# 1. Overview

The scientific interventions of ICAR have impacted the lives of millions of farmers and rural families through enhancement of agricultural productivity, natural resource conservation, efficient use of farm inputs and energy, preventing food losses through processing, alleviating drudgery through mechanization and a host of other efforts leading to enhanced livelihood, food and nutritional security.

This year, we had to make special concerted efforts to minimize the adverse effects of delayed monsoon, destruction by Hudhud cyclone and floods in some parts of India. During summer, there was drought like situation in many states as onset of monsoon was way behind. The Council took proactive action, formulated specific contingency plans for 580 districts in 23 states by joining hands with state departments, agricultural universities and developmental agencies in specific areas. Farmers were advised on alternate crops that need less water and can tolerate longer intervening spells of no-rains. Adequate stocks of seeds of alternate crops were arranged. Farmers were advised to take up *in situ* moisture conservation measures in view of proven benefits under low rainfall situations. Special teams including scientists, visited the cyclone affected areas of Odisha and Andhra Pradesh to salvage the damage caused by cyclone Hudhud, restoring the horticultural plantations. The National Agricultural Research and Education System (NARES) stood in solidarity with people in Jammu and Kashmir in the midst of devastating floods.

Honorable President of India, Shri Pranab Mukherjee, at the Conference of ICAR Directors and Vice Chancellors of agricultural universities in January 2014, and Hon'ble Prime Minister of India, Shri Narendra Modi during the 86th ICAR Foundation Day Celebrations in New Delhi in July 2014, applauded the efforts of ICAR scientists for achieving self sufficiency in foodgrains and ensuring food security. The Prime Minister called upon the agricultural research community to develop technologies for 'more crop per drop', soil health, promote mechanization of small farms, improve farmers' income, usher protein revolution through enhancing pulse production and blue revolution, make India self-reliant in edible oils, meet information needs of farmers through community radio and ensure effective transfer of technologies through Lab-to-Land programme. The Council has taken steps to fulfill this vision of national leadership. A total of eighty-one high yielding field crop varieties/ hybrids having tolerance to various biotic and abiotic stresses were released for cultivation in different agro-ecosystems of the country. Diversified integrated farming system models and allied farming system packages were developed for irrigated and rainfed systems suitable for marginal and small farmers. Realizing the potential of the conservation agriculture (CA), a Consortium Platform on Conservation Agriculture is being implemented in different agroclimates during the XII Plan to fine-tune region-specific CA package of practices. India joined the Svalbard Global Seed Vault to safeguard global food security for the coming generations. In cutting edge science, the genetic blue print of bread wheat genome was unveiled in collaboration with the International Wheat Genome Sequencing Consortium. The genetic blueprint is an invaluable resource to plant science researchers and breeders. Further work is in progress to unveil the complete reference sequence.

Birth of male buffalo calf 'Rajat' made history of sorts in the world of animal cloning. One of the high ranking progeny tested buffalo bulls at NDRI, Karnal was cloned by using the nuclear material from the somatic cell obtained from its frozen semen. This is for the first time in the world that any animal has been cloned by sourcing somatic cell from the semen that was frozen in a semen bank years ago. Shrimp farming in inland saline areas of Haryana opened new avenues for high vlue aquaculture in inland saline waters.With an inclusive vision to manifest Blue Revolution in the country, the Council planned a mariculture programme to contribute to fisheries sector. Some cost-effective farm technologies have been making positive impacts on the productivity and quality of farm produce and an overview of the same is presented in the report.

### Soil and Water Productivity

For ensuring enhanced soil and water productivity, strategies are being developed for different agro-ecological regions of the country. Geo-referenced soil fertility maps were prepared for 173 districts depicting major and micronutrients status in soil, that could be used for soil fertility management and fertilizer prescription at farm-level. Micro-level soil resource map and land management unit maps were developed for Bali Island in Gosaba block, 24 Parganas (South) district of West Bengal. Land resource inventorization at 1:10,000 scale for scientific land use planning was initiated in 60 blocks in the country. A low- cost runoff sampler was developed for monitoring runoff, nutrient and carbon losses in different land use management practices. State-wise analysis of secondary and micro-nutrients revealed prominent sulphur deficiency in 12 states. The technology developed for removal of heavy metals from municipal solid waste could reduce heavy metal load from mixed wastes and partially segregated

wastes by 34-58% to improve the quality of compost prepared from municipal waste. CSR-Bio, an eco-friendly growth enhancer, developed for tomato and banana, enhanced their fruit yields by 22 and 15%, respectively.

**Farming System**

A five-member family farming model on 1 ha plot comprising diversified cropping systems in the south Bihar alluvial plain zone demonstrated round-the-year income. Integrated Farming System model for 1 ha plot developed for Vindhyan zone in eastern Himalayan region comprised diversified cropping systems, horticulture, dairy, poultry and fisheries. Promotion of organic farming in niche locations, especially, the low nutrient consuming tribal areas of the country offers great potential to enhance soil and crop productivity along with livelihood security for the people. Swarn Vaideh, first ever variety of *makhana* was developed and released.

**Climate Change**

Farm pond technology package led to cultivation of sorghum during *rabi* in the tribal areas of Adilabad district in Telangana, where this crop was not grown previously. A pilot study to reduce greenhouse gas emissions has been taken up in three villages of Warangal district, Telangana, to explore the possibilities of linking such activities to Clean Development Mechanism. The effect of elevated $CO_2$ on growth of rice was studied in open-top chambers. Elevated $CO_2$ significantly affected the total leaf area, tillers/plant, net photosynthesis and transpiration in cultivated rice and weedy rice biotypes. A new technique of weed and crop seed preservation for long periods at ambient temperature was developed. To assess the consequences of global warming on productivity of crops, the changes in the simulated yield potential for soybean caused by changes in the temperature, $CO_2$ and rainfall for Bhopal region was investigated. Increase in $CO_2$ masks the yield by the adverse impact of rise in temperature on crop growth.

