ANNUAL REPORT 2020

Indian Council of Agricultural Research
Department of Agricultural Research and Education
Ministry of Agriculture & Farmers Welfare
Government of India
New Delhi

“. . . भारत में पौषण अभियान को ताकत देने वाला एक और अहम कदम आज उठाया गया है। आज गेहूँ और धान सहित अनेक फसलों के 17 नए बीजों की वैराइटी देश के किसानों को उपलब्ध कराई जा रही हैं। हमारे यहाँ अक्सर हम देखते हैं कि कुछ फसलों की सामान्य वैराइटी में किसी न किसी पौष्टिक पदार्थ या micronutrient की कमी रहती है। इन फसलों की अच्छी वैराइटी - Biofortified variety इन कमियों को दूर कर देती है, अनाज की पौष्टिकता बढ़ाती है। . . . ऐसे बीजों की research और development में भी बहुत प्रशंसनीय काम हुआ है . . .।”

– Prime Minister of India on the occasion of World Food Day
on 16th October, 2020

Annual Report
2020

Indian Council of Agricultural Research
Department of Agricultural Research and Education
Ministry of Agriculture & Farmers Welfare
Government of India
New Delhi

Indian Council of Agricultural Research

President, ICAR Society, and Union Minister of Agriculture and Farmers Welfare	:	**Shri Narendra Singh Tomar**
Senior Vice President, ICAR Society, Union Minister of Fisheries, Animal Husbandry and Dairying	:	**Shri Giriraj Singh**
Vice President, ICAR Society, Union Minister of State for Agriculture and Farmers Welfare	:	**Shri Kailash Choudhary**
Union Minister of State for Agriculture	:	**Shri Parshottam Rupala**
Secretary, DARE and Director General, ICAR	:	**Dr Trilochan Mohapatra**
Additional Secretary, DARE and Secretary, ICAR	:	**Shri Sanjay Singh**
Additional Secretary and Financial Adviser, DARE/ICAR	:	**Shri B. Pradhan** (Till October, 2020) **Shri G. Srinivas** (from 12 October, 2020)

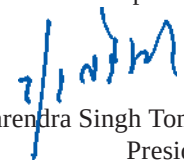
Foreword

Agriculture is the primary source of livelihood for about 58% of India's population and contributes about 17% to Gross Value Added (GVA). The Indian food industry is poised for huge growth, increasing its contribution to world food trade every year owing to its immense potential for value addition, particularly within the food processing sector. Agricultural research and development is fundamental for planned growth and sustainable development of agriculture in the country. Indian Council of Agricultural Research (ICAR) is an apex organization in the field of agricultural research at national level which plays a crucial role in promoting and accelerating agricultural research, education, extension and support in demonstrating the use of new technologies in agriculture. The year 2020 saw one of the most threatening catastrophes witnessed ever by humanity, the COVID-19 pandemic tested our capabilities almost in all the fields and agricultural sector is one of the them. Despite these difficulties, we have the responsibility to feed above 1.3 billion people of the country, and I am satisfied that our farmers and scienists worked hard during this difficult period and achieved about 3.4% growth of this sector.

During this year ICAR released 270 varieties of field and horticultural crops including 18 biofortified varieties taking the total to 71 in different crops. Dedication of 17 biofortified crop varieties by the Prime Minister to the nation on the occasion of World Food Day-2020, is a testimony of commitment of Indian Council of Agricultural Research (ICAR) towards fulfilling country's food and nutritional security. Efforts of ICAR during this period have been internationally appreciated and ICAR recommended advisories for the fishery sector have been recognized by the FAO, Rome. Livestock and fishery sectors have immense importance for Indian agriculture and to ensure good health of cattle and fishes ICAR is continuing to develop vaccines and diagnostics and during this year also good progress was made in this area. Registration of indigenous breeds of livestock and poultry was strengthened and 16 indigenous germplasm were registered this year.

I am pleased that ICAR is not only focusing on developing technologies to increase production of various agri-commodities but working intensely with the farming community. Immediately after onset of COVID-19 pandemic ICAR issued guidelines and advisories for farmers of all the States and KVKs network exhibited ground level presence and supported the farmers with all means including innovative Agri-solutions, trainings and technology demonstrations. Agricultural education is vital to develop trained and skilled human resource to take up present and future challenges confronted by Indian agriculture due to climate change and constraints to natural resources and ICAR is fully committed for this. During this period ICAR issued advisories to Universities to take necessary steps to connect each student through online tools and guidelines were prepared for e-learning, implementation of Student READY programme, conducting examination etc. The National agricultural higher education project (NAHEP) has provided excellent support to universities and now implemented in 58 agricultural universities and 3 Deemed Universities across 23 states.

ICAR remained exceedingly vibrant, fully realizing the dividends of digital technology to not only address the farmers' needs but successfully organizing national and international events. ICAR's continuous efforts in development of innovative technologies for the benefit of Indian farmers is praiseworthy. I hope that ICAR Annual Report 2020–21 will be useful to different stakeholders and boost the research and development in agriculture.



(Narendra Singh Tomar)
President
ICAR Society

“...the country is very well familiar with the green revolution and white revolution. Time has come to bring about the changes in the lives of our fishermen brothers through blue revolution and to supplement the income of our farmers through honey-bee keeping and honey production. We have been working to bring blue revolution, sweet revolution along with green revolution and white revolution.”

— Narendra Modi

Contents

The Mandate of the Indian Council of Agricultural Research

- Plan, Undertake, Coordinate and Promote Research and Technology Development for Sustainable Agriculture.
- Aid, Impart and Coordinate Agricultural Education to enable Quality Human Resource Development.
- Frontline Extension for Technology Application, Adoption, Knowledge Management and Capacity Development for Agri-based Rural Development.
- Policy, Cooperation and Consultancy in Agricultural Research, Education and Extension.

Vice President of India visits ICAR-CIFT, Vizag Research Centre

The Vice President of India, Shri M. Venkaiah Naidu accompanied by Shri Muttamsetti Srinivasa Rao, Minister for Tourism, Culture and Youth Advancement, Government of Andhra Pradesh visited the Visakhapatnam Research Centre of ICAR-Central Institute of Fisheries Technology, Cochin, Kerala on 7 December, 2020. Shri Naidu stressed on the role of Indian fisheries, the most flourishing and enterprising sector as one of the major contributors to the food and nutritional security. He emphasized on the health benefits of fish consumption as an affordable and easy source of animal protein for combating the malnutrition status of the country. He also urged the scientists for understanding and exploring the need-based research issues for the well-being of the large scale fishers and undertaking the innovative and modern research as a future agenda.

1. Overview

The Indian Council of Agricultural Research (ICAR) under Department of Agricultural Research and Education, Government of India, established in 1929, has recently entered the centenary decade of its existence. During the last nine decades this premier organization has immensely contributed to Indian agriculture. The Council has always been ahead of its times and visualizing the future agricultural scenario and accordingly developing appropriate futuristic technology solutions for farmers. ICAR is developing competent human resources and trained manpower and is reaching out to farmers to train them and demonstrate various technologies at their fields to ensure its adoption. The Council has been coordinating with various stakeholders to mitigate the challenges confronted by Indian Agriculture. During the past few years, the production of food grain and horticultural crops has climbed new heights. Even during COVID-19 pandemic, India's food grain production expected to reach the record 298 mt during the current year. Similarly, the production of horticultural crops touched an all-time high of 310.74 mt during 2018-19 and is expected to touch 320.47 mt during 2019-20. The Indian Council of Agricultural Research has proactively taken efforts to tackle the challenges arising out of the pandemic. Timely advisories and ground level support extended to farmers by ICAR institutes and the countrywide KVK network proved to be of immense help to the farming community and earned the National and International recognition.

The ICAR has played a pivotal role in making agriculture sustainable through use of eco-friendly management and innovative technologies which helped the country to achieve the production of food grains four times, horticultural crops six times, fish nine times and eggs twenty-seven times since 1951. This enabled the nation not only to be food and nutrition secure but also improved livelihood of the farmers. Since 1965, ICAR has developed 5,334 improved field crops varieties which include 2685 of cereals, 888 of oilseeds, 999 of pulses, 200 of forage crops, 395 of fibre crops, 129 of sugarcane and 38 of potential crops. The salient achievements of the council during the year are given below.

Soil and water productivity: During 2020, the NRM division made a significant contribution in preparing Land Resource Inventory (LRI) on 1:10000 scale for 3 North Eastern states, namely Manipur, Nagaland, and Sikkim to workout block level land use planning. The potential area for rice and oil palm in the country were delineated. Two innovative devices viz., 'Ekcel-CompostR' and 'Ekcel-ShredR' for rapid decomposition of waste biomass were developed. Glauconite nano-particle as a potential source of potassic fertilizer was evaluated.

Climate change and resilient agriculture: Two microbial consortia, viz. *Pseudomonas putida* P7 + *Bacillus subtilis* B30 (consortia 1) and *Pseudomonas putida* P45 + *Bacillus amyloliquefaciens* B17 (consortia 2) were developed for drought tolerance and enhancing crop productivity. Multi-enterprise integrated farming system models for Andhra Pradesh, Gujarat and Rajasthan were recommended. Organic farming packages for 4 cropping systems suitable to Gujarat, Kerala, Rajasthan, Sikkim and Uttarakhand were also proposed. New climate resilient rice genotype IET-24306 (Swarna Samriddhi Dhan) and NICRA Aerobic Dhan-1 were developed. Standardized subsurface drip irrigation in cereal based systems and automated drip fertigation in okra were developed.

Genetic resources: A total of 25 explorations were undertaken and 1,764 accessions (1,368 cultivated and 396 wild) were collected from various states. During this year 8,222 accessions of orthodox seed species were added to the National Gene Bank for long-term storage taking the total holding to 446,636 accessions. Screening against biotic (1,450 accessions), abiotic stresses (1,130 accessions) and herbicide resistance (2,000 accessions) undertaken in different crops. A total of 124,152 samples were processed comprising germplasm accessions, nurseries/trial breeding material of various crops including both true seed and vegetative propagules for quarantine clearance. National Genomic Resources Repository conserved 6,447 genomic accessions of 45 species at both –70°C and –196°C. A total of 186 germplasm accessions of fruit crops were collected from 15 states and Union Territories. In vegetable crops a total of 440 and in perennial spices 43 germplasm accessions were collected from different states and Union Territories. One stable, andro-monoecious sex form in watermelon (AHW/BR-5) with the ability to set fruits and produce viable seeds under net house conditions without pollinators and production of viable seeds was identified.

Thirteen new breeds of livestock and poultry and three breeds of dog were registered. The total number of indigenous breeds of livestock, poultry and dog are now 200. Five indigenous livestock populations of Kathani cattle, Balangir goat and Marwari, Sindhi and Kharai camel were characterized using a panel of 25 microsatellite markers, specific for each species. Metabolic profile of serum samples of livestock species in Ladakh (Ladakhi cattle, Jersey cattle, Ladakhi donkey and Changathngi goat) adapted to high altitude was evaluated assessing complement systems-wide approach to elucidate the influence on these species. The post translational modifications were observed in low and high abundant proteins of genetically diverse goat breeds/genotypes. High levels of PTMs were observed in 120 goat milk proteins. The somatic cell bank was

strengthened with fibroblast cell line from Jaisalmeri and Bikaneri camel, Halari donkey and Zanskari horse with at least five samples from each. A new freshwater fish species, *Barilius torsai* from Torsa river, Brahmaputra drainage was identified.

Crop improvement: During 2020-21, a total of 172 varieties/hybrids including 17 biofortified varieties were notified and released for commercial cultivation. These high yielding varieties included 62 varieties of cereals, 23 of oilseeds, 33 of pulses, 39 of commercial crops, 15 of forage crops and other crops. Using marker-assisted selection strategy, lipoxygenase-2 free soybean variety NRC 132 was developed and identified for cultivation in Southern and Eastern zones. Two SNP markers linked to wilt resistance in castor variety 48-1 were identified. These markers can be further used in the MAS for development of wilt resistant castor varieties. The miR156 binding site of the *Ideal Plant Architecture gene 1*(*IPA1*) was edited through CRISPR/Cas9 technique in Swarna rice. The edited lines showed ~40% increase in number of the spikelet's per panicle. *Cicer microphyllum*, a wild relative of *C. arietinum*, may serve as a source of genes responsible for drought tolerance. During 2019-20, total breeders seed production in field crops was 115,711.9 q against the indent of 85,752.8 q. The cereal crops had a major share in total breeder seed production. During 2019-20, the total production of quality seeds including all classes was 420,812.6 q against the target of 376,553.0 q.

In horticultural crops during this year, a total of 65 improved varieties/hybrids comprising fruits (11), plantation crops (8), vegetables (22), onion (4), garlic (1), potato (9), tropical tubers (2), flowers (1), spices (3), medicinal plant (1) and mushrooms (3) were identified for cultivation in different agro-climatic conditions of India. A total of 258.96 q of Breeder's seed of 193 varieties and hybrids of different vegetable crops were produced. Further, as a part of technology dissemination, a total of 227.2 q truthful label seeds of 56 varieties/hybrids of vegetables and 226 q TL seeds of seed spices was produced and distributed to farmers.

In pummelo, Arka Chandra and Arka Anantha with high yield and suitable for fresh consumption were developed. Arka Supreme avocado having 370-400 kg fruit yield was developed. Solapur Lal, the first biofortified hybrid pomegranate useful for juice or fresh consumption, was bred. ARI-516 grape, a high yielding, early ripening, evenly maturing hybrid with long, cylindrical, medium sized fruit bunches with 20-22°Brix and musky flavor was developed. Thettu Amalika tamarind was identified for cultivation in semi-arid zone of Andhra Pradesh. The coconut varieties notified were Kalpa Haritha, Kalpa Jyothi, Kalpa Surya and Kalpa Srestha. VTLCP-9 cocoa is a promising hybrid with 3 kg dry beans/tree/year yield and suitable for chocolate industry. Two onion varieties, viz Bhima Subhra and Bhima Safed were registered with PPV&FRA under extant category for their protection. Kashi Baingani French bean which flowers at 70-80 days after sowing, has been identified for cultivation in Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Madhya Pradesh, Maharashtra, Goa and Karnataka. Promising onion hybrids identified were DOGR Hy-73, DOGR Hy-173 and DOGR Hy-179. White onion variety GJWO-3 was identified for cultivation during *rabi*. Promising potato varieties identified were Kufri FryoM, Kufri Karan, Kufri Manik, Kufri Sahyadri, Kufri Thar-1, Kufri Thar-2, Kufri Thar-3, Kufri Sangam and Hybrid Kufri Chipsona-4. High yielding seed spices varieties developed were Ajmer Ajwain-73 and Ajmer Nigella-1. For the first time, a draft genome sequence of the popular Indian cashew cv. Bhaskara was generated using hybrid genome assembly approaches.

