668 germplasm accessions of orthodox seed species were stored; 48 shoot tips/ meristems of different vegetatively propagated species were cryo-stored and 11 accessions were added to *in-vitro* storage for long-term storage. From 45 countries, 32,552 accessions were imported including international trial material. Thirty-six novel germplasm lines were registered.

A total of 1,503 indigenous and 195 exotic collections comprising fruits, vegetables, tuber crops, plantation crops and nuts, spices, medicinal and aromatic plants, ornamental crops and mushrooms were made from different sources. One *ber* accession (CIAH-Ber-S-15) for early maturity, one *bael* (CISH-B-18) for high fruit yield, four walnut accessions with higher nut and kernel weight, three almond accessions with more kernel recovery, two chili accessions (BS-20 and BS-79) with field tolerance to leaf curl, Dolichos Yellow Mosaic Virus tolerant accession of Indian bean (VRSEM 12) and turmeric (Acc. 849) with high yield were identified. Fifteen species of spiders belonging to six families were recorded and in a first of its kind study spider population in rainfed cotton agro-ecosystem of central India was documented.

Registration of seven new breeds of indigenous livestock during 2015 took the total number of registered indigenous breeds in the country to 151 (39 cattle; 13 buffalo; 24 goat; 40 sheep; 6 horses and ponies; 9 camel; 3 pig; 1 donkey; and 16 chicken). Belahi cattle, Gangatiri cattle, Pantja goat, Kachaikatty Black sheep, Kharai camel, AgondaGoan pig and Mewari chicken are the newly registered breeds. Molecular breed signatures of Gir, Sahiwal and Tharparkar were developed. The National Gene Bank at NBAGR now stores 129,174 frozen semen doses belonging to 44 breeds of cattle, buffalo, goat, sheep, camel, equine and yak. Screening of Frieswal bulls and bull calves for genetic diseases revealed a carrier prevalence percentage of 4.6 for BLAD (bovine leukocyte adhesion deficiency) in Frieswal bull calves, while no carriers were noticed for deficiency of uridine monophosphate synthase, bovine citrullinaemia. Four native chicken populations, PD-4 (Improved Aseel), Aseel, Ghagus and Nicobari fowl were conserved at the ICAR-Central Avian Research Institute.

Fish biodiversity was assessed in the basins of rivers Sharavathi, Valapattanam, Chaliyar, Chandragiri, and upper Mahanadi and in Torsha and Gandak rivers of Ganga-Brahmaputra basin.*Tor putitora* and *Cyprinion semiplotum*, the endangered species in IUCN list, were also recorded from Torsa river (West Bengal) and Balarampur. *Ailia coila, Nangra nangra, Puntius conchonius, Sicamugil cascasia* and *Botia lohachata, Eutropiichthys vacha, Ompok pabda,* which are respectively in the list of vulnerable and endangered category were found in Gandak river. A new fish species *Clarias serratobrachium* sp. nov. was discovered from the wetlands along Indo-Burma border.

Crop improvement

Development of improved varieties/hybrids of food crops and their cultivation are central to increased farm production and consequently national food and nutritional security. During the year high-yielding varieties of cereals (21), oilseeds (16), pulses (8), forage crops (6) and commercial crop (3) were released from our institutions for cultivation in different production ecologies of the country. Biofortified rice variety CR Dhan 310 was commercialized successfully in the Indo-Gangetic Plains belt and Swarna Shreya, a new rice variety for drought–prone conditions was released. To ensure a faster spread to farmers' fields, 978, 17,562, 12,847, 14,000, and 3,418 tonnes of breeder, foundation, certified, truthfully labelled seed and planting material, respectively, were produced. Further nearly, 2,026 lakh of planting material and tissue-cultured plants were produced.