**Genetic Resources**

A total of thirty explorations were undertaken wherein 1,591 accessions, including 620 of wild species, were collected. About 334 herbarium specimens were added to the National Herbarium of Cultivated Plants; and 40,879 accessions were imported from 38 countries. Promising introductions are wheat genetic stocks resistant to rusts and powdery mildew; rice stocks tolerant to lodging, shattering, heat and blast (from the Philippines); maize showing resistance to maize streak virus, turcicum leaf blight, common rust and grey leaf spot with excellent combining ability (from Mexico). Six Phytosanitary Certificates were issued for export of 1,248 samples. About 24,824 accessions of different crops were characterized and evaluated, including wheat for terminal heat tolerance, and rice for tolerance to submergence and drought.

Fifty-three genotypes of rice were found moderately resistant to sheath blight, and two were found resistant to brown spot, while 118 lines showed resistance to bacterial leaf blight. Brown planthopper resistance was confirmed in nine farmers' varieties of brown rice (*Oryza rufipogan*). Complete genome sequence of the Indian isolate of Rice tungro spherical virus (RTSV) from Andhra Pradesh was deciphered and deposited in the NCBI database.

Indian mustard *(Brassica juncea)* genotypes, NPJ 182, TM 101, RH1089, Pusa mustard 25 and BPR540-6, were rated as thermotolerant; and genotypes DRMR1153-12, RGN 348, MCP 802, NPJ 182, DRMR 10-40 and NPJ 183 were found suitable for drought tolerance. A total of 10,295 pulse crop accessions including chickpea, lentil, mungbean, urdbean, pigeonpea, lathyrus, rajmash and fieldpea were maintained. For breeding programmes, wild accessions of *Cicer*, *Vigna*, *Lens* species and pigeonpea as well as Mediterranean landraces of lentil were characterized. A total of 41 proposals related to agri-/horti- crops were approved for germplasm registration. A software, 'Microbial Culture Collection Database', was developed to enlist characteristics of microbes. Fifteen new agriculturally important species of insects were reported and described.

*Mangifera griffithi* and *M. andamanica*, two salt tolerant mango (*M. indica*) accessions, were collected from tsunami affected sites in the Andamans. Indigenous mango cultivars, PRVRRN 3 and TMRM, having high total carotenoid content were collected. Farlang, a new guava variety, was introduced from Thailand. Trait-specific pomegranate accessions (132) were introduced and more than 200 pomegranate accessions representing both indigenous and exotic origins were processed. An early, short, precocious and high yielding promising chironji nut CHES C 7, was identified at Bikaner. Mountain sweet thorn, a potential fruit crop, was collected and planted in the field gene bank at Bengaluru. More than 820 different vegetable accessions were collected and conserved. A unique, white and multiplier onion accession (WM 514) was identified (yield, 20 tonnes/ha) at Karimnagar in Telangana. A unique native cucumber, *mat kachari* (*Cucumis pubescens), tinda* (*Praecitrullus fistulosus*) and three dual purpose clusterbean accessions were collected based on the specific traits and were conserved. A monoecious muskmelon (AHM/BR 8) was identified for hybrid seed production. A promising cashew hybrid, H 126 with jumbo size nuts (11-12 g/ nut) was identified and is being evaluated.

Germplasm of tropical tuber crops (5,832) was conserved in the field gene bank at Thiruvananthapuram. One extra dwarf (35 cm) fennel was identified (average height 150 cm) and maintained through selfing. Dura oil palms, belonging to Guinea Bissau and Zambia sources, having high tolerance to moisture stress were utilized for development of Dura × Dura and Dura × Pisifera hybrids. Distinctiveness, uniformity and stability (DUS) descriptors were identified for 10 morphological

characters in medicinal plant *kalmegh* (*Andrographis paniculata*). More than 210 unique mushroom accessions were collected from the forests of Himachal Pradesh, Mizoram, Arunachal Pradesh and Gujarat. Two scented species of orchids, viz. *Dendrobium ovatum* (NOAC-324) and *D. macrostachyum* (NOAC-329), were taxonomically identified.

Phenotypic characterization of Sanchori, Belahi and Manipuri cattle, Gojri buffalo and Harringhata Black chicken was completed to register them as new breeds. The average daily milk yield of Sanchori cattle is 9.08±0.16 litre/day, and peak milk yield 6-18 kg/ day in a lactation period ranging from 8 to 15 months. Under *ex-situ* conservation, frozen semen doses of Tharparkar cattle, Osmanabadi sheep, Mehsana buffalo, Assam Hill goat, Zanskari horse, Marwari horse, French donkey and Arunachali yak were added to the repository in the National Gene Bank of NBAGR. A new instrument Kalrumpscale was designed for digital quantification of dairy characters in buffaloes. Leptin gene showed significant associations with protein percentage in 24 weeks of lactation period in Murrah buffaloes. Four haplotypes, identified in the seminal acidic fluid protein gene from Murrah bulls, showed good correlation with respect to conception rate, and are being investigated further to establish them as markers for bull fertility. First time male specific genes of yak were identified and related six miRNAs were expressed in yak sperm that are likely to be associated with yak bull fertility. Whole genome of Aseel bird was sequenced indicating the presence of approximately 23,000 genes.