Livestock improvement: The cattle Frieswal was declared a breed and subsequently a trademark Frieswal^{TM} was obtained. Frieswal, a crossbred cattle variety, was released and included as a breed in national milch herd. A bull mother farm of Frieswal cattle was established at ICAR-NDRI, Karnal by selecting 208 Frieswal cows/heifers from 850 elite cows. The average 300-day lactation milk production potential of Frieswal cows is 3,335 kg. The total lactation milk yield of this breed is 3,628 kg. The average age at first calving (AFC) of Frieswal progenies decreased by 15.77% in KVASU (957.1 days vs 1136.4 days), 31.91% in GADVASU (811.6 days vs 1192 days), 18.79% in BAIF (793 days vs 976.5 days) and 14.2% in GBPUAT Unit (985.8 days vs 1149 days). Under the Indigenous Breeds Project (IBP), genetic improvements of three breeds, viz. Gir, Kankrej, and Sahiwal were carried out through the selection of elite animals. Under Mega Sheep Seed Project, the improvement of indigenous sheep breeds was carried out by propagation of superior germplasm in the farmers' flock. A total of 345 improved goat germplasm of different breeds were supplied to farmers and different developmental agencies for improving production performance in field conditions. The institutional flock of Jakhrana goats exhibited an average milk production 147.72±3.66l litres in 90 days and 192.40±5.58 litres in 120 days. The follicular dynamics concerning the changes in concentrations of hormones during the estrous cycle in pubertal mithun was evaluated.

Two male lines of poultry, viz. PD-1 (Vanaraja male line) and PD-6 (Gramapriya male line) and two female lines, PD-2 (Vanaraja female) and PD-3 (Brown egg layer line) were improved. A total of five crosses were produced by crossing Aseel males with females of PD-1, PD-2, PD-6, PB-1, PB-2 lines and evaluated up to 12 weeks of age.

The indigenous ornamental fish, *channa stewartii*, collected from beels of Assam was raised to broodstock in concrete tanks. The complete technology of breeding and seed production of ornamental fish silver moony was developed and is ready for transfer and entrepreneurship development. Captive breeding and seed production of an important food fish, mangrove red snapper was successfully undertaken, which not only is a suitable species for farming in brackish water ponds and open cages, but it also grows fast, tolerates salinity and accepts pelleted feed. A portable fiberglass reinforced plastics (FRP) hatchery was designed and fabricated for pabda. It possesses the capacity to accommodate 45,000-50,000 fertilized eggs, which can produce 10,000-15,000 early fry in a single cycle. By adopting multiple stocking and

multiple harvesting (MSMH) farming models with milkfish, productivity could be increased in small and traditional ponds. In 180 days, this model yielded 3.0-3.8 tonnes/h fish with a benefit-cost ratio of 1.50-1.66.

Crop management: A decision support tool (APSIM) to design suitable crop management in sorghum interventions for locations and to optimize *rabi* sorghum systems productivity was developed. Simulation study indicated that refined APSIM setup with gridded NASA data could be successfully used to simulate the yields of *rabi* sorghum across the country. Work on organic farming (OF) in pulses especially in long duration pigeon pea showed that higher crop performance could be realized with OF *vis-a-vis* inorganic or recommended practice. Intercropping of maize + cowpea (1:1) was most effective with higher grain yield of maize (66 q/ha) compared to that in maize – chickpea system (63.90 q/ha). Crop intensification with foxtail millet as pre-*rabi* crop, is recommended in rainfed *Alfisols* of Prakasam district for an additional net income of ₹ 10,000 to 25,000/ha, where farmers normally grow tobacco and Bengal gram in *rabi*. Maize-tobacco cropping system is recommended as remunerative cropping system in terms of tobacco leaf yield (2,380 kg/ha) and net returns (₹ 139,285) in tobacco growing *Vertisols* of Andhra Pradesh. The maximum soybean yield was recorded under conventional tillage carried out after two years and remained at par with sub soiling once in four years and conventional tillage carried out every year. A novel rhizobial strain *Bradyrhizobium daqigense* was isolated for the first time from root nodules of soybean. Five resources based farmer specific IFS models each of one ha size were developed and demonstrated by IGFRI, Jhansi to enhance the livelihood of Bundelkhand farmers. *Trichoderma* isolates from pulses rhizosphere were tested under *in-vitro* and green house conditions at ICAR-IIPR, Kanpur; one isolate, 11PRTH-31 (*Trichoderma asperellum*) was identified for maximum inhibition of mycelial growth of wilt pathogens, promoted root length, shoot length, and tolerated temperature up to 50°C. Blast pathogen *Pyricularia grisea* infect the spike or finger of finger milletat flowering stage. Yield loss due to this disease varies from 28-36% and may go up under favourable conditions for disease. Multiple parasitoid species for biological control of fall armyworm identified were *Spodoptera frugiperda, Glyptapanteles creatonoti, Campoletis chlorideae, Cotesia ruficrus, Coccigidium transcapsicum, Chelonus formosanus* and *Phanerotoma* sp.

Application of FYM (10 kg/tree) with Arka microbial consortium along with 100g AM fungi was observed effective in replacement of 25% of recommended dose of fertilizers in custard apple Arka Sahan. Fertigation of 75% NPK along with irrigation at 80% ER and polythene mulching in combination with foliar spray (2%) of micronutrient formulation Banana Shakti and bunch spraying with 2% potassium sulphate significantly enhanced the yield of banana in Karnataka, Odisha and Andhra Pradesh. In Grand Naine banana, the application of poultry manure + groundnut cake + rural compost + wood ash + VAM + PSB + KSB yielded bunches (23.5 kg) which were on par with 100% inorganically fertilized banana plants. At Shillong, application of 75% of recommended-Phosphorous (RDP) as rock phosphate along with PSB inoculation exhibited potato tuber yield at par with the treatment receiving 100% RDP indicating a saving of about 25% RDP. Soil application of liquid formulation of *Beauveria bassiana* along with bunch spraying with acephate followed by bunch covering with polypropylene sleeve were found effective in management of banana scarring beetle. Utility of genome editing of mango fruit fly mediated by CRISPR/Cas 9 was demonstrated by disrupting white gene, spermatogenesis pathway genes such as *topi, per*. Integrated management of leaf curl virus in chilli Pusa Jwala was standardized with reduced incidence of leaf curl disease which increased yield by 78.61%.

Livestock management: New variety of sorghum fodder, CSV-43 BMR developed through pedigree method improved the performance of growing and lactating buffaloes. A composite feed additive developed was effective in reducing enteric methane production and enhancing performance in lactating murrah buffaloes. A study indicated that Murrah buffalo males can grow faster, attain early puberty and AFE with better semen quality when provided with improved feeding and shelter management. Supplementation of *Tinospora cordifolia* stem powder @2% in concentrate feed for 14 days could prevent sub-acute lactic acidosis in small ruminants. The low live birth rate obtained with cloned embryos limits this technology on a large scale. Studies revealed that treatment of cloned embryos with Dickkopf-1 improved their developmental competence, quality and live birth rate. The growing goats and sheep fed with moringa based complete feed for long duration attained higher body weight and appreciably highest efficiency of feed conversion in comparison to other group of animals of similar age and fed with traditional ration. A pregnancy-associated glycoproteins-based diagnostic assay was developed for early detection of pregnancy in bovine. Study under controlled thermal stress conditions in psychrometric chambers and in different seasons revealed that crossbred cattle are more immune to stress than indigenous cattle. A novel phytogenic blend was developed to replace antibiotic growth promoters in broiler production. Dietary supplementation of the bland significantly improved body weight gain and feed conversion ratio and reduced *Salmonella* and coliform counts in the caecum.

Two effective kits, namely Surravey-kit for population survey of Trypanosomiasis and indirect ELISA for detection of antibodies against Classical Swine Fever in pigs using recombinant Erns protein were developed and launched. A total of 6,100 pig and 25,599 small ruminant serum samples received through AICRP-ADMAS centres were added to the National Livestock Serum Bank. An indigenous ELISA kit was developed to know the early presence of Rotavirus in diarrheic calves. Live attenuated CSF cell culture vaccine was developed from an indigenous strain. The vaccine will be highly cost effective and can be easily scaled up. A study aimed at treating mastitis and metritis diseases in cattle by treatment with Mesenchymal stem cells (MSCs). All the animals were cured completely demonstrating the

potential of MSCs for treatment of mastitis and metritis in cattle.

A PCR-based identification kit was developed which can identify *magur* and *gariepinus* and their hybrid in just two steps with genomic DNA as starting material. The full-length *lgp2*-cDNA sequence obtained through rapid amplification of cDNA ends-PCR consisted of 2299 nucleotides with an open reading frame of 2034 bp encoding 677 amino acids. To quantify the burden of antimicrobial resistance in food-producing animals and aquaculture through structured surveillance, ICAR in cooperation with FAO initiated a Network project known as Indian Network for Fisheries and Animal Antimicrobial Resistance (INFAAR). Lumiphage-a bacteriophage-based therapy as an alternative to antibiotics was developed for shrimp hatchery operators for the prevention and control of bacterial diseases. A medicated feed mix, CIFE-ARGUNIL, which is effective for the control and treatment of *Argulus* and other ectoparasites of fishes was developed and granted patent.

Mechanization and energy management: A tractor-mounted six-row high speed (5-7 km/h) planter was developed with the pneumatic metering mechanism. The approximate cost of the machine is ₹ 90,000 and its cost of operation is ₹ 615/h. The breakeven point and payback period of the planter were 64.8 h/year and 1.96 year, respectively. The development of suitable matching equipment for the small tractor is of prime importance due to small fragmented land holdings, hill agriculture, shifting cultivation and lack of mechanization for the horticultural sector. The spraying system has been attached to the platform for the application of fungicide/pesticide. The developed system can be used in orchard crops for pruning, spraying and fruits plucking. One of the possible ways to increase the digestibility of poor quality roughages like rice and wheat straw is urea treatment. The handling task can be minimized substantially by treating straw with a retrofitted urea solution spraying system on the straw baler. The capacity of straw baler with urea spraying system is 109 bales/h for paddy at a straw load of 8.3 t/ha. A three-row multi-crop planter cum herbicide applicator was developed for planting of seeds and application of herbicide simultaneously. The performance of the implement was evaluated for the sowing of soybean, green gram and fodder maize crops. The cost of the implement is ₹ 15,000. A high-pressure variable range sprayer prototype was developed to control the hopper and adult locust. The other implements developed for farm mechanization were: animal cast mounted solar sprayer, ultra-low volume spraying system, tractor operated intra row cum inter row weeder for orchards, sprayer equipped with electro-pneumatic system to control whitefly in cotton crop, tractor operated planter for tissue culture banana, dust separation system for the wheat straw combine, trimming mechanism type banana sucker pairing equipment, banana pseudo stem injector, tractor operated banana bunch harvester, cashew apple slicer, cleaner for multiplier onion, lifting platform for operations in green house, power-operated mini rhizome planter, power-operated groundnut stripper cum decorticator, dust protection mask, solar fan-assisted headgear for environmental heat stress, solar-assisted micro-algae harvesting system and non-thermal plasma pyrolysis reactor. Initiatives were undertaken to tackle the COVID-19 pandemic. The portable touch-free hand wash system, hand sanitizer unit and pedal-operated sanitizer dispensing unit were developed to prevent spread of COVID-19.

Post-harvest management and value-addition: Green pea is used as fresh, frozen, canned and in dried seed form. The shelling/de-poding of pea seeds from the matured pods is a requisite operation. A small to medium scale green pea de-poding machine was developed with a capacity of 45-55 kg/h, shelling efficiency of 90-95% and 2-3% damage. The on farm solar assisted dryer for drying groundnut pods was developed. After drying, the groundnut pods can be stored for a longer time. The other machinery developed for post-harvest management and value-addition were: primary makhana roasting machine, loading/unloading device, poultry processing cum by-product collection unit, automated amylose detection sensor system for assessment of ageing of rice grain, portable solar dryer for hills, portable ozone-based fruits and vegetables washer-cum-purifier/portable smart ultraviolet-C disinfection system.

A novel process to produce protein isolates/concentrates from oilseed cakes/meals without the addition of strong or diluted acid was developed. The protein produced using this method is superior in terms of solubility, wettability, water absorption capacity and degree of hydrolysis. A process for preparation of fat/oil free flavoured makhana was developed. Fat free flavoured makhana is useful for the health-conscious consumers. Testing kits for detection of adulterants in selected spices, e.g. turmeric powder, red chillies, black pepper, coriander etc. were developed based on biochemical tests. The kit contains chemicals, glassware and procedure for the detection of adulterants, viz. metanil yellow, lead chromate, sudan dye, rhodamine, starch and papaya seed powder in spices. The other processes and products developed were activated carbon from walnut hull, natural dye extracted from walnut hull, rose petal jam, soy based composite edible film, omega 3 rich flax seed and chia seed fortified eggless chocolate cake, cotton gin trash treatment system, cotton interlined sleeping bags for better comfort, agro-residue reinforced natural rubber garden pots, innovative lysimeter for on–farm water management, high value fine textiles from banana/jute/regenerated cellulosic fibres, sorghum yoghurt, omega-3 fatty acid fortified butter, seaweed-based products etc.

Agricultural human resource development: The Education Division, ICAR, continues to strive for strengthening and quality assurance of higher agricultural education through implementation of scheme 'Strengthening and Development of Higher Agricultural Education in India'. Quality assurance of AUs was ensured through accreditation and ranking of the AUs. Capacity building of the students and faculties was enhanced in 16 programmes supported under Niche Area of Excellence including, one new programme sanctioned in 2019-20. Learning resources were enriched and strengthened with e-books/print books and ICT in all disciplines. Twenty new Experiential Learning Modules

were supported under student 'READY' component for developing entrepreneurial skills of students. Financial support was also provided for strengthening, renovation and modernization of the structures pertaining to learning and teaching as well as for infrastructure pertaining to student amenities, viz. student hostels, laboratories, examination halls, smart classrooms. AUs were also supported for encouraging holistic development of students.