Five different antioxidant genes, characterizing antioxidant defense system from two Indian maize inbred lines, were cloned and registered with Gene Bank as a part of the International Nucleotide Sequence Database Collaboration (INSDC). Insect bioassay of selected lines of chickpea and pigeonpea exhibited larval (*Helicoverpa armigera*) mortality in the range of 20-100%. Allele-mining of drought-responsive factors CcCDP, CcHyPRP and CAP2 gene was accomplished in selected set of chickpea and pigeonpea genotypes. Eleven stress induced miRNAs including those responsive to heat stress in pigeonpea were identified. First time whole genome and transcriptome sequencing of *Colletotrichum falcatum*, red-rot pathogen of sugarcane was reported. Genome sequence of psychro-tolerant bacteria *Staphylococcus xylosus* strain LSR_02N, isolated from the water (sediment) at the confluence of river Zanskar and Indus at Leh, Jammu and Kashmir, was deciphered. The complete genome sequence of *Virgibacillus* sp. bacterium revealed the presence of genes for osmo-regulation and oxidative stress tolerance. Genetic diversity analyses were done in rice (6,984), wild Oryza (48), barnyard millet (94), kodo millet (96), prosomillet (16), sponge-gourd (45), bread wheat (48), pearl millet (90) and giloe (24). Trait-specific markers were developed for terminal heat tolerance, HKT2:1 gene and rust and spot blotch resistance genes in wheat, yield-related genes in rice,

FAE1/ KCS1 gene in Indian mustard, transcription factor families in giloe, and abiotic stress tolerance in horsegram and pigeonpea.

Arka Udaya, mango hybrid with medium-size fruits, firm and deep yellow pulp; Arka Rashmi, guava hybrid with pink pulp; PDKV Baharacid lime with higher fruit yield; Kalpa Haritha, dual-purpose coconut for copra and tender nut; a hybrid cashew (H126) with jumbo nut; Bhima Safed, white onion with 22-25 tonnes/ha bulb yield during *kharif*, Arka Agni and ArkaAlankara, two male sterile marigold hybrids with higher fresh flower yield; Appangala 2, mosaic Virus (katte) resistant cardamom hybrid with 9.3 q/ha dry capsules yield and improved varieties of seed spices like fenugreek (AFg-4), ajwain (AA-93) and nigella (AN-20) having desired traits for yield etc. were developed and recommended for cultivation. Complete plantlets of Nagpur Mandarin and Sweet Orange were successfully regenerated from hybrid endosperm via somatic embryogenesis.

Nutrient management schedule for organic production of Grand Naine and Nendran banana; the technology for production of iron-fortified oyster mushrooms (*Hypsizygus ulmarius*); fertilizer adjustment equation for targeted yield (690–1140 kg/ha) of Appangala 1 and Green Gold varieties of cardamom and integrated nutrient management schedule with improved corm yield of turmeric variety Sudarsana, were developed. An integrated cropping system having coconut + cocoa + banana + pineapple with net income of ₹ 3.77 lakh/ha was developed and successfully demonstrated at Aliyarnagar, Tamil Nadu.

Livestock improvement

India has been holding the position of leading milk producing nation in the world for the last several years with sustainable increase in the annual milk production wherein the research developments played a crucial role. Studies showed that average first lactation 305 days milk yield of cows was 3,703.6±31.3 kg and average age at first calving was 1,036.6±10.2 days. Under Conservation and Genetic Improvement of Indigenous Cattle Breeds, the milk yield showed an increasing trend among the progenies of different sets, and average 305 days milk yield increased from 1,958 kg in first set to 2,604 kg in 10th set. Semen doses of Gir, Kankrej, Sahiwal were produced and utilized for insemination.Cloning of the only alive Wild-buffalo of Chhattisgarh has opened up new avenues of cloning technology application in conservation of endangered species. Prolific sheep strain GMM × P (Garole-Malpura-Malpura × Patanwadi) revealed a multiple birth of 50%. Under Mega Sheep Seed Project, flocks of Chottanagpuri, Mandya, Mecheri, Sonadi, and Malpura were built in their respective breeding tracts for production of superior seed stock and their breeding rams were distributed among farmers for improvement of indigenous sheep breeds. AICRP on Goat Improvement significantly affected conservation and improvement of goat genetic resources as it increased population of goats true-to-the breed and productivity amongst 13 descript breeds and three lesser known genetic resources. The implementation of goat husbandry technologies in famers' flock provided average employment ranging between 80 and 140 man days in a year; and income improved from 67 to 257 % of investment in Assam hill goat. The triple cross pigs ($D_{50}H_{25}G_{25}$) showed significantly higher body weight and pre-weaning and post-weaning growth rate.