New fish species, *Plectranthias alcockii* and *Pempheris sarayu* were characterized from the Arabian Sea and *Labeo icarae* was identified from the freshwaters of Western Rajasthan. Genetic stock identification of silver pomfret revealed one stock along the western coast (Gujarat to Kerala) and two stocks along the eastern coast (West Bengal to Andhra Pradesh and Tamil Nadu). A DNA chip was developed to determine the loci associated with resistance to white spot syndrome virus and sex, the two important traits affecting shrimp production.

## Crop Improvement

Eighty-one high yielding field crop varieties/ hybrids having good tolerance to various biotic and abiotic stresses were released for cultivation in different agro-ecosystems of the country. These include 19 of rice, 12 wheat, 6 barley, 11 (hybrids) maize, 9 millets, 7 oilseeds, 11 pulses (including 2 of greengram, 2 each of pigeonpea and fieldpea and 1 each of blackgram, chickpea, lentil, horsegram and cowpea), 2 sugarcane and 4 varieties/hybrids of forage crops. Commercial cultivation of Heera, a short-duration rice variety, released in early 1990s, was initiated as nutrient-dense (an excellent source of protein, iron and zinc) speciality rice, in Odisha.

Breeder seed (94,953 q), foundation seed (144,369 q), certified seed (163,466 q), truthfully labeled seed (172,352 q) and planting materials (73,185 q) were produced during the year. Further, 155.59 lakh planting materials and 5.60 lakh tissue culture plantlets of field crops were also produced.

A chromosome-based draft sequence of genome of bread wheat, one of the hardest crop-plants to decode due to its huge genome size and three sets of highly similar chromosomes in the genome, was published by the scientists of the ICAR's National Research Centre on Plant Biotechnology, Punjab Agricultural University and Delhi University, in collaboration with the International Wheat Genome Sequencing Consortium. The availability of wheat genome will accelerate gene discovery efforts and fast track development of superior wheat varieties. Eleven possible rice donors of super traits (heavy panicle, high spikelet number and long panicle) were evaluated for designing *next generation rice*. Co-expression network analysis divided the stress responsive genes into tightly co-expressed modules in rice. A new rice blast resistance gene was cloned, which confers high degree of resistance against blast. Over-expression of *Pi54of* in two rice genotypes belonging to *indica* and *japonica* background imparted enhanced resistance against highly virulent strains of rice blast fungus *Magnaporthe oryzae*.

A megaspore mother cell-specific promoter 'FM-1' was isolated from *Arabidopsis*, confirmed by sequencing and cloned into *pCAMBIA* 1305.2. The vector was transformed into *Agrobacterium* strain EHA 105 and was used for transforming sorghum. Kunitz tryspin inhibitor-free soybean genotypes and high oleic-acid soybean IC 210 were commercialized. A unique trait of histological fibre content was identified in jute indicating the scope for improvement in its fibre yield through selection.

A novel *adult plant resistance (Apr)* gene for leaf rust resistance was transferred from wild relative of wheat (*Aegilops markgrafii),* which helped in achieving high degree of resistance to both leaf and stripe rust at the adult plant stage. Pathotype specific SCAR-(sequence characterized amplified region) marker was developed to identify existing as well as emerging pathotypes of downy mildew causing fungus *Sclerospora graminicola*, across pearl millet regions of India. Fifteen independent putative transgenic events of *Brassica juncea* var. NRCDR 2 were developed. A marker was developed for specific and rapid detection of *Alternaria brassicicola,* which caused 35-46 % yield losses in rapeseed–mustard. Whole genome and transcriptome of the red rot pathogen of sugarcane was sequenced.

A mango hybrid, H 12, with 220-240 g fruit weight and 75-77% pulp recovery was evolved by crossing Amrapali and Arka Anmol. A guava hybrid, H 3-29, with high lycopene and ascorbic acid, was developed for table and processing purposes. French plantain (banana) NjockKon, an exotic accession with semi-dwarf plant stature, recorded higher bunch weight compared to Nendran cultivar. A dwarf banana (NRCB Sel.-10), similar to Karpoorvalli (ABB), but early (367 days after planting) was identified for high density planting. A promising accession of khoonphal

(*Haematocarpus validus*) collected from a custodian farmer's field in Andaman and Nicobar Islands has commercial potential.

Varieties/hybrids (13) of vegetable crops were identified for release. Hybrid-369 and Hybrid-371 of tomato with triple resistance to ToLCV+BW+EB (tomato leaf curl virus+bacterial wilt+ early blight) diseases, high yield (80 tonnes/ha) and firm fruits were developed. CIARI Brinjal 1, with green, oblong fruits, 25-30 tonnes/ha yield and inherently resistant to bacterial wilt was released for Island ecosystem. Arka Neelachal Prabha (CHCL 92), a high yielding chilli variety (493 g/plant equivalent to 109 q/ha) was identified for cultivation in east coast ecosystem. Arka Arjun, a French bean variety resistant to Mungbean yellow mosaic virus was identified for summer cultivation in South India.

Kufri Lalit, a hybrid potato variety, resistant to late blight was identified for Indo-Gangetic plains. Triploid cassava hybrids, viz. Sree Athulya with high starch (34.8%) and Sree Apoorva (33.3% starch) were recommended for release in Tamil Nadu and Andhra Pradesh, and Tamil Nadu and Kerala, respectively. CARI Poi Red, a multi-cut poi (*Basella alba*) variety with higher yield and rich in anthocyanin was identified. A marigold variety, *Arka Bangara*, with yellow gold, petaloid sterile, medium size (5-6.5 cm diameter) and higher yield, first flowering at 40-45 days after transplanting (continues up to 65 -70 days) was identified for release. Three hybrids in orchids were released.