Various programmes/activities also facilitated promotion of higher agricultural education. These include centralized admissions in UG/PG and PhD to reduce academic inbreeding, infuse merit and promote national integration; award and distribution of fellowships to attract and retain the talent and promote merit, admission of foreign students for globalization of agricultural education, capacity building of faculty through summer-winter schools and Centre of Advanced Faculty Training, National Professorial Chairs and National Fellow Scheme for promotion of excellence in research, Emeritus Scientist/Emeritus Professor Schemes as a structural method of utilizing skill bank of outstanding superannuated professionals.

The support for Girls' hostels, under the scheme of Agricultural Education Division was a step towards gender mainstreaming which increased the percentage of girls in higher agricultural education to 43.6%. The upgraded, improved and expanded infrastructure also increased the overall intake of the students across AUs.

The National Agricultural Higher Education Project (NAHEP) is becoming increasingly visible to have contributed towards transformation in agricultural higher education, enhancing its quality and relevance and development pursuit of the ICAR. The project implementation witnessed a desired pace during this year. By now, 58 Agricultural Universities across the country were awarded projects under different components of NAHEP. During the year, activities majorly focused on teaching and research infrastructure development, faculty development and training, networking and industry collaboration, vocational training, students job placement, own revenue generation, strengthening of teaching and research infrastructure etc. Till now, nearly 377 students and 120 faculties had undergone the international level trainings in reputed foreign universities, whereas more than 2000 national level workshops / seminars have been conducted for UG, PG and Ph.D. level students under different components. Moreover, industry visits and Skill development programs have also been organized primarily to cater the current market needs and enable the students to emerge as "Job Creators" rather than "Job Seekers". During the period, activities undertaken are strengthening of key digital infrastructures of ICAR AU system such as ICAR – DC (Krishi Megh), e –enabled learning activities in AUs through demonstrations of virtual classrooms, implementation of Academic Management System in 52 AUs, development of AU – PIMS, progress on constitution of External Advisory Panel, technical committee meetings to catalyze the participation of state government representatives in raising the quality and relevance of agricultural higher education etc. So far, this program has benefited around 54,000 beneficiaries across agriculture and allied sector.

Social science: The frequency of climatic hazards such as droughts, floods, heat waves and cold waves has increased in the recent past and is predicted to increase in the future, that will affect the performance of agriculture and livelihood of millions of people. In India, the climatic hazards are estimated to reduce agricultural growth by about one-fourth. Keeping in view the current resource constraints, particularly the water in the Bundelkhand region, sustainable cropping pattern, and crop-livestock mix were envisaged. A goal programming model was developed to maximize net returns and minimize water use with set of physical, economic and environmental constraints. A composite agricultural sustainability indicator (CASI) was designed especially suitable for the rice-wheat production system. The index covers four broad dimensions, viz. soil, water, ecological and economic encompassing 79 indicators. The barometer so developed was applied to gauge the sustainability of Trans Gangetic plains of India. The trends in scientific publications of emerging technologies such as synthetic biology and artificial intelligence in agriculture were studied. Applications of these technologies such as deep learning and algorithms to predict diseases and pest outbreaks, genome editing for new improved varieties are already in the market. To study the functional nature of Extension and Advisory Services (EAS), a system level analysis was carried out with 36 service providers from Maharashtra and Odisha; including Public Private, Farmers' Producers Organizations (FPOs), and Non-governmental Organizations (NGOs). All public EAS providers reported linkages and cooperation with other public EAS providers as well as non-public EAS providers. The linkages among non-public EAS providers were not as expected; particularly, FPOs and some private EAS providers worked in isolation. The Government of India is committed to doubling of farmers' income (DFI) by 2022 with DFI strategies now under implementation. ICAR-NIAP estimated the interim growth rates in income for effective monitoring of DFI strategies. The income assessment was done using seven sources of growth. The real income growth was estimated from 2015-16 to 2018-19. The estimates are a positive direction of change. Several initiatives of the government are seen to be yielding positive results, and the growth momentum can be expected to pick up further. A value chain analysis of three major spices-ginger, turmeric and chilli in the north-eastern region was analyzed to work out comparative costs and returns mapping of value chain actors and estimation of compliance cost, investment and margins along the value chains.

In statistics and computer applications the following methods were developed: latin hypercube designs, modelling and forecasting of drought index using machine learning techniques, machine learning techniques based hybrid model for forecasting in agriculture, regression analysis from sample survey data using calibration approach, robust and efficient small area

estimation methods for agricultural and socio-economic surveys, development of state level estimates of crop area and production, etc..

ICAR-CIWA has mandate of undetaking research on gender issues in agriculture and allied fields, gender equitable agricultural policies/programmes under gender-sensitive agricultural sector responses and co-ordinating research through its AICRP. The Institute's primary activities include standardisation of methodologies for livelihood analysis and developing vulnerability framework for farm women, community and NRM based technological interventions for livelihood security, skill and entrepreneurship development of women and striving for food and nutritional security of farm families including water, health and sanitation.

Information, communication and publicity services: The ICAR-Directorate of Knowledge Management in Agriculture (DKMA) is mandated to showcase ICAR's technologies, policies and other activities through the state-of-the-art dissemination methods that cater to various stakeholders in the field of agriculture. In the fast-changing knowledge intensive era, the DKMA is committed to promote ICT-driven technology and information dissemination system for quicker and more effective outreach. The ICAR-DKMA has already taken steps to disseminate knowledge by using up-to-date most popular ICT tools for benefitting the national as well as global agricultural world. *The Indian Journal of Agricultural Sciences* and *The Indian Journal of Animal Sciences*, the prestigious monthly research journals with international impact factors were available online (http://epubs.icar.org.in/ejournal). The popular periodicals like *Indian Farming* and *Indian Horticulture* and *Kheti* and *Phal Phool* were brought out to disseminate up-to-date knowledge and technologies to the stakeholders involved in agricultural production and processing in the country.

To disseminate information in real-time, the ICAR website was updated on regular basis, and in total 3,965 pages were updated, with page-views from more than 200 countries. On ICAR Facebook, total 399 posts were published, and it has 2,20,207 followers. The YouTube Channel of ICAR has video films, animations, lectures/ interviews by dignitaries and eminent scientists, proceedings of national and international events, etc. The Channel presently has 54,800 subscribers. The ICT Roadmap of ICAR has been prepared for the development and implementation of various software, IT tools, databases and e-Governance software in line with the Digital India Mission of the country. This ICT Roadmap envisaged short term and long-term ICT/IT activities which are needed for undertaking ICT/IT projects based on disruptive ICT technologies such as precision agriculture, dynamic decision support and advisory system, e-Governance software using AI, DL, ML, blockchain and big data analytical techniques. In order to make paperless/ environmental friendly office, e-office software has been implemented across 113 ICAR Institutes along with their Regional Stations/Sub-Stations in the country.

Technology assessment, demonstration and capacity development: During the year, 12 new KVKs were established taking the total number of KVKs to 722 in the country. Besides lab to land activities for outreach, important programmes such as Farmers FIRST, Attracting and Retaining Youth in Agriculture (ARYA), Cluster Frontline Demonstration of Pulses and Oilseeds, Cereal Systems Initiatives for South Asia (CSISA), National Innovations in Climate Resilient Agriculture (NICRA), Pulses Seed Hubs, Mera Gaon Mera Gaurav and awareness creation on government schemes etc. were taken up to address various challenges of engaging youth in agriculture, bringing self-sufficiency in the production of pulses and oilseeds, sustainable agriculture, etc. Technology assessment is one of the main activities of KVKs to identify the location specificity of agricultural technologies developed by the National Agricultural Research System (NARS) under various farming systems.

A total of 5,421 technologies of various crops were assessed at 13,094 locations by KVKs through 25,357 trials on farmers' field under thematic areas, namely cropping systems, drudgery reduction, farm machineries, integrated crop management, integrated disease management, integrated nutrient management, integrated pest management, integrated weed management, processing and value addition, resource conservation technologies, seed and planting materials production, storage techniques besides varietal assessment for cereals, pulses, oilseeds, fruits, vegetable crops and commercial crops. Under livestock, 1,034 technologies interventions across 3,338 locations covering 5,156 trials on animals under the thematic areas of disease management, evaluation of breeds, feed and fodder management, nutrition management, production management, processing and value addition were taken up for assessment. The Indian Council of Agricultural Research, New Delhi initiated National Level Cluster Frontline Demonstration (CFLDs) on Pulses and Oilseeds with main objective to demonstrate the production potential of new varieties and the related technologies. A total of 17.27 lakh farmers/farm women, rural youth and extension personnel were trained on various aspects through 57,879 training programmes. KVKs produced technological products like seeds and planting materials of improved varieties and hybrids, bio-products and elite species of livestock, poultry and fish which benefited 26.37 lakh farmers in the country. Soil, water, plant and manure samples brought by farmers were analyzed at KVKs, and suitable advisories based on analysis were provided to them. Soil health cards (4.56 lakh) were also issued to the farmers by KVKs. During the year, 5.81 lakh farmers visited ATICs for obtaining solutions related to their agricultural problems.

Research for tribal and hill regions: During the year, the following crop varieties were released and notified: VL Sweet Corn Hybrid 2, VL Masoor 148, VL Bhat 202 and VL Matar 61. A total of 220.52 q breeder seed of 42 released varieties/inbreds of 15 crops was produced. The 15.18 q Truthfully Labelled (TL) seed of 25 varieties of 16 crops were produced. Sixty rice genotypes were evaluated for leaf and neck blast diseases under the Uniform Blast Nursery system. Four genotypes (VL 865U, A57, GSR 125 and GSR 142) for leaf and five

genotypes (VL 3187, VL 31851, VL 31916, VL 31997 and GSR 132) for neck blast were found highly resistant, with 1 disease score on 0-9 scale. The susceptibility of greenhouse whitefly against different insecticides, viz. Thiomethaxam, Imidacloprid and Pymetrozine were high with LC_{50} values 12.30, 18.62 and 22:38 ppm, respectively. The brinjal accessions both cultivated and wild relatives were screened against the virulent strain Fom-Megh 1 isolated from Meghalaya. All cultivated varieties of brinjal, Pusa Bhairan, Pusa Shyamla, Pusa Uphar, Pusa Ankur and Pusa Purple Round were highly susceptible to Fom-Megh 1 in northeastern region. Dragon fruit cultivation has a huge potential in Mizoram as the climatic condition is highly suitable for better yield and quality with market demand. Shweta Kapila, a cattle breed from Goa was registered with ICAR-NBAGR, Karnal. The value-added formulation CCARI Bio 3 and CCARI Bio 4 was evaluated for their growth-promoting efficiency in the soil @ 50 g/m^2. Growth parameters were higher in the value-added formulation compared to untreated control. To improve the livelihood of the tribal farmers of Goa and coastal districts of Maharashtra and Karnataka farm and process machinery, technologies developed by ICAR-CCARI were distributed. Training and awareness required were also carried out for the capacity building of the farmers.

Organization and management: Fifty-three new patent applications were filed during this year in different subject domain of agricultural sciences at the Indian Patent Office (IPO). The cumulative figure of patent applications at ICAR has now risen to 1,172 applications. To protect the plant varieties, proposals for 45 varieties (24 extant and 21 new varieties) were filed at Plant varieties and Farmers' Rights Authority (PPV&FRA). For applications filed earlier, 54 varieties (43 and 11 new) were granted registration certificates during this period, which raised the cumulative figure of registered varieties to 900. Thirty-seven trademark applications were filed by eight ICAR institutes for different products and processes. Till date a total of 168 trademark applications have been filed. This year, 325 partnership agreements were formed for Consultancy/ Contract Research and Service with 174 public and private organizations.

Under the promotion quota following posts were filled up during this year, five Director/Joint Director cum Registrar, one Director (F)/Comptroller, one Deputy Director (F)/Chief Finance & Accounts Officer, three Deputy Secretary & three Chief Administrative Officer, eleven Senior Finance & Accounts Officer, three Under-Secretaries, five Senior Administrative Officer, three Deputy Director (OL), one Principle Private Secretary, ten Administrative Officer, nine Finance & Accounts Officer, three Section Officers and two Private Secretary. During the year, 69 eligible officers and staff of ICAR (Hqrs.) and Institutes were granted the benefits of financial up-gradation under the Modified Assured Career Progression scheme in accordance with the Government of India (Department of Personnel and Training) instructions in this regard.

During the period under report, 4 ICAR Institutes/ Centres were notified in the Gazette under office Language Rule 10(4). Till date, 141 ICAR institutes/ centres have been notified. Four meetings of the Official Language Implementation Committee were organized. In most of the ICAR institutes/centres, the Official Language Implementation Committee was constituted, and their meetings were being conducted regularly. The quarterly progress report was sent online to the Regional Implementation office of Rajbhasha Department. The quarterly progress reports received from various institutes were reviewed and suggestions were given to them for effective implementation. In accordance with the instructions/orders of the official Language Department, Ministry of Home Affairs, a total of 11 institutes were inspected for assessing the progress of Hindi during the period under report and suggestions were given to rectify shortcomings observed during the inspection.

Two meetings of Directors of ICAR institutes and ATARIs were held under the Chairmanship of Secretary, DARE and DG, ICAR through Video Conferencing during COVID-19 period. It was emphasized to strictly follow lockdown guidelines, maintain hygiene, use of mask and social distancing under any circumstances. Besides these, various action points regarding the research protocols to be developed and observed were decided. It was decided to ensure the technology and input delivery among the farmers and other stakeholders using ICT and all other possible means were decided to minimize the impact of COVID-19 on farmers and the agricultural sector. The Umbrella Memorandum Understanding (UMoU) was signed between the ICAR and host Institutions, i.e. Central/States Agricultural Universities and other Departments to cooperate in conducting research through AICRPs/Revolving Fund Scheme/ and any other such schemes funded/ sanctioned by the Council. To commemorate the 92nd Foundation Day of ICAR, the Award Ceremony was organized. Various Awards for ICAR Awards 2019 were presented to the winners on the occasion. The awards were given in 20 different categories to 161 awardees, these comprised 94 scientists, 10 administrative personnel, 6 journalists and 31 farmers. Two institutes, one university, two AICRPs and 14 KVKs were also awarded.

Finance: The Revised Estimates in respect of DARE/ ICAR for 2019-20 was ₹ 7,846.17 crores. An internal resources of ₹ 368.37 crores (including interest on Loans & Advances, income from Revolving Fund Schemes and interest on Short Term Deposits) was generated during the year 2019-20. The total allocation Budget Estimates for 2020-21 is ₹ 8,362.58 crores.