Captive stocks of *Rita chrysea*, an indigenous catfish endemic to Mahanadi river, were successfully induced-bred in hatchery conditions. The fish has good consumer preference and market demand. Giant snakehead (*Channa marulius)* and milkfish (*Chanos chanos)* were also induced bred. Milkfish with its ability to grow with other fishes and shrimp and also being disease resistant is an ideal fish for polyculture.

Crop management

Endophytes, *Bacillus subtilis* REN51N and *B. firmus* J22N isolated from seed, root and stem of groundnut were effective in mitigating drought stress and enhancing growth and yield of the crop. *Bacillus aryabhattai* MDSR14 (JF792521) and arbuscular mycorhizal fungi significantly increased dry-matter accumulation, seed yield and phosphorus-use efficiency in soybean and maize intercropping. Application of ethrel, gibberelic acid (GA3) and cytokinin at critical growth stages of sugarcane in autumn planted crop enhanced plant population, tiller survival, number of millable canes and cane yield compared to control.

Stem-rot *(Sclerotium rolfsii)* tolerant genotype of groundnut (CS 19) showed higher constitutive level of pyrocatechol. Intercropping *bajra* with groundnut (3:1) supported lowest population of thrips, hoppers and aphids as compared to other intercrop combinations. Azadirachtin 1.5% @ 7.5 ml/L and standard check of monocrotophos 36 SL @ 1.2ml/L were effective for checking thrips. A detached leaf technique was standardized to screen castor genotypes against grey mold caused by *Botryotinia ricini*. Destruction of infested tomato plants and fruits, preservation of potential natural enemies like *Nesidiocoris tenuis*, *Necremnus* sp., *Orius* sp., and *Trichogramma* spp., mass trapping of male moths both in nursery and main field using nanomatrix, lure trap and use of biopesticides *(Bacillus thuringiensis*, *Beauveria bassiana)* and entomopathogenic nematodes proved promising in management of *Tuta absoluta*. A new invasive mealy bug, *Phenacoccus madeirensis* Green, known to occur in South American region, was recorded on cotton in severe form in Chamrajnagara (Karnataka) infesting 80% plants. For biocontrol, potential Gnat predator, *Diadiplosis hirticornis*, infesting invasive mealy bug, was documented. Unique association was observed between predator gnat and mealy bug. The predator can be easily mass produced in laboratory on pink mealy bug and utilized as a potential biocontrol agent.

An eco-friendly integrated pest management (IPM)

technology in rice was demonstrated successfully with farmers' participation mode over cluster of villages in Gautam Budh Nagar, Uttar Pradesh. Bio-acoustic gadgets equipped with alarm and distress calls of different animals when installed effectively warded off birds and wild animals from feeding on crops. Eco-friendly protocol for trapping melon-fly resulted in trapping 2.5 times more fruitfly, as compared to conventional trap. *Lepidiota mansueta,* a biennial species of white grub, is a severe endemic pest of multiple field crops in Majuli river island of Asom, and tribal people here relished cooked/ fried adults of *L. mansueta*. The beetles serve as the source of protein rich food, having nutritional and nutraceutical value. The seed cotton yield was 38% higher in open-pollinated plot and 17.5% higher in *Apis cerana* pollinated plots as compared to pollinator excluded plots.

The incidence of South American tomato leaf miner or tomato moth *(Tuta absoluta)* was documented around Bengaluru for the first time in India. The incidence of banana skipper, an invasive butterfly pest (*Erionota torus*) was recorded across Kerala in monsoon. Protocol for the detection of Tristeza virus in citrus aphids *(Aphids citricola)* was validated and real-time PCR protocol was developed for specific detection of *Phytophthora meadii* that causes fruit rot of arecanut.