A nutmeg variety, IISR-Kerala Shree, having bold nuts, rich in sabinene and myrcene developed through farmers' participatory breeding, was recommended for release. A high-yielding turmeric variety, Duggirala Red with improved rhizome quality (curcumin 4.1%, oleoresin 8.8% and dry matter 23.5%) was recommended for cultivation in Andhra Pradesh, Telangana, Tamil Nadu and Bihar. High-yielding arecanut varieties, viz. Madhuramangala for Karnataka and Konkan; and Nalbari for Karnataka, North Bengal and North East were notified for cultivation. Vallabh Isabgol-1, a new high yielding isabgol (medicinal plant) with superior seed yield (24.5% higher) and high mucilage recovery (9.21 g/kg seed) was developed. A high-yielding variety of button mushroom, DMR-U3-54 (22-24 kg/100 kg compost) was developed at Solan.

### Livestock Improvement

Female cloned buffalo calf named 'Lalima' was produced through 'Hand-guided Cloning'using the donor cell from the ear of a high yielding Murrah buffalo. A male cloned calf named 'Rajat' was also produced through cloning using the donor cell from the frozen semen of a highly ranked progeny-tested Murrah buffalo bull. This is the first ever report in which frozen semen was used for cloning of any farm animal. Collection of semen from champion Murrah bulls, available with Haryana's progressive farmers, was initiated, which became immensely popular among them. Prolific sheep developed by crossing crossbreds of Garole × Malpura (GMM) with Pattanwadi sheep (P) (GMM × P), produced 25 % more lamb and 13 % more litter weight (kg) at three months of age over Malpura sheep. The Goat Improvement programme helped in conservation of threatened goat breeds, viz. Sangemneri and Surti, as their population in breeding tract increased by about four-fold. The strain cross from Bengaluru centre recorded body weight of 1,532 and 1,988 g, respectively, at six and seven weeks of age with corresponding feed conversion ratio (FCR) of 2.22 and 2.40.

The minor carps (*Labeo daro*, *L. dyocheilus* and *Chagunius chagunio*) in the coldwater region of the country were for the first time, induced bred in the captivity. This would help produce seeds *en masse* for ranching and aquaculture diversification of coldwater sector. Surrogate brood fish, fry and fingerlings were produced by xenogeneic transplantation of isolated germ cells in catla, rohu and common carp, confirming that donor-derived gametes can be produced in a related host species (carp to carp). Surrogate production would help in conservation and efficient utilization of genetic resources. A designer fish, an enriched human food source, was developed by feeding nano-Se and nano-Fe supplementation. National marine fish brood bank was established at the ICAR-CMFRI Regional Centre, Mandapam, to hold broodstock of commercially important marine finfishes and to supply quality eggs/ newly hatched larvae.

### Crop Management

INFOCROP-Wheat, a web-based decision support system to identify location-specific suitable varieties, optimum sowing time and schedule for the wheat crop, was developed. Free air temperature increment (FATI) facility was developed to characterize effects of global warming on crop-plants. A phospho-compost inoculated with phytate mineralizing fungal consortium improved the availability of bicarbonate P in cattle manure+straw compost. Intercropping wheat + lentil in 2:1 and 1:1 row ratio was superior to sole wheat and wheat + *toria* intercropping. In groundnut cultivar TG37A, application of DAPG-producing fluorescent pseudomonads improved pod yield and also reduced plant mortality. A fairly good crop of sugarcane could be obtained with 23 irrigations (75% of total requirement) by adopting composted coir-pith application. 'CRIJAF Sona', an improved retting technology was found suitable for quality fibre production in stagnant water.

The new packaging material, the insecticide impregnated laminated bags, was found effective in maintaining insect infestation below 0.5% up to four months of storage under ambient conditions. A microarray virus chip for all the known plant viruses and viroids was designed. A multiplex-PCR kit for detection of viruses, viz. mungbean yellow mosaic india virus, mungbean yellow mosaic virus, horsegram yellow mosaic virus, dolichos yellow mosaic virus, affecting legumes, was also developed. Soil treatment with

*Trichoderma* + seed treatment with *Trichoderma* @ 5g/kg, imidacloprid and rhizobium + coriander intercropping and two foliar sprays, one of NSKE at flowering and the second of chlorantraniliprole at podding stage was the best IPM module for chickpea. A mechanized sett treatment unit for rapid delivery of fungicides to manage red rot, smut and wilt diseases of sugarcane was developed, which reduced sett treatment time and economized fungicides. CaneDES, a web-based expert system, was developed for diagnosis of sugarcane disorders and their management. Integrated pest management (IPM) technology was validated in rice crop cv. Pusa Basmati 1121 in an area of 200 ha in farmers' participatory mode; only one buprofezin spray instead of 2-4 sprays in farmers' practice enhanced levels of organic carbon content, increased natural enemy count, reduced pest population and increased yield. Economic impact analysis of accelerated pulse production programme (A3P) indicated significant reduction in the number of chemical pesticide sprays, 4.27 in IPM plots vs. 7.34 in farmers' practice.