Partnership and linkages: ICAR works closely with the Consultative Group on International Agricultural Research (CGIAR) institutes. ICAR/DARE has strong collaboration in the field of agricultural research and capacity building through active MoUs and work plans with 12 out of 15 CGIAR institutes. During 2020-21, ICAR entered into a work plan agreement with The International Fertilizer Development Center (IFDC), Alabama, USA. Work Plan for the period 2020-25 was signed between ICAR and the International Food Policy Research Institute (IFPRI) to promote and accelerate the

collaborative efforts for research and training in food and agricultural policies. To foster the agricultural research in the Global South, a MoU has been signed between ICAR and Asia Pacific Association of Agricultural Research Institutions (APAARI), Bangkok, Thailand. The ICAR has been pioneering in the human resources development for agricultural research in Afghanistan by establishing the Afghan National Agricultural Sciences and Technology University (ANASTU) at Kandahar. The significant improvement in the expansion and infrastructure development of CAUs happened during 2020 with Prime Minister dedicating the new building of the School of Agribusiness and Rural Management of RPCAU, Pusa, Samastipur and academic building for College of Agriculture, Horticulture and Forestry, administrative building, hostels and faculty residences at RLBCAU, Jhansi. Shri Narendra Modi, Prime Minister of India, dedicated the newly constructed the Academic and Administrative buildings to the nation. As a measure to reach out to cross sectional agencies and entities involved in the development of agriculture and the farmers in the country, ICAR entered into MoUs with the National Cooperative Development Corporation (NCDC), New Delhi, Indian Farmers Fertilizers Cooperative (IFFCO), New Delhi; Ministries of MSME for entrepreneurial development, and MoFPI for technical support and capacity building in food processing and promotion of one-district one product programme of Government of India. Agrinnovate India Limited has successfully been able to turn a new leaf in the recent past by initiating effective partnerships with ICAR institutes and private companies. The company's revenue from operations touched ₹ 153,76,950 for the first time, as against 3,057,630 during the previous year. With a revamped website and increased efforts at bringing technologies developed by 35 ICAR institutes under AgIn's purview, nearly 340 technologies were added to the list of technologies ready for commercialization through AgIn.

Supporting basic and strategic research: The National Agricultural Science Fund supports basic and strategic research in agriculture. The main objective of the scheme has been to build capacity for basic, strategic and cutting-edge application research in agriculture and address issues which can be solved by intensive basic and strategic research jointly by a team of organizations/ institutions. The scheme has already funded 205 projects, mostly in consortium mode. At present, 66 projects are in operation and out of which 62 are multi-institutional in nature. During the last one year, NASF had taken many new initiatives like the inclusion of allele mining, metabolomics, precision agriculture, application of sensors and nanotechnology in agriculture and policy in agriculture as new strategic areas; and one mega-project on captive breeding of hilsa *Tenualosa ilisha*: Phase II. Besides supporting, reviewing, monitoring and evaluation of the ongoing projects during the year, NASF evaluated 66 new full projects proposals received under different themes. A total of 27 new projects were approved during the period. Besides having more than 70 research publications in reputed journals, NASF had seven patents and 10 technologies.

Training and capacity building: As a new initiative, the Competent ICAR Institutes organized Trainers Development Programme for Developing Masters' Trainers in ICAR, training programme for Technical and/ or Administrative staff dealing with Security or Security Officer, Court cases, Assets Management, Works/Estate/ Building Maintenance, Capacity Building Programme for CJSC Members and establishment matters for LDCs and UDCs of ICAR. Training programmes for Guest House Caretakers/Incharges, stenographers grade, technical staff, regular drivers, farm manager, PME Cell Incharges, ITMU/ZTMU Incharges, Vigilance Officers, etc. were also organized. An Executive Development Programme on 'Developing Effective Organizational Leadership for Senior Officers of ICAR' was also organized in which 45 Seniors Officers in 2 batches with both In-country and International exposurevisits, participated.

All the ICAR-Institutes and HQ submitted the ATP online for all the categories of employees through TMIS. During the reporting period, 1,055 scientists; 728 technical; 1,321 administrative including finance staff and 340 SSS were trained. Overall, 3,444 employees were trained which is about 20.1% of the total employees' strength of ICAR. Compared to 2013-14, there was considerable improvement in a number of employees who received trainings particularly in case of Technical, Administrative and Skilled Support Staff, where improvement was 96.8, 118.0 and 750.0%, respectively along with the overall improvement of 43.0% in all the categories of employees. Compared to 2013-14, ICAR-Institutes/HQs organized 67.2 and 440.0% more training programmes for technical and skilled support staff, respectively with overall 4.1% higher trainings during 2019-20. ICAR-Institutes had also organized the Field/ Exposure visit of 288 SSS to other ICAR-Institute(s) within or nearby states.

For the first time, a study conducted on the effectiveness of trainings attended by 1,782 staff of all four categories during 2017-18 revealed that pooled perceived training effectiveness index (PTEI) was 3.86, referring medium effectiveness of trainings. Significant behavioural changes and changes in practices as a consequence of exposure to the trainings were observed and it was concluded that the trainings organized by ICAR should continue for all staff to bring about desirable changes in competencies.

For a better understanding of the needs of agriculture, I present these achievements of the Council to the policy planners, researchers and all stakeholders, and hope that these will help them in future research and innovations for the improvement of Indian agriculture.

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

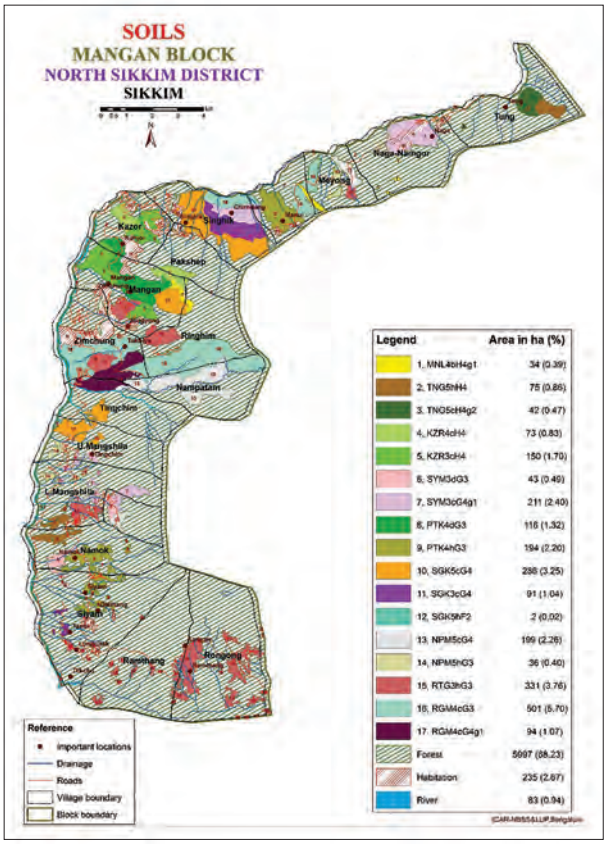
2. Soil and Water Productivity

Soil quality assessment: Soil samples from five different bio-climates were analyzed for soil organic carbon (SOC) and soil inorganic carbon (SIC) to assess soil quality. SOC content reduced upon moving from per-humid to dry semi-arid and arid (Nimone series) climatic conditions. However, the SIC ($CaCO_3$) content was higher in soils of drier areas with lower rainfall and soils under rainfed agriculture. Soil quality assessment was done in areas dominated by cotton and sugarcane-based cropping systems (AESR 6.1) and rice-based cropping system (AESR 18.4). Majority of districts with cotton-based cropping systems have relative soil quality index (RSQI) of Class II (80–90) whereas the districts with sugarcane-based cropping systems have RSQI of Classes II and III (70–80) in AESR 6.1. In AESR 18.4, the RSQI class is III and IV (60–70) in majority of districts with small patches of classes I (>90) and II. A positive correlation between RSQI and crop yields in both AESRs suggested that the former could serve as unified criterion for comparing regional soil quality.

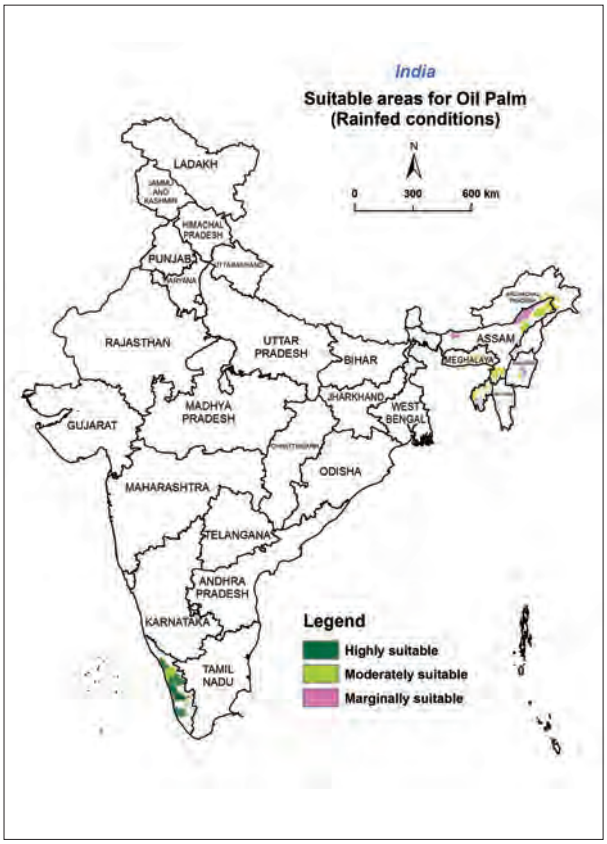
Land Resource Inventory: Land Resource Inventory (LRI) on a 1:10000 scale were prepared in GIS environment for the different blocks of Manipur, Nagaland, and Sikkim to generate site specific information needed for farm/village level planning. Detailed database generated at farm level and its subsequent abstraction to village, mandal, taluk, district, state and country will form the basis needed for prioritizing, initiating and executing soil conservation measures, irrigation planning and precision agriculture.

Glauconite nano-particle—a potential source of potassic fertilizer: The entire requirement for potassic fertilizer is imported in our country. Glauconite as it is available in our country can be an alternative low cost source of potassic fertilizer for sustainable crop production. An attempt was made to test glauconite nano-particle as a potassic fertilizer. Glauconite nano-particles (GNP) were prepared by top down method and obtained the GNP of size 19.9 nm. Besides 6–10% K_2O, GNP also contains Si (51%), Al (2%), Fe (16%) etc. Application of GNP recorded higher crop yield and proved steady releasing behavior of K from GNP throughout the growth period of crop.

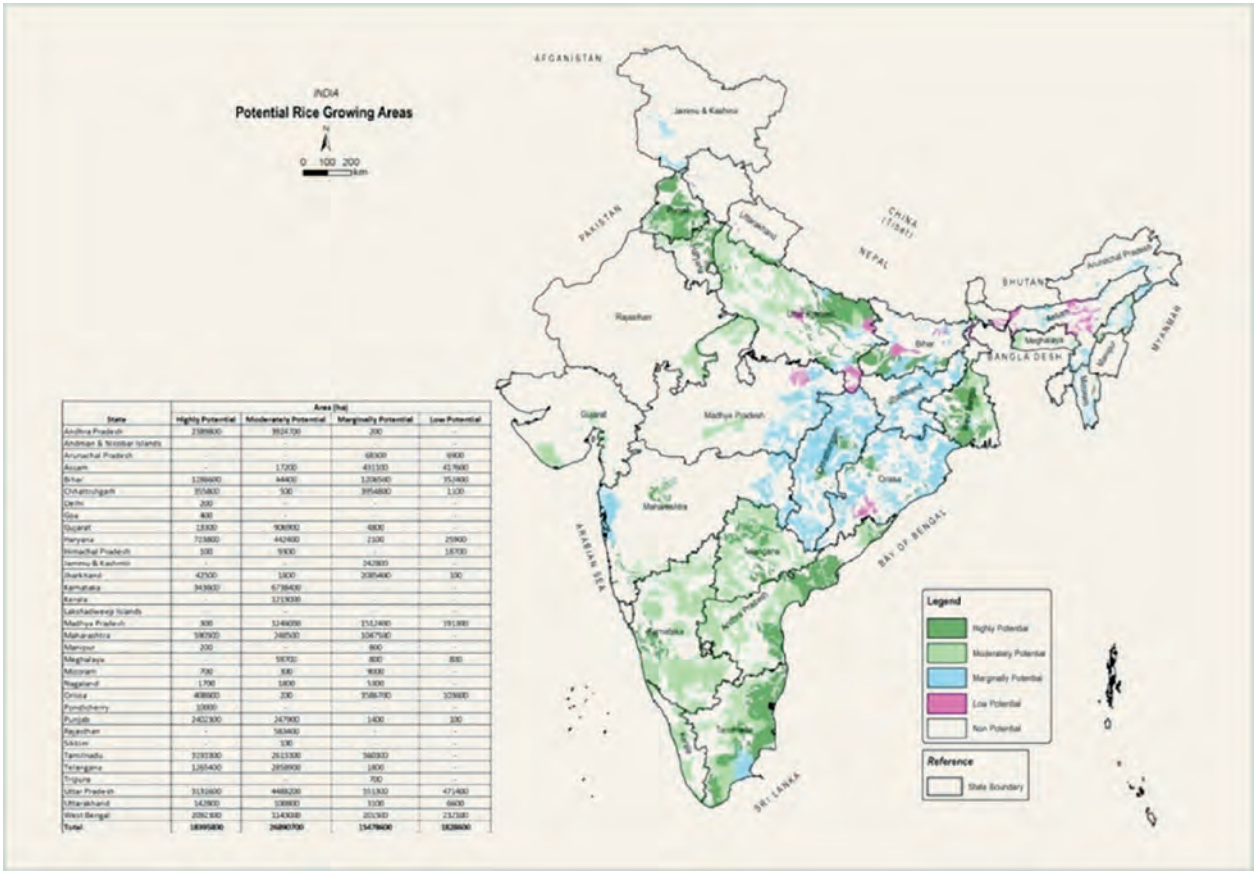
Potential crop zones delineated: Area/region specific efficient and remunerative crops and cropping sequences were delineated based on soils, landforms, rainfall, temperature, length of growing period and



Soil map of Mangan block of Sikkim at 1:10000 scale



Revised oil palm suitability map of India for rainfed condition



Potential areas of rice

irrigability. Potential crop zoning involves development of Land Management units (LMUs), bio-physical suitability evaluation and linking of bio-physical suitable maps to the relative spread and productivity of reference crops and cropping sequences. The potential areas of rice and oil palm of the country were delineated.