Livestock management

With a view to economise the feeding cost, sugarcane mud was successfully incorporated up to 20% in concentrate mixture of growing calves without any adverse effect on growth of both, pre- and post-ruminant calves.Linseed oil feeding improved the omega-3 content of meat of birds, whereas conjugated linoleic acid (CLA) accumulation in meat significantly increased with increasing CLA level in the diet of broilers. Liposome proved to be a better alternative to egg yolk as buffalo bull semen extender. The adoption of accelerated lambing system in Malpura sheep produced 32.58% more lambs in comparison to one lamb in a year under conventional system. A real time PCR assay was developed for the diagnosis of *Brucella melitensis,* the most common abortion causing agent in small ruminants. A new vaccine was developed for protection against infectious bovine rhinotracheitis. Molecular diagnostics were developed for porcine circovirus 2, *Brucella* isolates and *Clostridium difficile.* Methicillin resistant *Staphylococcus aureus* (MRSA) was isolated and characterized from milk samples collected from bovine and caprine mastitis. The supplemental feeding of leaves of *Aegle marmelos* and *Murraya koenigii* augmented fertility in delayed pubertal heifers both at farm and field conditions. Equine infectious anaemia antibodies were not reported from surveyed animals in the country. Presence of MRSA in food-producing animals and retail meat are a cause of concern about exposure of humans through food chain. A PCR protocol for rapid detection of mithicillin-resistant *Staphylococcus aureus* (MRSA) from pigs was standardized for routine screening of pigs. Aqueous and methanolic extracts of *Nicotiana* spp. and *Zanthoxylum alatum* showed effective hirudinicidal activity. Risk path analysis of notifiable avian influenza (NA, HPNA1, LPNAI) was identified for the import of chicken, meat and by-product and also live birds. A lateral flow kit for the diagnosis of *Listeria* species was designed. Detailed phylogeny indicated role of migratory birds in the spread of H5N1 virus, although trade of poultry/poultry products cannot be ruled out. PCR assays for the detection of 17 prioritized exotic and emerging viruses were developed. FMD virus serotype O vaccine strain with enhanced thermo-stability was constructed using reverse genetic approach.

Fisheries management study on hilsa revealed that there is 40% over-exploitation of spawning stock biomass (SSB) and further increase in exploitation levels might cause serious decline in the fishery. About 20% reduction in fishing effort, restriction on use of small mesh sized gill nets and banning of fishing during breeding season may be implemented for restoring the hilsa stocks. In marine tropical fishes, otolith morphometric studies were standardized for species/ stock confirmation.

Mechanization and energy management

For enhanced productivity and profitability of different farming systems, need-based and region-specific mechanization and energy management technologies were developed. These include: tractor-operated check-basin former (96% saving on cost of operation over conventional manual method); planting system for small seeds (useful for small and marginal farmers of tribal areas to promote production and productivity of millets); tractor-operated small seed planter (saving of 50.4% in operation cost and 81.1% in labour requirement as compared to conventional method of onion cultivation); micro-controller-based variable rate granular fertilizer applicator (met closely the target fertilizer application rate for grid size of 8 m × 8 m); pineapple harvester, to mention a few. Bioreactor was developed for accelerated composting. Energy audit of biomass gasification based power plants (seven plants having total capacity 67.5 MW) in the Punjab State revealed that these plants can generate 10 billion units of electricity worth ₹ 6,000 crore every year. Coconut wood canoe of dimensions 9.0 m LOA 1.50 m BOA and 0.70 m depth was designed to accommodate eight to ten people and is suitable for gill net, seine net and hook and line operations.

Post-harvest management and value-addition

The post-production systems in agriculture sector faces huge losses estimated to range from around 4% for foodgrains to 18% for fruits and vegetables. Value-addition and preservation in post-harvest chain would help making greater and healthier food choices for the consumers throughout the year. Cottage-scale pilot plant for probiotic soy-cheese spread and soy milk

powder was developed. Probiotic soymilk powder exhibited antioxidant and antimicrobial properties. Heat treatment and ripening chamber for banana was developed to enhance the shelf-life of banana and for product safety.