A new web portal 'Indian fauna of Pteromalidae' and a new web based identification guide to the Indian genera of Mymaridae were hosted on the National Bureau of Agriculturaly Important Insects website. In rice crop, burrow baiting with wax blocks of rodenticides flocoumafen resulted in 60-74% control success, whereas difenacoum achieved 58-63% control of rodents in Karnataka. Likewise, in coconut, both these rodenticides showed 80-100% success in trials undertaken in Karnataka and Andamans. The spread of infection of nosema disease due to *Nosema apis,* a fungus (which was earlier thought to be a protozoan), was managed by replacing infected combs with fresh ones and avoiding confinement of the bees in the hive. Use of farmer friendly pollen-insert in apple orchards, having low proportion of pollinizer (10-15%), increased fruit-set by 2.5 times.

Artificial diet and mass multiplication protocols were developed for *Chrysomya megacephala*, an important pollinator in mango. Complete nucleotide sequences of DNA-A of 10 chilli leaf curl causing begomovirus isolates were determined. An entomopathogenic fungus, *Isaria farinosa*, causing natural epizootics on whitefly infesting crop in polyhouse was characterized. Formulations of *Chaetomium* sp. were developed for biological management of early blight of tomato through induced systemic resistance. Molecular characterization of begamoviruses and tobamoviruses infecting chilli and tomato respectively, was completed. Encapsulation of a plant growth-promoting rhizobacterium (IISR GRB 35-*Bacillus amyloliquefaciens*) in gelatin capsules effectively delivered plant growth promoting rhizobacteria (PGPR) for growth promotion and rhizome rot disease management in ginger.

Forecasting model (JHULSACAST for West Bengal), web-based decision support system (for western Uttar Pradesh) and Indo-Blightcast (applicable pan India) were developed for the management of late blight in potato. Bioinoculants, *Kera Probio* (a talc formulation of *Bacillus megaterium*) and *Cocoa Probi* (containing *Pseudomonas putida)*, were developed for raising of robust and healthy coconut seedlings. Botanical cake in tablet form was developed for effective field delivery and sustained release of active ingredients for subduing rhinoceros beetle incursions in coconut.

**Livestock Management**

'Indian Livestock Feed Portal', made available online for various stakeholders, will play a vital role in refining management of feed resources and planning livestock development schemes. Based on the methane production potential (MPP) value, livestock census and feeding practices, district-wise methane production data were generated for Karnataka. Incorporation of rumen bypass fat (RBF) in ration (4%) of growing lambs enhanced body weight by 12% at 6 months and increased FCR by 13.56%. The tree leaves of Indian willow (*Salix tetrasperma)* could replace 50% of the local grass (*brachiaria* and *setaria*) in the diet of growing Gaddi goats with no adverse effects. The leaves can be fed to goats during winter when there is a fodder scarcity in the region.

Frieswal bulls having less scrotal skin fold thickness (<4.5 mm) showed significantly higher sperm concentration/ml, initial progressive sperm motility per cent and total sperm yield per ejaculate as compared to bulls having thicker scrotal skin fold (≥ 4.5 mm). One of the IFN-τ stimulated genes (ISG) in peripheral blood leukocytes and its serum protein levels indicated distinguishing pattern during early pregnancy, opening a potential new avenue for early diagnosis of pregnancy in buffaloes.

Two divergent lines of sheep (resistant or susceptible to *Haemonchus contortus*) were developed through selection. Amniotic fluid-mesenchymal stem cells and umbilical cord blood-mesenchymal stem cells were differentiated into tenocytes, which could be exploited for regeneration of ruptured or damaged tendon in race horses. Surface plasmon resonance-based biosensor assay was developed for detecting serum cancer biomarkers associated with canine mammary cancer.

In diagnostics, a new real-time PCR assay for porcine circovirus-2 detection and loop mediated isothermal applications for detection of *Babesia gibsoni* infection in dogs, were developed. A methodology was developed for assaying the risk of introduction of notifiable avian influenza in India. Whole genome sequences of three classical swine fever vaccine strains, *peste des petits ruminants* virus (PPRV) Sungri/96 vaccine strain and F vaccine strain of Newcastle disease virus (NDV), were deciphered. Currently used FMD vaccine strain O/INDR2/1975 provided near optimal antigenic coverage to the field isolates. RNA transfection using lipofectamine to rescue FMD virus from clinical materials was optimized that will help in transportation of clinical materials without application of cold chain. This innovation is of immense significance for FMD surveillance and diagnosis programmes in India.

Short-neck clam *(Paphia malabarica)* fishery of

Ashtamudi Lake has become the first eco-labelled fisheries of India, a milestone in Marine Stewardship Council (MSC) certification for the country. The certification enhances conservation and sustainability of the resource and provides greater economic benefits. ICAR-CIBA was affirmed for accurate diagnosis of seven fish and shellfish viruses of regional concern. Demonstration of cage culture of striped catfish in Karnataka and pen culture of Indian major carps in Uttar Pradesh, exhibited a prototype model for livelihood security of fish farmers.

**Mechanization and Energy Management**

Improved machines, implements and equipments were developed for efficient farm operations, resource conservation, renewable energy technologies, and gender-friendly and drudgery reducing tools for women farm-workers. These include sugarcane bud chip planting equipment to replace the manual method of sugarcane planting; rotary assisted raised bed former-cum-seeder to provide sufficient bed height of more intact and smooth bed; three-row rice transplanter for women workers based on the anthropometric data and strength parameters; universal tractor mounted ultrasonic sensor based pomegranate spraying system; axial flow multi-crop thresher for threshing cowpea, soybean, black gram, paddy and wheat crops; hydraulically operated cone penetrometer for measuring soil cone indices, etc. Tractor operated equipments developed include, fertilizer dibbler for ratoon sugarcane, turmeric rhizome planter, turmeric digger and cassava harvester. Animal power-operated equipments developed include, garlic planter cum fertilizer applicator and garlic digger. Equipments for protection and safety for reducing drudgery and health risk include protocol for appropriate diving gear for makhana harvesting and hand protection devices for workers shelling cashew nut. Kalparasa, a device for collection of fresh hygienic coconut inflorescence sap was refined and the technology was commercialized. An improvized butter melter system was also designed.