Subsurface drip irrigation in cereal based systems: Water and nutrient (N) management in rice–wheat systems using subsurface drip irrigation (SDI) was standardized with laterals spacing and depth at 67.5×20 cm in normal soil and at 45×15 cm in salt affected soils, respectively. On system mean basis, SDI saved 47% (93.6 cm/yr) and 45% (29 cm/yr) irrigation water under rice–wheat (RW) and maize–wheat (MW) system, respectively, compared to flood irrigation system under same management level. The highest (4.46 q/ha-cm) irrigation water use efficiency was recorded with MW system and lowest (0.58 q/ha-cm) with farmers' practice. The SDI system reduced the fertilizer N requirement by 20% (30 kg N/ha) under each crop of rice, wheat and maize and on system basis. On system basis, RW and MW systems recorded 45 and 50% higher partial factor productivity of N (PFP_N) with SDI compared to conventional till (CT) flooding. The crop productivity and farm profitability of RW-mungbean system increased by ~11 and 29%, respectively, under SDI system compared to farmers' practice (FP) of flood irrigation system. However, in MW system, ~20% higher productivity, 49% higher profitability was recorded under SDI system compared to flood RW system. The SDI enabled integration of mungbean in cereal (RW/MW) systems, which contributed to ~10 and 20% increase in productivity and profitability, respectively, irrespective of cropping systems.

Bioreactor for rapid composting

Ekcel-CompostR and Ekcel-ShredR for rapid decomposition of waste biomass, were developed. Ekcel-ShredR is used to produce fine textured cellulosic food waste materials (3–6 cm) from different sources of food stuff. Ekcel-CompostR enhances the decomposition rate of shredded waste using thermophillic ligno-cellulolytic Accel microbial consortia, in turn reduces composting.

All ingredients and microbial consortium are mixed and fed together with required amount of water. The mesophilic microbial consortium was added at initial stage and thermophilic bio-inoculum was used after 15 days of decomposition. The final compost product was ready within 25–30 days of decomposition.

Bioreactor for rapid composting

Erosion induced loss of soil organic carbon: Main objective of the project is to estimate erosion-induced loss of soil organic carbon from a soil affected by different phases of erosion. Profiles from reference as well as eroded sites were sampled by a depth incremental sampling procedure. The sample of each layer was well mixed and an amount of approximately 1 kg was kept for ^{137}Cs activity determination as well as for chemical and physical analysis. The inventory of ^{137}Cs data from 8 runoff plots representing various phases of erosion were analyzed for quantification of soil erosion. Carbon enrichment ratio (CER) was determined based on the soil organic carbon (SOC) concentration in eroded sediment and SOC concentration in surface soil (0.15 m) of experimental runoff plots involving different levels of erosion. The higher values of CER (between 3.28 and 3.62) were observed in slight to moderately eroded sites whereas relatively lower values (between 2.04 and 2.32) were observed in severe to very severely eroded sites.

Taking an average values of erosion from run off plots, it was observed that every year about 225 kg of SOC and 36 kg of N, P, K is lost with 15 t/ha of soil erosion. Additionally, about 1 tonne of FYM, 52 kg urea, 15 kg superphosphate and 21 kg murate of potash per year will be required to replace the nutrients lost through erosion. On extrapolation of data on carbon enrichment ration at national level, it is estimated that out of 115.36 Tg/yr of displaced organic carbon, about 34.61 Tg C is being emitted to atmosphere as CO_2 every year through erosion which emphasizes the importance of soil erosion as a widespread threat and cause of both greenhouse gas emissions and soil degradation in India. This raises the potential to reduce both problems by regenerating degraded soils using recommended management practices (RMPs) to stabilize soil and increase C-sequestration. Results also revealed that between 19 and 27 Tg C/yr could be sequestered in soils by adopting achievable technological options in erosion-affected areas of India, offering the potential to reduce about 24.5% of total greenhouse gas emissions from agricultural soils of India (94 Tg C).

Field evaluation of groundwater recharge filters: Three different designs of groundwater recharge filters, viz. one stage downward flow type, one stage upward flow type and two stage upward-downward flow type groundwater recharge filter was developed by ICAR-IISWC, RC-Vasad with the following attributes:

One stage downward flow recharge filter: Gravity concept based one section downward flow type recharge filter design was constructed for field evaluation. The peak discharge rate obtained at the inlet and outlet of groundwater recharge filter was 15.84 l/s and 6.73 l/s, respectively. The average sediment filtering efficiency was 95.98%, and it ranged from 91.03% to 99.52% for different events. The sediment trap installed before the recharge filter was able to trap 64.6% of the sediment entering the recharge filter through runoff water. The mean peak recharge rate for one stage downward flow type groundwater recharge filter was 9.05 l/s and sediment filtering efficiency was 89.75%.

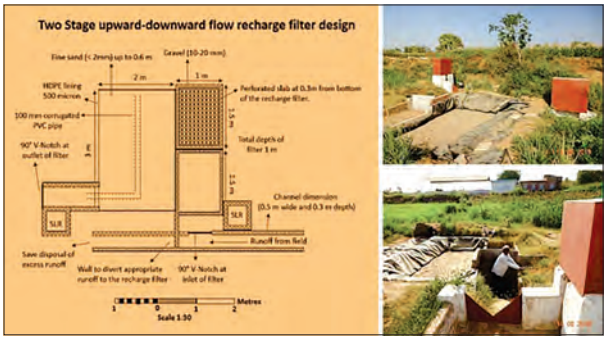
One stage downward flow recharge filter

One stage upward flow recharge filter: The peak discharge rate obtained at filter inlet and outlet was 10.23 l/s and 7.97 l/s, respectively. The average sediment filtering efficiency was 91.54% and it ranged from 90.28 to 92.62% for different events. The sediment was deposited in the open space below the filter and no sediment deposition was observed in the sand layer. Its mean peak recharge rate was 4.86 l/s and sediment filtering efficiency was 89.63%.

One stage upward flow recharge filter

The useful working life of one stage downward flow type, one stage upward flow type and two stage upward-downward flow type groundwater recharge filter was one year, four years and two years, respectively. The frequency of maintenance for one stage downward flow type, one stage upward flow type and two stage upward-downward flow type groundwater recharge filter was six times, three times and four times in a rainy season, respectively.

Two stage upward-downward flow recharge filter: The peak discharge rate obtained at filter inlet and outlet was 11.23 l/s and 6.80 l/s, respectively. The average sediment filtering efficiency was 95.14% and it ranged from 94.10% to 96.96% for different events.



Its mean peak recharge rate was 6.0 l/s and sediment filtering efficiency was 90.73%.

Automated drip fertigation: Automated drip fertigation in okra crop were evaluated for improving water use efficiency at Udaipur, Rajasthan. Different components of automated drip system were soil moisture sensor, controller, water meter and relay system. Irrigation water was applied automatically based on availability of soil moisture in the crop root zone sensed by soil moisture sensor. Crop performance was better with automated drip irrigation at 100% field capacity (FC) along with application of 100% recommended dose of fertilizers (RDF) through fertigation in equal splits at 4 days interval. Under this treatment, okra yield was 8.60 t/ha and water use efficiency was 0.24 t/ha-cm. There was 41.6% total water saving and 109% higher crop yield compared to the control (i.e. water application through manual drip irrigation along with 100% RDF through fertigation in equal splits at 6 days interval).

Automated drip fertigation for increasing water productivity of okra crop at Udaipur

Organic farming packages and models: Organic farming packages for 4 cropping systems suitable to Gujarat, Kerala, Rajasthan, Sikkim and Uttarakhand were developed as per National Programme for Organic Production (NPOP) standards. Groundnut-wheat-green gram system registered 6.1 t/ha of groundnut equivalent yield with ₹ 1.43 lakh/ha as net returns while cassava-groundnut system in Kerala resulted in cassava tuber equivalent yield of 32 t/ha under organic production system. Fennel-cluster bean system recorded fennel equivalent yield 2.2 t/ha with net income and B:C ratio of ₹ 75,808/ha and 2.21 respectively. Under Sikkim conditions, maize + ginger – French bean resulted in 15 t/ha of maize equivalent yield with net return of ₹ 2.99 lakh/ha.

Organic farming packages

State	Cropping/ farming system	System (base crop) equivalent yield (t/ha)	Net returns (₹/ha)	B : C ratio
Gujarat	Groundnut–wheat–green gram	6.1	143,085	1.04
Kerala	Cassava–groundnut	32.0	274,554	2.29
Rajasthan	Fennel–clusterbean	2.2	75,808	2.21
Sikkim	Maize + ginger–French bean	15.0	299,390	3.04

Integrated Farming Systems (IFS) models: Four integrated farming system models were established for round the year income and employment. A 0.56 ha wetland IFS model comprising field crops (rice, maize, sorghum (grain and fodder), redgram, greengram) + horticulture (banana, papaya, guava, pomegrante, apple ber, rosewood, pomelo citrus vegetables), livestock (Ongole cow, Kadaknath and Aseel poultry) + fish (rohu/Indian carp and grass carp) have been developed for Andhra Pradesh. Similarly two IFS models for Gujarat and Rajasthan comprising crops, horticulture and livestock were established.

Integrated Farming System models established

State	Location	IFS model	Area (ha)	Net income (₹ in lakh/year)	Employment (man days)
Andhra Pradesh	Maruteru	Field crops + horticulture + Ongole cow + poultry + fish	0.56	1.31	449
Gujarat	Junagadh	Field crops + horticulture + Gir cow + fish	0.50	0.88	317
	Navsari	Field crops + multi-storied horticulture + farm pond	0.60	0.83	300
Rajasthan	Kota	Field crops + 2-tier horticulture system + dairy	1.00	1.40	417

Integrated Farming System model for Wetland ecosystem of Andhra Pradesh

Sediment accumulation rate and carbon storage in ponds due to fish farming: Effect of feed loading on sediment accumulation rate, carbon storage and fish growth under a polyculture system of Indian major carps was assessed in 16 ponds (5.0–56.0 ha) located at Moyna, East Medinipur district of West Bengal. The highest mean sediment accumulation rate (13.0±3.0 cm/year) was observed in ponds with high feed loading (20–22 t/ha/year) followed by moderate (10.0±2.5 cm/year) and low (7.0±2.0 cm/year) accumulation rates in ponds with moderate (14–16 t/ha/year) and low (8–10 t/ha/year) feed loading. Also, ponds with high feed loading had the highest mean carbon storage (734±30 gC/m²/year), which was significantly higher than ponds with moderate (526±24 gC/ m²/year) and low feed loading (343±17 gC/m²/year). With the FCR ranging from 0.95 to 3.5, the net fish production varied from 4.0 to 9.5 t/ha/year. The lowest FCR was noticed in ponds where a minimum amount of feed was given. ❑

Cassava under organic production system

“Women have an important role in agriculture. We need to introduce technology, which will help us harness the potential of women in agriculture. We need to divide the agriculture sector into three parts – regular farming, farming of trees and animal husbandry. If we are able to do this, the contribution of our women will increase even more.”

— Narendra Modi

3. Climate Change and Resilient Agriculture

Groundwater management for enhancing adaptive capacity to climate change in sugarcane based farming system: In Muzaffarnagar district of Uttar Pradesh owing to indiscriminate use of groundwater for irrigation, the groundwater table is declining at an alarming rate in three blocks (Shahpur, Budhana, Baghra). To stop the decline of groundwater table, a two pronged approach (supply side and demand side management) was pilot tested in village Rasulpur Jattan of Sahapur block. Climate resilient improved irrigation systems such as underground pipe conveyance system in sixty farmers' field were installed to minimize conveyance loss. Solar powered drip system and rain-gun system were also installed in the farmer's field (demand side management) for precision irrigation. Groundwater resource was augmented (supply side management) through installation of artificial recharge structures (recharge cavity wells) along with check dams. In addition to above interventions, the pilot study also recommends crop diversification (shifting from water guzzling crops to low water requiring crops) in over-exploited areas for sustainable use of groundwater.

Microbial consortia to enhance drought tolarence in rainfed crops: Plant beneficial microorganisms have a great potential to enhance the drought tolerance and crop productivity. Two microbial consortia, viz. *Pseudomonas putida* P7 + *Bacillus subtilis* B30 (consortia 1) and *Pseudomonas putida* P45 + *Bacillus amyloliquefaciens* B17 (consortia 2) were developed and evaluated at Ballowal Saunkhri (Punjab), Parbhani (Maharashtra), and Vijayapura (Karnataka) in maize, *kharif* sorghum and *rabi* sorghum, respectively. The seed + soil application of consortia 1 recorded highest grain yield in maize (32.46%) and *rabi* sorghum (29.48%) over uninoculated control at Ballowal Saunkhri (Punjab) and Vijayapura (Karnataka), respectively. Whereas, the seed + soil application of consortia 2 recorded highest grain yield in *kharif* sorghum (22.47%) at Parbhani (Maharashra) in comparison with uninoculated control. Both the consortia showed encouraging results for the last two years by improving the grain yield of maize, *kharif* sorghum and *rabi* sorghum over uninoculated control.

Rainfed crop varieties to cope up with delayed onset of monsoon: Agricultural production, productivity and stability in rainfed areas is more vulnerable to climate variability particularly during *kharif* owing to

Fingermillet var. MR-1 (Bengaluru, Karnataka)

Groundnut var. TG 37A (Arjia, Rajasthan)

Underground pipeline

Drip irrigation system

Recharge cavity well

its high dependency on south-west (SW) monsoon. The short duration and drought tolerant varieties identified for delayed onset of monsoon under diverse rainfall and soil types are soybean (var. JS-9560) and cotton (var. PKV-Rajat) under semi-arid (hot moist), vertisols/20 days delay in onset (Akola); fingermillet (var. MR-1, GPU-28), ricebean (var. RBL-1), pigeonpea (var. BRG-2, TTB-7) and fieldbean (var. HA-3, HA-4) under semi-arid, alfisols/15 days delay in onset (Bengaluru); rice (var. Gitesh, Ranjit, Dishang) and blackgram (var. Pant U-19) under perhumid, alfisols/inceptisols/ 18 days delay in onset (Biswanath Chariali); rice (var. Vandana, Sahbhagi Dhan), fingermillet (var. A-404), sorghum (var. CSV-20), sesame (var. Shekhar) and horsegram (var. Madhu, GHG-19) under semiarid (hot dry), inceptisols/ 20 days delay in onset (Chianki); horsegram (var. AK-41, AK-42), groundnut (var. TG-37A) and sorghum (var. Pratap 1430) under semi-arid, vertisols/ 15 days delay in onset (Arjia); pearlmillet (var. GHB 558), clusterbean (var. GG 2), greengram (var. GM-4) and castor (var. GCH-7) under semi-arid/arid (hot dry), entisols/ 21 days delay in onset SK Nagar; pigeonpea (var. TS 3R), pearmillet (var. ICTP 8203), mothbean (var. KBMB 1) and horsegram (var. GPM 6) under semi-arid (hot dry), vertisols/ 30 days delay in onset (Vijayapura). On an average, these varieties gave about 15–35% higher yields compared to local/farmers' varieties under delayed onset of monsoon.