An instrument, developed to measure electrical insulation of jute and allied fibre-based technical textiles, is useful for assessing suitability of fabric for electrical insulating products like gloves, jackets, floor covering etc. The process protocol for large-scale production of nano-cellulose from cotton linters was optimized. This product can be a potential candidate for use as reinforcing agents in polymeric composites, concretes, natural rubber composites; as rheology modifier in paints and as carrier for pesticides and micronutrients.

Biosynthetic pathway of aleuritic acid, one of the widely used compounds by perfumery industry, was reported for the first time. Application of fortified lac mud, a waste of lac-processing industry, proved a good nutrient source for vegetable and flower production. A natural nail polish formulation was developed based on the lac resin (a natural material), which besides being glossy, hard, smooth and durable is non-hazardous to health, and conforms to requirements of BIS standards (IS: 9245:1994). India is the largest producer of guar gum in the world. Carboxymethyl derivative (anionic) of guar gum was synthesized, which is useful in fabric printing, oil well fracturing, mud drilling and industrial applications and preparations as stabilizer, thickener and suspending agents.

An eco-friendly bio-treatment process was developed for production of paper from the lignocellulosic fibre produces. The paper produced has improved optical and physical properties and the process generated less pollutants. ZnO was selected as a suitable nano particle for jute textiles to impart flame retardancy. Flame-retardant nano-particles were synthesized chemically. A process for production of nano fibre mat from cellulose acetate (CA) was developed; this mat can be used as matrix for the development of nanosensors. Rotary knife roller gin, a high-capacity option, gave better fibre-spinning quality thus increasing profitability of ginning business and ensured timely processing of cotton. Methods to prepare functional and nutraceutical food products like composite flour eggless cake, Nutri-laddoo, Multi-grain tortilla chips, Antioxidant-rich pasta from vegetables and buckwheat, White ragi-malt based designer, and Extruded snacks from broken walnut kernels were developed.

Processes for total utilization of commercially unmarketable pomegranate fruits into juice, wine, pomegranate seed oil, organic mouth wash and bio-colour from rind was standardized. A combination of edible coating (pectin or PVA) and modified atmospheric packaging of minimally processed carrots extended its storage life up to 21 days at 8°C without significant deterioration in quality. The novel feature of the test, developed for detection of *Escherichia coli* in milk, is rapid detection within 15.0 ± 1.15 h as against 3-5 days protocol in conventional method. *Sous-vide* processing technology prolonged the shelf-life of chicken sausages to more than 90 days under refrigeration temperature compared to a shelf-life of only 20 days. An antidiabetic extract (ADe) product, Cadalmin™ with potential activity against type-II diabetes, was developed from a blend of marine macro algae.

Agricultural education

For maintaining and upgrading quality and relevance of higher agricultural education, financial and monitoring support was provided for Niche Area of Excellence (28), Experiential Learning Units (21 new), besides refurbishing and maintenance of educational structures, student and faculty amenities, course curricula revision/improvement, strengthening of libraries with ICT and modernization of teaching with multimedia learning resources. HRD programmes/ activities facilitated promotion and execution of ICAR sponsored schemes that include centralized admissions in UG/PG to reduce inbreeding, infuse merit and promote national integration; award and distribution of fellowships to attract talent and promote merit, admission of foreign students for globalization of agriculture education, capacity building of faculty through summer-winter schools and Centre of Advanced Faculty training, National Professorial Chairs and National Fellow Scheme for promotion of excellence, Emeritus Scientist Scheme as a structural method of utilizing skill bank of the outstanding superannuated professionals.