**Post-harvest Management and Value-addition**

Novel products and technologies were developed for the reduction of post-harvest losses, utilization of by-products and creation/generation of employment opportunities besides enhancing farmers' income. These include a compact fruit grader with minimum fruit damage; *bael*/wood apple pulper machine; a funnel shaped collector for conversion of nano fibre into twisted yarn; mechanical moringa leaf stripper to separate them from tree branches; cabinet dryer with gravel bed heat storage system for drying tomato; automatic pala doffing system to separate the fine particulate matter from cotton gin during ginning process; suitable bamboo framed shade net-houses for cultivation of vegetables; process protocols for multi nutrient snack bars; efficient process for regeneration of frying cotton seed oil for reuse; on-line moisture measurement system for jute processing; exploitation of potential varieties of ber for lac culture in case of lac crop failure; and a model chicken retail outlet within the food safety parameters as per FSSAI. Solar drying saved 29, 31 and 28% of total drying time for cinnamon, clove and black pepper, respectively.

Methods to isolate DNA from animal fat and milk fat, detect *Listeria monocytogenes* in milk in a single day with nearly 10 times less cost, detect any mixing of non-food items into food, and to prepare *Aloe vera* supplemented probiotic *lassi* and a functional milk beverage with extracts of *Terminalia arjuna* (which is good for heart patients) were developed. Separate strips for detection of neutralizers, urea, glucose and hydrogen peroxide in milk within five minutes were developed and validated. Healthier chevon nuggets were developed through standardization of PUFA/SFA ratio. Amphiphilic succinyl chitosan polymer-based hand sanitizer was developed, which does not contain synthetic antibacterial compounds and hence is suitable for fish processing industry workers. A solar-powered boat, the sunboat, which can achieve a speed of about 4.0 knots/hr and can run for 2-3 hr once completely charged, was designed and developed.

**Agricultural Human Resource Development**

Strengthening and upgradation of higher agricultural education continued to be the major focus during the year. Financial assistance was provided for infrastructural development, Niche Area of Excellence (25 nos) and Experiential Learning (21 new units). For capacity building of faculty through Summer-Winter Schools, Centre of Advance Faculty Training, National Professor and National Follow Schemes, Emeritus Scientist Scheme were some of the main activities to achieve excellence in agricultural education and research. Four agricultural universities were accredited to ensure quality of agricultural education in the country. Senior Research Fellowship was awarded to 183 students for pursuing Ph.D. degree in agricultural universities. In order to globalize the agricultural education, 203 students from 29 countries were helped to join different agricultural universities under different fellowship programmes and as self financed candidates.

**Agricultural Economics, Marketing and Statistics**

The acceleration in growth of Indian agriculture was broad-based, and technology and diversification toward high-value crops are the important factors of this growth. The rising trend in total factor productivity growth suggested that the recent growth in agriculture is sustainable as it is based on improved technology and efficiency. Fresh estimates of optimal mix of various nutrients were prepared. The deficits in the use of fertilizer nutrients and the imbalance in fertilizer application in terms of relative use of the NPK nutrients need immediate attention of the policy makers. The returns on investment in public extension systems were quite attractive as users of information realized 12%

higher net returns over non-users. The first supercomputing hub for Indian Agriculture ASHOKA (Advanced Super-computing Hub for OMICS Knowledge in Agriculture) was established at Centre for Agricultural Bioinformatics, Indian Agricultural Statistics Research Institute, New Delhi. Implementation of MIS & FMS system was initiated at ICAR headquarters and ICAR institutes to provide high availability, quick scalability, secured access, efficient management and optimized utilization of resources to deliver the unified communication among 25,000 ICAR personnel.

**Information, Communication and Publicity Services**

Directorate of Knowledge Management in Agriculture (DKMA) acts as a 'hybrid clearing house' of agricultural information as print as well as online information products are made available to the target audience. Special updates developed by ICAR institutes and Subject Matter Divisions were posted during deficient monsoon conditions and cyclonic storm, Hudhud. The website also hosts e-publishing platform (http://epubs.icar.org.in/ejournal) of the Council, that includes *The Indian Journal of Agricultural Sciences*, *The Indian Journal of Animal Sciences, Indian Journal of Fisheries, Indian Farming* and *Indian Horticulture,* along with 15 Journals of related professional/academic societies. In sync with open access policy of the ICAR, the website also hosts various other publications and reports in open access mode, such as *ICAR Reporter*, *ICAR News, ICAR Mail, ICAR Chitthi (Hindi), Agbiotech Digest* and *India-ASEAN News on Agriculture and Forestry*. Nearly 30,000 pages, covering nearly 230 publications, were published during the period. The DKMA organized and participated in nearly 20 exhibitions, showcasing ICAR technologies, on different occasions of national and international events across the country.