Drought-prone multi-stress tolerant rice genotype for rainfed areas: A medium duration high yielding rice genotype IET 24306 (Swarna Samriddhi Dhan) was identified for rainfed areas of Bihar. This variety is suitable for cultivation under transplanted condition in irrigated as well as rainfed shallow lowland ecology of Bihar. Swarna Samriddhi Dhan is semi-dwarf, high yielding (5.5–6.0 t/ha), medium duration (135–140 days), multiple stresses (drought, submergence, disease and insect pest) tolerant, lodging resistant with desirable cooking quality traits and having long slender grain type. Quality wise, Swarna Samriddhi Dhan possesses 77.8% hulling, 62.0% milling, 55.6% head rice recovery (HRR) with desirable intermediate alkali spreading value, amylose content (24.33%) with long slender grain type. Besides drought tolerant, this variety can also tolerate 10–12 days submergence.

NICRA Aerobic Dhan 1: This is a medium early duration, 100 cm tall erect, highly vigorous, non lodging, non-shattering and dark green in colour. Plants come to flowering within 85–86 days, produce good biomass, long panicle, and have short bold grain with white kernel (length 5.72 mm, breadth 2.3 mm and suitable for cultivation in upland/aerobic conditions of Jharkhand, Chhattisgarh and Karnataka. Grain quality is very good (hulling 76.55%, milling 68.6%, head rice recovery 65.9%, amylase content 22.18, gel consistency 34.5). Yield increase ranged from 5.26 to 18.41%, 11.72–30.58% and 22.03–75.95% in Jharkhand, Chhattisgarh and Karnataka, respectively.

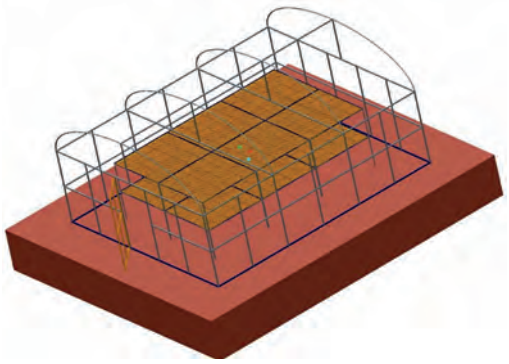
NICRA Aerobic Dhan 1/TRC 2015-5 (IET 26178) field view, paddy and milled rice

Climate change impact on runoff and soil losses under different farming systems in Umiam, Meghalaya: Effect of projected climate change scenarios on runoff and soil losses under different farming system combinations in the eight micro-watersheds at ICAR Research Complex for NEH Region, Umiam, Meghalaya revealed an increasing

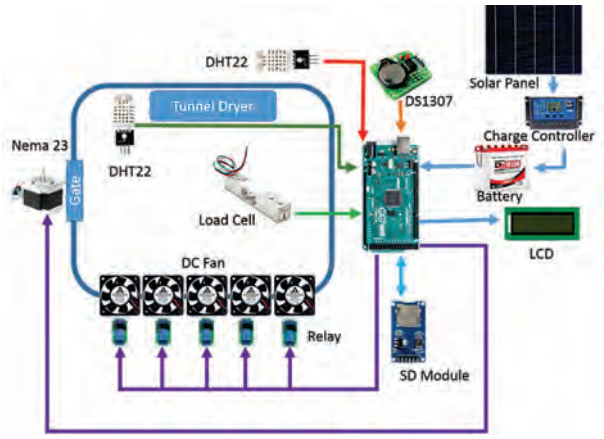
Soil loss projections in IFS based micro-watersheds [Water Erosion Prediction Project (WEPP)]

		Soil loss, t/ha/year							
		Average of 18 years measured soil loss (1983–2006)							
		FSW1*	FSW2	FSW3	FSW4	FSW5	FSW6	FSW7	FSW8
Observed	Average	13.01	11.23	9.81	9.95	9.82	9.54	16.92	17.96
		Percent (%) increase in soil losses over observed soil losses in each IFS system							
Projection period	**RCPs**	**FSW1**	**FSW2**	**FSW3**	**FSW4**	**FSW5**	**FSW6**	**FSW7**	**FSW8**
2020 (2010–2039)	RPC 2.6	4.27	5.12	6.64	7.98	4.30	4.63	9.57	7.78
	RCP 4.5	4.59	4.52	5.04	8.20	3.14	3.90	11.82	11.28
	RCP 6.0	4.59	5.54	7.34	3.49	5.83	3.69	8.54	7.92
	RCP 8.5	8.48	8.37	8.71	10.31	7.17	5.09	13.24	13.87
		FSW1	**FSW2**	**FSW3**	**FSW4**	**FSW5**	**FSW6**	**FSW7**	**FSW8**
2050 (2040–2069)	RPC 2.6	4.15	6.40	10.74	3.05	4.24	4.72	13.52	11.23
	RCP 4.5	5.82	5.63	4.69	8.11	5.92	5.45	11.74	8.84
	RCP 6.0	7.95	6.04	7.31	5.59	8.11	0.63	17.38	13.72
	RCP 8.5	9.75	8.89	10.40	14.35	6.77	5.38	19.21	20.99

*FSW1, Farming System Micro-watershed 1 Dairy Based; FSW2, Farming System Micro-watershed 2 Forestry; FSW3, Farming System Micro-watershed 3 Agroforestry: FSW4, Farming System Micro-watershed 4 Agriculture; FSW5, Farming System Micro-watershed 5 Agri+Horti+Silvi pastural; FSW6, Farming System Micro-watershed 6 Horticulture; FSW7, Farming System Micro-watershed 7 Cultivated Fallow; FSW8, Farming System Micro-watershed 8 Abandoned Jhum + Broom grass.



A 3D structural model of smart tunnel drier



Block diagram of the complete electronic system of the tunnel dryer

trend in annual rainfall across all periods of projection namely from base line (1983–2005), short (2020), medium (2050) and to long (2080) terms over observed long period average (LPA: 1983–2006) annual rainfall of 2,415 mm. Hydrological modeling using RUSLE and WEPP revealed an increasing trend in annual soil losses across all eight micro-watersheds under both low-to-high emission scenarios. Among the eight micro-watersheds, horticulture based IFS was relatively more resilient to climate change induced soil erosion and sediment losses.

Micro-controlled solar tunnel drier for heavy rainfall region of Northeast India: A solar smart tunnel drier of dimension 6×5 m was designed to have a capacity of drying 100 kg raw sliced turmeric/ginger in 12 trays. A microcontroller regulates the temperature and the humidity inside the tunnel drier and displayed in the attached screen. The system has capacity to rise inside temperature by 79% (up to 53.8°C in 3 days) and reduce humidity by 50% (up to 37.2%) in comparison to outside atmosphere. The tunnel reduces the moisture content of sliced material from 73% to less than 10% in 24 effective sunshine hours with overall 19% drying efficiency. Overall, 100 kg sliced ginger/turmeric dries (moisture 10% w/w) in 4–5 days under tunnel drier in comparison to 10–12 days under open solar drying at Meghalaya.

Oyster mushroom in low cost mushroom house: Mushroom cultivation has a potential for increasing the

Oyster mushroom strain (PL-19-04)

farm income of resource poor farmers. In Meghalaya, farmers are showing great interest in adopting this enterprise. Paddy straw was used as substrate. Seven oyster mushroom (*Pleurotus* sp.) strains were evaluated in low cost mushroom house. One oyster mushroom strain PL-19-04 was identified with biological efficiency of 96% after evaluation in low cost mushroom house. This strain took 17 days for spawn run.

Climate resilient approaches in coconut: In an open top chamber experiment with coconut seedlings, increasing CO_2 concentration (400–700 ppm) increased the rate of photosynthesis (Pn) by 45%, which resulted in high biomass accumulation (29.9 kg) as against the biomass of 14.9 kg for plants grown at ambient CO_2 (400 ppm). Plants under 700 ppm CO_2 [ECO_2] accumulated higher biomass in roots (27%) and stem (52%) as against 19% and 43%, respectively, at 400 ppm CO_2.

Camel dung vermicompost: Fodder production using camel dung vermi-compost was evaluated. Camel dung collected from corals was sieved to reduce soil content, mixed with leftover crop residues of feed mangers along with cut lawn grass. Use of vermi-compost improved growth and yield of sorghum and oat fodder that was evident from the improvement in plant height and weight of plant.

Contribution of shrimp culture practices to greenhouse gas emission: The emission of greenhouse gases (GHGs) in shrimp farms was quantified during the culture and fallow period. In shrimp farms with a single crop of *Litopenaeus vannamei* for 110 days, CO_2 equivalent emission was 110–134 kg/ha. Single crop with culture period of 110 days, drying period of 105 days, scrapping period of 13 days, and ploughing period of 9 days in a year contributes 17, 32, 9 and 7% of total GHGs emission respectively. In shrimp farms with two crops of *L. vannamei* per year, the CO_2 equivalent emission was 520 kg/ha and 493 kg/ha after first and second crops of 90 days' culture, respectively. The first crop culture period of 3.5 months, drying period of 2 months after first crop, second crop culture period of 3.5 months and drying period of 3 months after the second crop in a year contributed to 22, 31, 21 and 26% of total CO_2 emission equivalent respectively.

Harit Dhara

The effect of feeding of silkworm pupae oil (SPO), changes in archaeal community and protozoa reduction with oil supplementation, a reduction in methane emission could be achieved. In contrast, enteric methane emission in the Harit Dhara supplemented group was significantly reduced by 21% as compared to that of control. It is concluded that supplementation of Harit Dhara significantly decreases the enteric methane emission without affecting nutrient intake and digestibility.

❑

"भारतीय अर्थव्यवस्था को गति प्रदान करने में महिला कृषकों का योगदान सराहनीय है, उनके इस योगदान को मान्यता प्रदान करने और उन्हें सम्मानित करने के लिए सरकार द्वारा वर्ष 2017 से 15 अक्टूबर को राष्ट्रीय महिला किसान दिवस रूप में मनाया जाता है।"

— नरेन्द्र मोदी

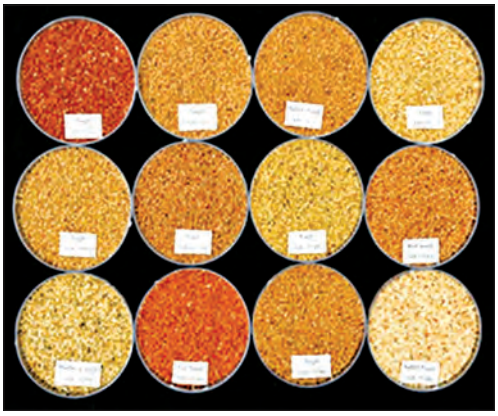
4. Genetic Resources

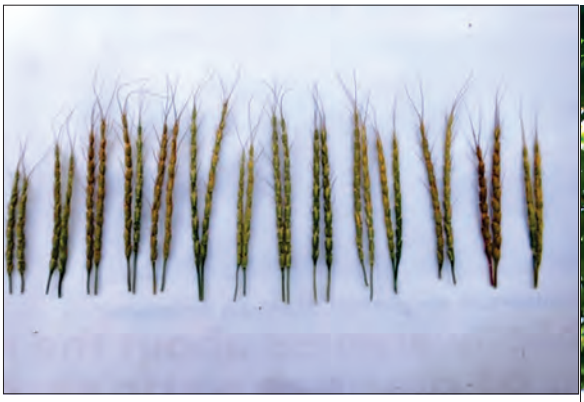
Germplasm augmentation, conservation and use: A total of 25 explorations were undertaken and 1,764 accessions (1,368 cultivated and 396 wild) were collected from parts of Andaman and Nicobar Islands, Arunachal Pradesh, Assam, Bihar, Gujarat, Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Mizoram, Nagaland, Odisha, Tamil Nadu, Telangana, Uttar Pradesh, Uttarakhand and West Bengal. Germplasm was collected in major crops including cereals (barley, wheat and maize-29), species of *Vigna* (179), *Cajanus* (173), millets (167), *Luffa* (97), *Oryza* (92), *Cucumis* (82), *Abelmoschus* (70), *Pisum* (63), *Brassica* (59), *Solanum* (56), *Phaseolus* (40), *Linum* (33), *Amaranthus* (30), *Momordica* (27), *Trichosanthes* (27), *Dioscorea* (21), *Musa* (19), *Glycine* (19), *Cicer* (16), *Zingiber* (15), *Coix* (14), *Citrus* (12), *Corchorus* (09), *Piper* (08), *Ocimum* (08), *Curcuma* (07), *Allium* (06), *Chenopodium* (06), and *Artocarpus* (03).

The significant materials collected include the landraces of rice–*kichali samba, senthalazhinel, malaiarusinel, thuyamalli, kuzhiyadichan,* and *kattuyanum* from Tamil Nadu; *ambe more, bangadu, chahpure, chimansal, chirli, colin, dangi, desi dangi, dobadia, dodadkiya, dudh-malai, dumania, hari, jeera bhat, kabrudolo, kajalheri, kala bhat, kala dangar, khadsi, krishnakamod, laldhanhar, lalkada, phutte, prabhavati, sathiya* and *tulasiabhat* from Gujarat; *birendhan, chanmunidhan, kali jira, lal bahadur, masuridhan, moktadhan, ronijatdhan, satuki* and *taposhee* from Assam; *aamker, axi, roing, noginaamo, day, laldhan, panikheti* and *naminama* from Nagaland; *sekughi, kumlupu, ghaboan, apaghi, ajo-ghi* and *tsungu-ghi* from Arunachal Pradesh; *laldhan, sirohidhan* and *jeera phool* from Madhya Pradesh and Rajasthan; and in sorghum–*karuncholam, sencholam* and *vellaicholam*; little millet–*kadaikanni* from Tamil Nadu; ricebean-*rains, rayans, naurangi, pili rains, lal rains, hara mass, bhura mass* and *gurunsh* from Uttarakhand; and in coriander–*kumbhraj, mithidhana, kudidhana, deshidhana* and *ramela* from Madhya Pradesh and Rajasthan. On-farm conservation was promoted amongst 63 farmers in 17 villages for *chwaridhan, chakrata local rajma, panchgain local rajma*, foxtail millet and *kala bhatt;* and amongst 37 farmers of 14 villages for *meshre* wheat landrace in Dehradun, Tehri and Uttarkashi districts of Uttarakhand. A total of 315 herbarium specimens were processed (in addition to 604 virtual herbarium specimens) and added to the National Herbarium of Cultivated Plants (NHCP), New Delhi bringing the holdings to a total of 24,306 specimens.