Social science

Study on crop planning for resource use efficiency and sustainability revealed that paddy, remains the most rewarding crop during *kharif* under market price situation, perhaps due to assured prices and higher yields. In *rabi* season, pea cultivation became more profitable than wheat in Punjab. A positive development was seen in reduction of disparity between a cultivator and non-agricultural worker after 2004-05 due to acceleration in agricultural growth and decline in the number of cultivators. Rural workforce that had increased by 50 million between 1993-94 and 2004-05, declined by seven million afterwards primarily due to exit of female workers from the agricultural works. Relatively faster growth in non-farm sectors, higher non-farm wages and improvements in literacy level of cultivators and agricultural labourers are some important factors responsible for the recent changes in employment.

During the reported period the GAP-India worked towards catalyzing the GAP activities in South Asia and link with partners in other countries to benefit and support gender equity actions in the region. Gender difference was observed as 13.04% girls were severely malnourished and 8.70% moderately undernourished in comparison to boys. The All India Co-ordinated Research Project (AICRP) on Home Science focused

on empowerment of women in agriculture and 23 technologies for mitigating drudgery of farm-women were developed/refined/tested at different centres. Eight technologies were ergonomically evaluated after field interventions. Technologies scaled up for introduction among Self-Help Group were harvest bags (basket), seed-cum-fertilizer bag, seed placement tube, head load managers, revolving milking stool and stand, *gopal khore, trishul* weeder and cotton picking apron.

Management Information System (MIS) and Financial Management System (FMS) (*http://icarerp.iasri.res.in*) were implemented in 108 ICAR institutions with more than 20,000 users; and nearly 10,000 personnel were trained on system. Online software was developed for easy accessibility and quick reference of polycross trials by the experimenters (*http://design.iasri.res.in/webpd*). First whole genome putative microsatellite DNA marker database (*http://webapp.cabgrid.res.in/sbmdb*) of sugar beet was developed for bioenergy and industrial applications.

Information, communication and publicity services

In a partnership with AgroInnovate India Ltd., a company of DARE/ICAR, the DKMA participated in the Global R&D Summit 2014 which was organized by Federation of Indian Chambers of Commerce and Industry (FICCI) wherein some of the cutting edge technologies, products and solutions of ICAR Institutes were exhibited to key customers, business buyers, investors, scientific community and media at large. The DKMA participated in an International Workshop on 'Development of Communication strategies for adoption of Agri-Biotechnology in Asia' in Thailand. The DKMA has signed an MoU with Project Director, The Essential Electronics Agricultural Library commonly known as TEEAL (An International Project from Cornell University, USA) for providing information on agriculture and allied sciences to the researchers working at places where the internet is patchy through TEEAL.

In order to strengthen 'Farmer FIRST', research work from across Institutes was disseminated through *The Indian Journal of Agricultural Sciences, The Indian Journal of Animal Sciences*. Besides, 24 journals of related professional/academic societies are also posted on the ICAR web site, visible globally in sync with open access policy of the ICAR.The *ICAR Reporter, ICAR Mail, ICAR Chiththi* (Hindi), *Agbiotech Digest, INDIA-ASEAN News on Agriculture and Forestry* were also published. Popular form of agri-information was carried in the *Indian Farming, Indian Horticulture, Kheti, Phal Phool* along with some special issues.

Towards strengthening the programme 'Student READY', a new project was launched in which authors were invited to write textbooks for the undergraduate students. Besides DKMA brings out a new publication on every third day. About 32,000 pages covering nearly 250 publications were published during the reported period. Press conferences, publicity material to press and exhibitions were also compliance by the DKMA for showcasing ICAR technologies on different occasions of national and international events across the country. Special trainings were organized to strengthen the capacity building programmed in interest of the scientists.