**Technology Assessment, Refinement and Transfer**

As an effective outreach arm of ICAR, the network of Krishi Vigyan Kendras (KVKs) was involved in assessment, refinement and demonstration of agricultural technologies, and capacity building of farmers and extension personnel. During the year, KVKs conducted 28,615 on-farm trials and 92,940 front-line demonstrations for technology update and its application in farmers' fields; organized 54,415 training programmes to enhance knowledge and skill of farmers and extension personnel; created awareness on improved technologies among 91.47 lakh farmers and other stakeholders through 5.55 lakh extension programmes and 1.33 lakh items covered in print and electronic media.The KVKs also produced 3.44 lakh quintal seed; 203.36 lakh planting materials; 136.80 lakh fish fingerlings, and analyzed 3.64 lakh samples of soil, water, plants and manure. Besides, Kisan Mobile Advisory provided 3.57 lakh short text messages to 16.28 lakh farmers on various aspects of agriculture, horticulture and animal husbandry. Agricultural Technology Information Centre provided technological solutions to 6.31 lakh visiting farmers.

**Empowering Women in Agriculture**

Conceptual frameworks for developing new gender related indices for different dimensions of empowerment of women in agriculture, farming systems and gender friendly technologies were prepared. A multistoreyed cropping model for coconut orchard was developed for efficient resource use and to enhance women's participation. Income generating potential of the second storey (banana, papaya and guava) and ground storey intercrops (cowpea, turmeric, elephant foot yam, pineapple in the interspaces of the main crop), cultivated by women, was ₹ 414,000 against ₹ 48,000 in sole crop. Technological interventions were made in some of the selected activities to reduce drudgery. The AICRP on Home Science focused on food and nutrition security in selected farming systems, drudgery assessment and mitigation, mitigating occupational health hazards, and on capacity development of youth engaged in agriculture and empowerment of women. Study on dynamics and performance of women's Self Help Groups revealed that the highest number of SHGs is in Andhra Pradesh (about 16.60 lakh), followed by Karnataka (2.2 lakh) and Maharashtra (2 lakh).

**Research for Tribal and Hill Regions**

The ICAR institutions – VPKAS (Almora), ICAR Research Complex for North Eastern Hills Region (Umiam), and Central Island Agricultural Research Institute (Port Blair) — developed technologies and evolved new varieties for difficult terrains of the Himalayas and island and coastal areas. Vivek Maize Hybrid 47, VL Dhan 157, and VL Mandua 352 were developed for the west Himalayas. Korgut, a traditional rice landrace from Goa, was registered as a unique germplasm for tolerance to salinity stress at seedling stage. Cashew selections, viz. Tiswadi 3, Ganje 2 and KN 2/98, were found suitable for commercial cultivation in Goa. Molluscan species (64) were identified and catalogued *in situ* from Nancowrie group of Islands and 53 species from Great Nicobar Islands.

Under the Tribal sub-plan and NEH plan, tribals were made aware of the latest technological interventions through training-cum-sensitization to improve production, income and quality of life. To develop the road map for improvement of yak husbandry as well as socio-economic upliftment of yak herdsmen of Ladakh, an interface meeting was organized in collaboration with Ladakh Autonomous Hill Council wherein farmers, researchers and development workers participated. A complete feed block technology for yaks was demonstrated in Ladakh. A trout farming programme in Leh was also initiated. KVKs also facilitated in distribution of vegetable seed kits, goats, chicks, pigs, ice boxes, deep freezers, life jackets and ring buoy among tribal farmers of Car Nicobar under TSP. Yanadi tribal families in Andhra Pradesh were trained to undertake crab culture.

### National Fund for Basic Strategies and Frontier Application Research in Agriculture

National Fund for Basic Strategies and Frontier Application Research in Agriculture was established for basic, strategic and cutting-edge application research in agriculture. It has so far funded 102 projects, mostly in a consortium mode, and during the year, the NFBSFARA initiated the processing of 50 concept notes. The important projects are: Generation of pod-borer resistant transgenic pigeonpea and chickpea; construction of dominant nuclear male sterility to produce hybrid rice seed; comparison and deciphering behaviour of non-adopted pathogen, *Puccinia graminis tritici* and *Magnaporthe oryzae* on wheat and rice; development of biofuel from whey through stress-tolerant metabolically-engineered yeast; supplementation of selected amino acids and vitamins for reduction of high temperature stress in *Catla catla;* identification of nucleopolyhedroviruses to control *Helicoverpa armigera;* production of putative parthenogenetic embryo from goat for further investigations; production of microbial ethanol from agricultural biomass; detection and quantification of adulterants and contaminants in fruit-juices and milk; development of green fishing systems for tropical seas; identification of plant and nematode genes involved in disease development; and development of jute- based biocomposites.

### National Agricultural Innovation Project

The Council implemented the NAIP, a jointly funded venture by World Bank and Government of India, that became operational in September 2006 and with an extension of 18 months concluded in June 2014. The NAIP ushered important innovations into the system like scenario planning with full involvement of the clients, business planning and development through incubation and technology commercialization, ICT applications in agricultural research and education, integrated farming systems approach for livelihood improvement in disadvantaged regions of the country and emphasis on post project sustainability. The ICAR has considered to internalize, sustain and promote these new initiatives. The project was implemented through 203 subprojects, 856 consortium partners from ICAR Institutes (40.9%), State Agricultural Universities (24.5%), Central Universities and Organizations (9.1%), State Universities and Organizations (4.4%), CGIAR Centres (1.9%), Private Industries (8.5%) and Non-Government Organizations (10.6%). This is for the first time in the history of Indian agriculture that such a diversified group of partners has worked together under one project. Important achievements are: ASHOKA, the first advanced super computing hub for OMICS Knowledge in Agriculture for biotechnological research at IASRI, New Delhi; a Central Data Centre (CDC); 15 pilot plants under value chain for selected commodities; filed 331 licenses for commercial technologies and more than 186 patent applications, and 58 technologies were commercialized to 80 licensees; over 30 successful and economically viable value chains were developed; online knowledge resources were made available to the entire NARES on an unprecedented scale by providing access to over 3,000 professional and scientific journals, database of 7,627 Ph.D. theses, krishikosh, 425 online e-Courses (http://ecourses.iasri.res.in) and an e-publishing portal (http://epubs.icar.org.in/ejournals) having 20 scientific journals; integrated farming system (IFS) models for enhanced livelihood; and potential fishing zone (PFZ) advisories.