Seed variability in rice bean germplasm from Uttarakhand

Germplasm conservation: Germplasm added to the National Gene bank for long-term storage comprised 8,222 accessions of orthodox seed species and currently the base collection of National Gene bank has a total of 446,636 accessions. A total of 23 accessions of fruits, tubers, bulbs and medicinal plants were added to the *in vitro* Gene bank, making the total collection


Seed variability in foxtail millet from Gujarat

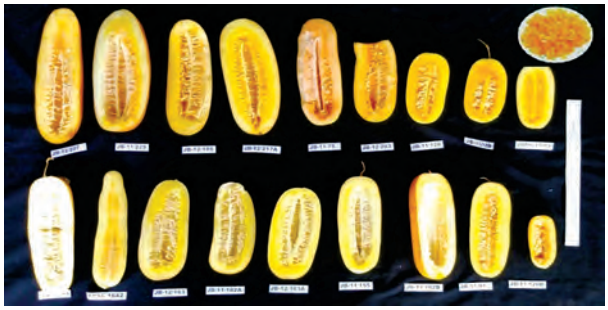

Variability in indigenous wild wheat germplasm of *Aegilops tauschi* collected from Jammu and Kashmir

of 1,902 accessions in the form of ~38,500 *in-vitro* cultures of 54 genera and 145 species. In the Cryo-gene bank, 113 accessions of seeds and pollen genomic resources of different crop species were successfully cryo-preserved, making the total collection of 11,839 accessions belonging to 850 species. In addition, 80 genomic resources were cryo-banked, making the total to 2,194.

Germplasm exchange: A total of 159,687 samples were imported from more than 23 countries including 31,226 germplasm accessions and 154,601 samples of CGIAR trial/nurseries. A total of 968 samples were exported under collaborative research projects. Important trait specific accessions that were imported are as follows: Wheat: wild wheat from Germany (EC1009520–1009548); paddy: landraces of rice from IRRI, Philippines (EC101559–101582), low amylose lines from Philippines (EC1030717–EC1030726); maize: genetics stocks in maize from USA (EC1040934–1040942); pulses: susceptible and resistant lines of chickpea, to five races of fusarium wilt, from USA (EC1023944–EC1023949); vegetables: improved chilli varieties (sweet pepper and hot pepper) namely redskin, liberty belle, atomic, longhorn, chenzo, garden pearl, loco, fire cracker, megabite and others (EC1030751–EC1030762) from UK; carotenoid rich lines of cucumber from USA (EC1024114–EC1024117), downy mildew resistance germplasm of cucumber from USA (EC1041437–EC1041438); oil seeds: high yield potential lines, herbicide tolerance to imidazolinone and high oleic acid composition in the seed oil and resistance to *Sclerotinia* and *Phomopsis* stem canker lines in sunflower from USA (EC1035329–EC1035331); soybean variety Polanka (EC1026157); fruits: avocado variety *Gwen* (EC1027328), cold tolerant avocado variety *Fuerte* (EC1027330); wild species of papaya *Vasconcellea* spp. from USA (EC993392–EC993397); and wild species of persimmon *Diospyros digyna* from USA (EC1033578–EC1033580). Besides, a total of 968 samples of wheat, taro and different leguminous crops were exported under collaborative research projects, out of which 5 accessions each of *Dolichos* were sent to Burkina Faso, Ghana, Kenya, Mali, Niger, Nigeria, Senegal, Namibia, and Uganda and 211 samples of crops, namely *Dolichos* (50), mungbean (50), horsegram (50), cowpea (9), pigeonpea (2) and mothbean (50) were sent to Namibia under a collaborative research project.

Germplasm characterization/evaluation: A total of 26,320 germplasm accessions were characterized for agro-morphological traits at New Delhi. Agro-morphologically diverse core set is being developed in lentil, cowpea, linseed, sesame and pea. Screening against biotic, abiotic stresses and herbicide resistance in different crops was done in 1,450, 1,130 and 2,000 accessions respectively. Biochemical evaluation of 3,200 accessions was undertaken in different crops for oil content, fatty acid profile, protein, sugar, minerals, amino acids, antioxidants and active principles.

Drone-view of cowpea germplasm characterization at Issapur farm of ICAR- NBPGR



Variability in cucumber germplasm characterized and maintained at NBPGR, RS, Thrissur, Kerala

Plant quarantine: A total of 124,152 samples were processed (122,842 under import and 1,310 for export) comprising germplasm accessions, nurseries/trial breeding material of various crops including both true seed and vegetative propagules for quarantine clearance. Of these, 5,443 samples were subjected to X-ray radiography. A total of 1,272 samples were infested/infected with different pests; 1,184 samples were salvaged through physico-chemical methods and 88 samples were rejected due to fungal and viral pathogens, and insects of quarantine importance. Important interceptions included—fungi *Claviceps purpurea* in barley from Morocco, *Tilletia barclayana* in rice from China, *Bipolaris maydis* in maize from Thailand; insects *Bruchus ervi* and *B. dentipes* on *Lens culinaris* and *Vicia faba*, respectively, from Lebanon; nematodes *Aphelenchoides besseyi* on *Oryza sativa* from China, Philippines and USA, *Tylenchorhynchus* sp. on *Persea americana* imported from Kenya; and weeds *Bromus secalinus, Echinochloa crus-pavonis* and *Lolium rigidum*.

A total of 665 samples of exotic germplasm of various legume crops were grown in PEQ greenhouses, and indexed for viruses; and 25 viruses were detected and intercepted, viz. ArMV, BBWV, BCMV, BCMNV, BPMV, BYMV, CLRV, CMV, CMMoV, CPMV, GFLV, HPV, MCMV, PMMoV, PepMV, PSV, RpRSV, SBMV, SMV, TBRV, TBSV TRSV, TSV, ToMV and ToRSV. Ten viruses, viz. BPMV, CLRV, HPV, MCMV, PMMoV, PepMV, PSV, RpRSV, TBSV and ToRSV are not reported to occur in India and are quarantine pests for India. This resulted in rejection of 61 accessions including soybean (41), chilli (2), corn (1) and tomato

(17). The harvest of the virus-free plants was released to the indenters. In addition, 19 PEQ inspections of exotic germplasm of barley (4,651), carrot (29), chickpea (1,350), corn (4,951), chilli (255), faba bean (471), grass pea (326), lentil (2,157), soybean (792), tomato (1,130) and wheat (14,723) were undertaken at indenter's sites. A total of 14,928 seed samples were subjected to prophylactic treatment with fumigation; 2,642 samples of paddy were given mandatory hot water treatment; 1,153 vegetative propagules were also given prophylactic pesticidal dips treatment and 608 samples of *Capsicum* spp. and *Solanum lycopersicum* were treated with tri-sodium orthophosphate (10%). A total of 19 post-entry quarantine inspections were carried out by Plant Quarantine scientists for imported consignments. About 1,360 samples were processed for export after issuing 8 Phytosanitary certificates.

Seed health testing for pest-free conservation: A total of 4,906 indigenous samples including 139 cryo samples were processed for pest-free conservation. Out of the total, 904 samples were subjected to X-ray radiography and 491 samples were found infested with indigenous insect-pests of which 428 samples were salvaged through various physico-chemical methods while 63 samples were rejected due to heavy insect infestation. Additionally, 158 samples were found infected with different fungi of which 144 were salvaged and 14 samples were rejected due to *Tilletia indica* in wheat, *T. barclayana* in rice and *Ustilago crameri* in foxtail millet. About 54 *in-vitro* accessions of *Rubus* were virus-tested for associated viruses, viz. ArMV, RBDV, RpRSV, SLRV, SMYEV and ToRSV. Two accessions were found to be infected with ArMV and 52 were found free from six viruses tested.

DNA fingerprinting

Plant: A total of 7,020 wheat germplasm lines were evaluated for different agro-morphological traits during 2019–20 *rabi* season. Transcriptome-wide identification of 50 WRKY TF in little millet (*Panicum sumatrense*) was done. Potential accessions were identified from 1,635 little millet accessions for different traits (Days to 50% flowering, 1,000-grain weight etc.) based on phenotypic data taken at two locations (Akola, Maharashtra and Issapur, New Delhi). DNA extraction procedures were optimized for 25 food derivatives including oil and amplifiability was ensured using PCR/real-time PCR assays and inhibition test. GM testing services were provided for 12 consignments of papaya (10) and soybean (2). Molecular testing for 20 samples of imported transgenics of maize and cotton was done. GM testing lab successfully participated in USDA-AMS-FGIS Proficiency Testing and two Inter-laboratory Comparison Programmes organized by Export Inspection Council (Kochi) and NAWaL Analytical Laboratories (Hosur). National Genomic Resource Repository conserved 6,447 genomic accessions of 45 species at both –70°C and –196°C to cater to the needs of molecular crop breeders (http://www.nbpgr.ernet.in:8080/NGRR/Home.aspx). User friendly genome analysis tools and algorithms–K-mer Mate pair assembly algorithm and RNAseq pipleline were developed. *Luffa acutangula* draft genome assembly was improved using public domain chromosome level NCBI data and 89267 SSRs were mined from the assembly.

Microbes: To maintain the authenticity of biopesticides and to check the spurious and substandard products, the CIB&RC has included molecular identification and DNA fingerprint as mandatory requirement for registration and recognized ICAR-NBAIM as the nodal agency for developing DNA fingerprints of microbial cultures to be registered as biopesticides. More than 300 samples from more than 100 companies and biopesticide units under SAUs were processed for fingerprinting at NBAIM. The samples mainly contained *Trichoderma harzianum, T. asperallum, Beauveria bassiana, Metarhizium anisopliae, Verticillum lecanii, V. chlamydosporium, Paecilomyces lilacinus, Pseudomonas fluorescens, Bacillus thuringiensis, B. subtilis* etc.

Plant germplasm registration: The XXXXI meeting of Plant Germplasm Registration Committee was held on 29 September 2020 in virtual mode. Out of 88 proposals received, 78 belonging to 38 species were approved for registration. Some notable registered germplasms were, rice with high zinc in grains, purple leaves and panicles; wheat tolerant to drought stress; barley highly resistant to stripe rust with high 1,000-grain weight (47.5 g) and low protein content (9.5%); first CMS line in radish with higher heterosis for yield, root length and root weight; oil palm with more number of bunches and slow vertical growth; wild diploid potato with wider genetic base highly resistant to late blight disease etc.

Plant germplasm registered by PGRC during 2020–21 with current status

Crop group	XXXXI PGRC (29 September 2020)	Current status
Cereals and pesudocereals	22	565
Millets	1	83
Fibre and forages	1	120
Grain legumes	8	159
Vegetables	7	91
Commercial crops	4	104
Medical and Aromatic Plants and spices	10	101
Ornamentals	7	69
Oilseeds	15	218
Fruits and nuts	–	44
Tubers	3	42
Agro-forestry	–	8
Grand total	78	**1,604**

Trait-specific germplasm registered during 2020–21

Crop	National identity	INGR number	Novel (unique features)
Rice (*Oryza sativa*)	IC0599273	20001	High temperature tolerance
	IC0635011	20002	Carries xa5, xa13 and Xa21 genes for bacterial blight (BB) resistance
	IC0627947	20075	Tolerant to salinity stresses up to ECe 10 dS/m with long bold grain
	IC0635010	20003	High zinc (3,169 ppm) in grains, purple leaves, purple panicles
	IC0635009	20004	Tetraploid cytotype (2n=4x=48)
Wheat (*Triticum aestivum*)	IC0635014	20005	Resistant to stem leaf and stripe rusts. Resistant to flag smut. High yield potential
	IC0635015	20006	Resistant to leaf and stripe rusts. Resistant to Karnal bunt and flag smut. High yield potential
	IC0635016	20007	High sedimentation value under very late (January) sown conditions of northern plains and multiple disease resistance (leaf rust, Karnal bunt and flag smut)
	IC0635017	20008	High water use efficiency. Low drought susceptibility index
	IC0635018	20009	Heat tolerant genotype with lower grain yield reduction under heat stress
	IC0635019	20010	Drought stress tolerance and heat stress tolerance
	IC0635020	20011	High grain zinc content (784 ppm)
	1C063502	20012	High grain iron content (629 ppm)
	IC0635022	20013	Resistant to all pathotypes of brown rust except 77-8. Postulated *Lr19*/*Sr25* through host pathogen interactions and also confirmed the presence of using *Lr19*/*Sr25* STS markers Gb and PSY1-E1
	IC0633422	20014	High grain protein content (144%)
	IC0623434	20015	Number of grains per spike >60 Thousand, grain weight > 45 g iron content >42 ppm
	IC0635426	20016	High protein content (Av 1433%), high iron (Fe) content (49 ppm) and zinc content (435 ppm). Other desired quality traits (Hectolitre weight 807 kg/kl and Sedimentaion value: 595 ml)
	IC0635697	20017	Drought tolerant genotype. Low drought sensitivity index
Barley (*Hordeum vulgare*)	IC0635023	20018	Resistant against all the pathotypes of yellow rust and brown rust in seedling and also resistant to both the rust in adult plant stage. Seedling resistance against all the pathotypes of black rust except for pathotype 11
	IC0635698	20019	Highly resistant to stripe rust. High 1,000-grain weight (475 g). Low protein content (95%)
	IC0635430	20020	Resistant to yellow rust (ACI00). High yield potential in NHZ (292 q/ha). High bold grain percentage (894%) and other good agronomic traits
Maize (*Zea mays*)	IC0635024	20021	Resistant to Maydis leaf blight and moderately resistant to charcoal rot of maize
Finger millet (*Eleusine coracana*)	IC0635027	20022	Finger blast resistance
Pigeon pea (*Cajanus cajan*)	IC0626208	20023	Tolerant to waterlogging stress. Resistant to *Phytophthora* stem blight disease
	IC0635029	20024	No natural outcrossing. Twisted standard petal wrapped over wings. Free stamens (non-diadelphous condition)
	IC0635030	20025	High 100-green seed weight of 50–52 g. High 100-dry seed weight of 225–2304 g. Compact plant type with green colour stem, yellow colour flowers, brown colour pods of 95 to 1,025 cm length packed with 5–6 seeds/pod
French bean (*Phaseolus vulgaris*)	IC0635031	20026	Anthracnose resistance
	IC0635032	20027	Anthracnose resistance
Chickpea (*Cicer arietinum*)	IC0635033	20028	Wilt resistant
	IC0628574	20077	Resistant breeding line against Race-2 of *Fusarium oxysporum* f. sp. *ciceris.* Desi type of chickpea
Lentil (*Lens culinaris*)	IC0635701	20029	Five flowers and pods per peduncle in a few flowering nodes, multi-flowering (Penta-flowering trait), unique morphotype having five-flowers/ pod on a peduncle

(Contd...)