Technology assessment, refinement and transfer

The processes of Technology assessment and refinement are as important as the technology generation prior to transfer at the field level. During the reported period, 2,652 technology interventions were assessed across 4,003 locations by laying out 27,008 trials on the farmers' fields. Women specific income generation technologies (205) related to technological empowerment of rural women were assessed at 394 locations covering 2,917 trials under the thematic areas. Technological interventions (39) in 43 locations were refined through 398 trials on livestock, poultry and fisheries under the thematic areas, viz. disease management, feed and fodder management, nutrition management and production and management. During the reported period 98,624 Field-line demonstrations covering 52,326 ha were organized. Of these 90,974 (92%) demonstrations covering 47,001 ha were on crops. During reported period, 1.96 lakh q seeds of improved varieties and hybrids of different crops were produced and provided to 3.28 lakh farmers. In all, 228.75 lakh quality planting materials of elite species of different crops were produced and provided to 18.38 lakh farmers. Bio-agents, bio-pesticides, bio-fertilizers, vermin-compost, mineral mixture etc. were produced and supplied to the extent of 16,406 q benefiting 9.39 lakh farmers. Kisan mobile advisory (KMA), an initiative by the ICAR, sent 93,949 short text messages, 14,788 voice messages and 1,180 both SMS and voice messages to benefit 223.94 lakh farmers on various aspects of agriculture based on input provided by 557 KVKs.

Under the sub theme-Technology Demonstrations and Dissemination for Climate Resilient Agriculture, about 100 KVKs carried out demonstrations on natural resource management (6,968 ha), crop production technologies (4,450 ha) and on fodder and feed production (682.18 ha). About 17,315 animals/birds belonging to 3,092 farmers got benefited from the demonstrations related to livestock and fisheries. The Zonal Project Directorates upgraded the knowledge and skills of 3,182 staff of KVKs by arranging 76 capacity development programmes. The Agricultural Technology Information Centres (48) in the country served as single window delivery systems by providing technology information, technology services and technology inputs to 4.99 lakh farmers who visited the ATICs.

Research for tribal and hill regions

Eleven varieties of maize and 10 varieties of French bean were screened under organic farming in NEH Region. Under *jhum* improvement programme, ramie crop was introduced in Garo hills. *Labeo pungusia*, a

threatened and commercially high valued fish, was induced bred for the first time. This is an important breakthrough for aquaculture and conservation of threatened fishes of North East region. At Tripura centre, rice-fish-pig-tuber crop based integrated farming system (IFS) was found suitable farming model for marginal farmers of Tripura under rainfed ecology.

In Central Island region 12 varieties of crops—rice (2), amaranthus (2), poi (1), mung (3) and noni (4)—were developed and released for the benefits of Island farmers. In Island region, germplasms (57) were collected from different parts of Andaman and Nicobar Islands. Three varieties CIARI Mung 1, CIARI Mung 2 and CIARI Mung 3 were released. Other accomplishments in the islands included first record of shovel nosed lobster, *Thenus unimaculatus* from Andaman and Nicobar Islands; of rice land race Aath Number Dhan, and captive breeding of skunk clawn fish.

In Nagaland, vaccine bank for free supply of different vaccines for livestock and poultry to the beneficiaries directly or through KVKs and State Department was set up under Tribal Sub-Plan. Other tribal sub plan programmes included water transfer through gravity fed HDPE pipe line and integrated watershed development with the help of tribal community.

National Agricultural Science Fund

The National Agricultural Science Fund, established to support basic and strategic research in agriculture, beside supporting, reviewing, monitoring and evaluation of the ongoing projects also initiated funding of new projects which were in the process of evaluation. During the year 2015-16, the NASF delivered five patents and 38 technologies. Some of the important projects are: Phenomics of moisture deficit and low temperature in rice-double herbicide tolerant transgenic rice for weed management; development of transgenic pigeonpea and chickpea; dominant nuclear male sterility system in rice for hybrid seed production; development of genetically engineered vaccines against poultry viral disease; adaptive mechanism and capture breeding in hilsa; green fishing systems for the tropical seas, defense genes of tiger shrimp against bacteria and white spot syndrome virus besides several others.