### Intellectual Property Portfolio Management

Patent applications (60) from 27 research institutes were filed, taking the cumulative figure to 925 applications from 68 ICAR institutes. Indian Patent Office granted four patents, i.e. IN257958 for PCR-based method of differentiating cow and buffalo milk, IN260553 for a process for commercial manufacture of *kradi*, IN257783 for lab-scale process for preparation of low cholesterol *ghee*, IN262113 for thermal insulation value tester; taking the ICAR's cumulative number of granted patents to 167. Six copyright applications were also granted. ICAR institutes filed 81 copyrights; 20 design applications; and 53 trademark applications (out of that 19 applications are registered).

### Partnership and Linkages

Memoranda of Understanding were signed between ICAR and UK, Oman, Australia and the USA. Joint Working Group meetings on agriculture between India and Surinam and Mexico were held to finalize work plans. Collaborative projects were finalized with New Zealand, Hungary, Tanzania, Bangladesh, Indonesia, Malaysia, Myanmar, Srilanka, Thailand, UK, USA, Switzerland, Australia, Brazil and seven Indian Ocean countries (India, Australia, South Africa, Madagascar, Mozambique, France and Union of Comoros). The six Bureaus/Institutes under the ICAR system were designated by Ministry of Environment and Forests to act as repositories under the Biodiversity Act 2002 for different categories of biological resources.

### AgrInnovate India Limited

The AgrInnovate India Limited has finalized technology licensing agreement with a private firm for diagnostic assay that can differentiate infected animals from the vaccinated ones. Also, AgrInnovate motivated veterans (ex-servicemen), on the look out for agri-business opportunities, to select protected cultivation technology for transfer to their villages considering opportunities for growing high-priced vegetables in extreme weather conditions of North India. A project for preparation of feasibility report on Establishment of Tractor Assembling Plant and Farm Equipment Manufacturing Unit in Tanzania was initiated.

### Awards

For the best implementation of Official Language Policy, Third Prize of *Indira Gandhi Raj Bhasha Puruskar*, 2012 -13 was awarded to the Department

of Agricultural Research and Education on 14 September 2014; and to the Indian Council of Agricultural Research on 15 October 2014.

The Council conferred 89 awards under 16 different categories during this year, which include three institutions, one AICRP, 73 scientists (in which 11 were women scientists), ten progressive farmers and two agricultural journalists.

**Finance and Audit**

The Plan and Non-Plan allocations (R.E.) to DARE/ICAR for 2013-14 were ₹ 2,600.00 crore and ₹ 2,281.08 crore respectively. Internal resources of ₹ 228.67 crore (including interest on Loans and Advances, Income from Revolving Fund Schemes and interest on Short Term Deposits) were generated for 2013-14. The Plan and Non-Plan allocation (B.E.) for 2014-15 are ₹ 3,715.00 crore and ₹ 2,429.39 crore, respectively.

Having achieved a satisfactory level of food security in the country through technology-led enhancement in farm productivity and diversification of food basket, the challenge before Indian agriculture is to ensure household nutritional security for the citizens, projected to be two billion by 2050 A.D. Molecular genetics and genomics tools can complement traditional selection programmes by bringing accuracy in selection and shortening the generation interval for improving overall productivity. The ICAR is implementing a Consortium Research Platform on Genomics in the XII Plan, to consolidate and enhance research in genomics. The Council has also proposed Consortia Research Platform on different aspects, viz. Seed, Diagnostics and vaccines, Nanotechnology, Bio-fortification,Water, Natural fibres, Health foods, Hybrids, Secondary agriculture, Farm mechanization, Precision farming and energy, Genomics, Molecular breeding, Agrobiodiversity management, Conservation agriculture to emphatically address agricultural water management under changed climate scenario. Year 2015 has been designated as the International Year of Soils, thus indicating the central role of soil in sustainable agricultural processes and food security. ICAR/DARE Hqrs is an ISO 9001-2008 certified organization. To sustain the Quality Management Systems Certification, in-house trainings from ISO professionals were organized; where all the staff of ICAR/DARE Hqrs was provided on-the-job training. Our colleagues in the Institutes do deserve appreciation in timeliness and defined priorities that enabled DARE/ICAR to achieve a composite RFD score of over 90% for the third consecutive year. On a progressive note, discussions on draft Vision-2050 document of all institutes were completed. ICAR is committed to be a proud partner in the mission of national development.

I take this opportunity to express our gratitude to the Hon'ble Union Minister of Agriculture and President of ICAR Society, and the Hon'ble Union Ministers of State for Agriculture, for their valuable guidance, support and encouragement in all endeavours of the DARE/ICAR. The ICAR Institutes deserve all appreciation for their inclusive research in farmers' interest. I acknowledge the cooperation and support received from various Ministries and Departments of the Government of India, Central/State Agricultural Departments and Universities, National and International Organisations and other stakeholders for better performance of the Council. In the year 2015, the farm sector would have more visibility, enhanced productivity and new dimensions for nutritional security with the continued and concerted efforts of the DARE/ICAR.

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