Intellectual property portfolio management

Patent applications (49) from 25 research institutes were filed taking cumulative figures to 980 applications from 69 ICAR institutes. Indian Patent Office granted three patents: IN266213, for development and use of rubber disc with soft rubber layers as material for self-grooving roller in roller ginning machines; IN266707, zinc chloride pre-treatment of micro-crystalline cellulose for preparation of nano-cellulose by homogenization process; and IN266905, method for maximum percent recovery and detection of organo-chlorine and organophosphorus pesticides together from brackish water/coastal water, taking ICAR's cumulative number of granted patents to 170. ICAR institutes (23) filed 94 copyrights. Till date, 21 applications trademark have been granted registration. For applications filed earlier, 167 varieties (149 extant and 18 new) were granted registration certificates during this period.

Partnership and Linkages

Memoranda of Understandings were signed between ICAR and Auburn University (USA); University Court of the University of Edinburgh, Scotland (United Kingdom); Eastern Africa Statistical Training Centre (Tanzania), and Seychelles Agricultural Agency (Seychelles). The Work Plan was signed between ICAR and International Livestock Research Institute, Kenya. Memorandum of Agreement was signed between ICAR and Ministry of External Affairs, Government of India for setting up of an 'Advanced Centre for Agricultural Research and Education' at Yezin, Myanmar to help Government of Myanmar's efforts in capacity building of scientific and technical staff. India is a donor member of CGIAR system and accordingly, provisions in Plan and Non-Plan budget were made for the financial year 2015-16. The ICAR hosted 23rd International Grassland Congress with 500 delegates from 47 countries.

AgrInnovate India Limited

The AgrInnovate India Limited (AgIn) coordinated various training and capacity building programmes. The National Bureau of Plant Genetic Resources (NBPGR) signed a Memorandum of Agreement (MoA) with a private company, facilitated by AgIn for licensing of five DNA-based GMO screening technologies. AgIn licensed designs of 31 agricultural engineering machineries from Indian Institute of Horticultural Research (IIHR), Bengaluru to a private company. AgIn also facilitated in organizing training programmes for West Africa Agricultural Productivity Programme nominated Nigerian candidates in Fish Breeding Technology at Central Institute of Freshwater Aquaculture, Bhubneshwar; a 24-week certificate course on Food Science and Technology at Central Institute of Agricultural Engineering, Bhopal; a 6-month programme on Seed Technology at Directorate of Seed Research, Mau.

Awards

For encouraging use of Hindi in day to day working, the official language Rajarshri Tondon Rajbhasha Purskar Yojana for 2013-14 policy, first prize in three categories: Big Institutes, Institutes/Centre of 'A' and 'B' Region, and Institutes/Centre of 'C' Region were given to Indian Veterinary Research Institute (Izatnagar), National Bureau of Soil Survey and Land Use Planning (Nagpur), and Central Research Institute for Dryland Agriculture, Santoshnagar (Hyderabad).

The Council conferred 82 awards under 18 different categories, which includes three institutions, one AICRP, nine KVKs, 55 scientists, seven farmers and six agriculture journalists. Fifteen women scientists include the list of awardees. For the first time administrative

awards were also given to administrative, technical and skill supporting personnel of ICAR for their outstanding contributions.

Finance

The Plan and Non-Plan allocation (R.E.) to DARE/ ICAR for 2014-15 were ₹ 2,500.00 crore and ₹ 2,384.00 crore respectively. An internal resources of ₹ 200.68 crore (including interest on Loans and Advances, Income from Revolving Fund Schemes and interest on Short Term Deposits) was generated for the year 2014-15. The Plan and Non-Plan allocation (B.E.) for 2015-16 are Rs 3,691.00 crore and Rs 2,629 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, for their keen interest, valuable guidance, support and encouragement in all endeavours of the DARE/ICAR. I wish to thank the diverse stakeholders especially, 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 formulation of different research programmes of the ICAR, as well as all-round efforts at efficient-agriculture. We are confident that concerted efforts of the Council would lead to technological empowerment of farmers to achieve higher levels of input efficiency and productivity, to ensure sustainable agricultural growth.

It is hoped that the report would be useful for policy-makers, planners, development agencies, researchers, farmers and students alike in our endeavor to make Indian agriculture more resilient and the farmer, more prosperous.

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and
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