Crop	National	INGR	Novel unique features
Cauliflower (*Brassica oleracea* var. *botrytis*)	IC0632603 IC0632604	20030	Ogura based cytoplasmic male sterile line of early maturity group (25–30°C) of Indian cauliflower. CMS line with dwarf plant type. Good combiner for earliness and curd yield in early maturity group of Indian cauliflower
	IC0632601 IC0632602	20031	Cytoplasmic male sterile line of early maturity group (25–30°C) of Indian cauliflower. Carry Ogura sterile cytoplasm. Good combiner for earliness and curd yield
Raddish (*Raphanus sativus*)	IC0625064 IC0625065	20032	Cytoplasmic male sterile (CMS) line. First CMS line of radish from good combiner and higher heterosis for yield, root length and root weight
Watermelon (*Citrullus lanatus*)	IC0631247	20033	Derived from the cross *Clanatus* var. *citroides* × Arka Manik possessing resistance to WBNV disease
	IC0523059	20036	Possess resistance to *Fusarium oxysporum* f sp *niveum* race 1 and race 2. Performed good as a rootstock with respect to different yield and quality traits of a susceptible scion grafted onto it
Brinjal (*Solanum melongena*)	IC063540	20034	Purple colour with green tinge at distal end of the fruit, non-spiny nature, cooking quality (CRISPY nature)
Collard green (*Brassica oleracea* var. viridis)	IC0632940	20035	A tropical type– first of its kind in the world that bolts, flowers and sets seeds during spring season at Varanasi, Uttar Pradesh. It does not require vernalization to stimulate/induce bolting and flowering. Fast growing and high leaf yield potential, i.e. 45–50 t/ha
Linseed (*Linum usitatissimum*)	IC096496	20037	Early flowering
Indian mustard (*Brassica juncea*)	IC0635042	20038	Tetralocular siliquae, long main shoot (11.967 cm), high siliqua density (109)
	IC0635041	20039	White flower, yellow seed coat colour, appressed siliqua orientation
	IC0635043	20040	Extra dwarf (85 cm height), high oil content (413%), early maturity (127 days)
	IC0589658	20041	Resistant to powdery mildew disease
Oil palm (*Elaeis guineensis*)	IC0635046	20042	Medium height increment
	IC0635047	20043	More number of bunches and slow vertical growth
	IC0635048	20044	Medium height increment
	IC0635049	20045	Sterile Dura Virescence oil palm
	IC0635050	20046	Sterile Dura Broad leaf sheath
	IC0610027	20047	Pisifera with 985% sterility, nigrescence fruit form
	IC0610024	20048	Parthenocarpic pisifera palm, good fruit set (6862%)
Groundnut (*Arachis hypogaea*)	IC0635044	20049	High oil content (56%)
	IC0635045	20050	High oil (56%)
Cumin (*Cuminum cyminum*)	IC0632088	20051	White flower, compact plant
	IC0632089	20052	Hairy cumin seed, spreading plant
Lemon grass (*Cymbopogon* sp.)	IC0635431	20053	Methyl isoeugenol rich more than 48% of essential oil and myrcene is more than 39% in the essential oil
Sweet flag (*Acorus calamus*)	IC0635434	20054	Essential oil yield is more than 12% on dry weight basis. Cis asarone is more than 80% of the essential oil. The ploidy of the germplasm is triploid
Annatto (*Bixa orellana*)	IC0635435	20055	Bixin content is more than 1.1%. Normal range of bixin content is 0.3 to 1.3% in the germplasm
Lemon grass (*Cymbopogon* spp.)	IC0635702	20056	High geraniol content more than 83% in the essential oil
Tagar (*Tabernaemontana divaricata*)	IC0630605	20057	High essential oil content: 0.331% (3.31 g/kg)
Gymnema (*Gymnema sylvestre*)	IC0630558	20058	Leaf traits: Elliptic shape with obtuse base
White dragonhead (*Dracocephalum heterophyllum*)	IC0635704	20059	High biomass yield 3.11 kg/plot (6 m^2). Essential oil content 0.22%

(Concluded...)

Crop	National	INGR	Novel unique features
Wormwood (*Artemisia absinthium*)	IC0635705	20060	High biomass yield 8.175 kg/plot (24 m^2)
Tuberose (*Polianthes tuberose*)	IC0630783	20061	Open pollinated seedling selection from Arka Shringar
Gerbera (*Gerbera jamesonii*)	IC0632114	20062	Flower form: Semi-double flower form; flower colour: NN155A, white group
	IC0632115	20063	Flower colour: 65A, red purple group; flower form: double flower form
	IC0630599	20064	Double flower shape. Red flower colour
Lily (*Lilium* spp.)	IC0635707	20065	Multiple shoots/sprouting, 100% flowering and larger bud size. Low juvenile period. No vernalization requirement
Gladiolus (*Gladiolus communis*)	IC0620379	20066	Spike with variegated florets. Floret colour [Red-purple (65.B) having red-purple (62.A) streaks with red-purple (67.B) splash]
	IC0620380	20067	Resistant to fusarium wilt disease. Floret colour [Red (41.C) having red (41.A) margin. Blotch red (46.B) with yellow (13.C) border]
Sugarcane (*Saccharum* sp. hybrid)	IC0635051	20068	High sucrose at 240 days. Short duration clone (maturing @ 240 days). Sucrose %, 19.40
	IC0635052	20069	High cane population (number of millable canes 107,670/ha). Donor for ratoonability
	IC0635053	20070	Drought tolerance. Interspecific hybrid with broadened genetic base
	IC0635054	20071	Potential pre-bred material for drought tolerance. Higher relative water content and lower malondialdehyde content under drought. Second backcross progeny of the cross involving *Erianthus arundinaceus* and *S. spontaneum* having the cytoplasm of *E. arundinaneus*
Wild potato (*Solanum jamesii*)	IC0635057	20072	Highly resistant to late blight disease. Diploid wild potato species with wider genetic base
	IC0635058	20073	Highly resistant to late blight disease. Diploid wild potato species with wider genetic base
	IC0635059	20074	Highly resistant to late blight disease. Diploid wild potato species with wider genetic base
Cotton (*Gossypium* spp.)	IC0626294	20076	CISG 20 (GMS) is a spontaneous mutant identified from agronomically adapted line CISA 20 maintained by sib mating. One among few GMS lines available in diploid would serve as additional resource for hybrid development program in diploid cotton. The line CISG20 (GMS) has open red flower which facilitates easy crossing; red flower, red petal spot and red plant body characters shall be used as marker characters
Sunflower (*Helianthus annuus*)	IC0628528	20078	Resistant to powdery mildew (PDS<10%)

Insect resources: ICAR-National Bureau of Agricultural Insect Resources (NBAIR) is the only institution in the country that is involved in the collection, cataloguing and conservation of insects and related organisms of agricultural importance like mites, spiders and nematodes associated with arthropods covering all the agro ecosystems of the country.

The Insect Museum of ICAR-NBAIR is recognized by Ministry of Environment, Forest and Climate Change, Government of India as the National Repository for Agriculturally Important Insects, Spiders and Mites under the Biological Diversity Act, 2002 on 12 September 2012. It comprises ~2.80 lakh insect specimens. At present, the National Insect Museum has indigenous and exotic collections of around 188,830 dry mounted specimens, 349 primary and secondary type specimens and more than 1 lakh specimens preserved in alcohol, besides vouchers specimens of invasive species, specimens and representative specimens from different geographical regions collected from various agro ecosystems. The live insect repository at NBAIR holds live insects and insect derived resources with a total of ~139 insects comprising 108 parasitoids (species/strains), 17 predators and 14 host insects, besides 690 microbial comprising 203 *Bt* isolates, 18 insect viruses, 198 entomofungal pathogens, 148 fungal antagonists and 123 entomopathogenic nematodes. To maintain the authenticity of the insects, the DNA barcodes using CO1/ ITS genes of insects were developed for 676 insect species and 2,815 other insect derived resources.

Microbial genetic resources: The National Agriculturally Important Microbial Culture Collection (NAIMCC), designated as national repository for agriculturally important microorganisms by the National Biodiversity Authority under the National Biodiversity Act, 2002 was conferred the status of International Depositary Authority (IDA) under the Budapest Treaty by the World Intellectual Property Organization (WIPO) in 2020. At present, the total number of holdings in NAIMCC is 6,907 (bacteria 2,595, fungi 3,981, cyanobacteria 331). During the period under report, 107 agriculturally important microbial cultures were accessioned which includes 48 bacteria, 20 fungi and 39 cyanobacteria. Some of the bacteria of rare occurrence like *Chromobacterium violaceum*, *Thiobacillus*, *Kaistobacter, Devosia*, *Rhodoplanes*, *Marinobacter, Geobacter, Oceanobacillus, Kurthia*, *Halobacterium*, *Clavobacterium*, *Grimontia*, *Ochrobactrum pseudogrignonense* were added to the culture collection. Forty-two microbial cultures used in agricultural and in particular as biopesticides were deposited by public and private institutions under safe deposit. About 75 cultures were supplied to both academia and industry.

Acquisition of the status of International Depository Authority (IDA) to "*National Agriculturally Important Microbial Culture Collection*" (NAIMCC) a unit of ICAR-NBAIM by World Intellectual Property Organization (WIPO), Geneva

National Agriculturally Important Microbial Culture Collection (NAIMCC), a unit of the ICAR-National Bureau of Agriculturally Important Microorganisms, Maunath Bhanjan, Uttar Pradesh, India was accredited the status of International Depository Authority (IDA) by World Intellectual Property Organization (WIPO), Geneva, under Article 7 (1) of the Budapest treaty by its notification No. 338 w.e.f. 28 July 2020. Eighty-two countries are part of this treaty and there are about 48 IDAs across 26 countries. The microbial resource centres having status of IDA mainly accepts and maintains microorganisms for patenting of work related to live organisms that have medical, agricultural and other uses. In view of this, an agreement called as Budapest Treaty was passed in 1977 for deposition of microorganisms in culture collection centres for the purposes of patent procedure. NAIMCC is the third IDA of the country after Microbial Type Culture Collection (MTCC), Chandigarh and National Centre for Microbial Resources (NCMR), Pune. As IDA, NAIMCC will be entrusted to conserve microorganisms used to develop patents. NAIMCC, a designated microbial repository for agriculturally important microorganisms (AIMs) under the National Biodiversity Act, 2002, is an affiliate member of World Federation of Culture Collections (WFCC), and registered with the World Data Centre for Microorganisms (WDCM registration number 1060).

HORTICULTURE

Collection/augmentation of germplasm

Exotic sources

Tomato: Four genotypes of tomato were introduced from AVRDC, The World Vegetable Centre, Taiwan.

Potato: A total of 34 accessions of potato were imported from various countries including 15 diploids from the US potato gene bank, 3 from the Peru, 15 from Ireland and one from Denmark.

Indigenous sources

Fruit crops: A total of 186 germplasm accessions of fruit crops comprising acid lime (2), annona (8), avocado (116), banana (10), ber (4), citrus (4), guava (11), jackfruit (5), jamun (6), ker (12), lasoda (1), mango (6) and rose apple (1) were collected from 15 states Assam, Arunachal Pradesh, Bihar, Gujarat, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Manipur, Rajasthan, Tamil Nadu, Tripura, Uttarakhand and West Bengal, and Union Territories such as Andaman and Nicobar Islands,

Plantation crops: A total of 34 cashew accessions from Andhra Pradesh, Kerala, Karnataka, Chhattisgarh, West Bengal, Gujarat, Maharashtra and Tamil Nadu were collected.

Vegetable crops: A total of 440 germplasm accessions of vegetables crops such as amaranth (18), bitter gourd (4), brinjal (135), capsicum (2), carrot (6), cauliflower (5), chilli (10), cho-cho (52), cluster bean (3), cucumber (30), drumstick (25), ivy gourd (12), long melon (5), lotus (4), pea (43), pointed gourd (24), pumpkin (14), ridge gourd (6), satputia (1), spine gourd (10), sponge gourd (20), water melon (5), water chestnut (2) and water spinach (4) were collected from 10 states, viz. Andhra Pradesh, Bihar, Gujarat, Himachal Pradesh, Madhya Pradesh, Maharashtra, Meghalaya, Nagaland, Odisha, Punjab, Rajasthan, Uttar Pradesh, Uttarakhand and Tamil Nadu, and union territories such as Jammu and Kashmir.

Potato: Four germplasm accession in potato were collected from Jammu and Kashmir, Odisha and Manipur.

Tropical tuber crops: A total of 12 accessions comprising one wild *Amorphophallus* from Kerala, one *Curcuma augustifolia* from Chhattisgarh and 10 cassava accessions from Andhra Pradesh were added to the field gene bank.

Garlic: Five accessions of garlic were collected from Maharashtra and Tamil Nadu.

Spices: A total of 43 perennial spices comprising allspice (10), black pepper (15), cinnamon (6), Garcinia (6), ginger (3) and turmeric (3) from Andaman and Nicobar Islands, Karnataka and Kerala were collected

A unique black pepper accession with extra-long spike (34.5 cm) was collected from the Madikeri, Karnataka

Garcinia (*Garcinia andamanica*) collected from Andaman and Nicobar islands

for augmenting the breeding programmes.

Seed spices: A total of 86 new germplasm lines (50 in coriander, five in fenugreek, four in fennel, 15 in ajwain, 10 in kasuri methi and one each in cumin and nigella) were collected from Jammu and Kashmir, Rajasthan and Madhya Pradesh.

Medicinal plants: A total of 16 germplasm accessions of madhunashinee (*Gymnema sylvestre*) were collected from the Western Ghats of Maharashtra.

Mushrooms: A total of 236 specimen strains of different mushrooms were collected from 26 states of the country.

Wild mushroom *Cantharellus* sp.

Other strains of wild mushrooms

Characterization and identification of germplasm

Fruit crops

Litchi: Two promising genetic stocks of litchi were identified. NRCL-59 is selection from open pollinated

NRCL-59

NRCL-88

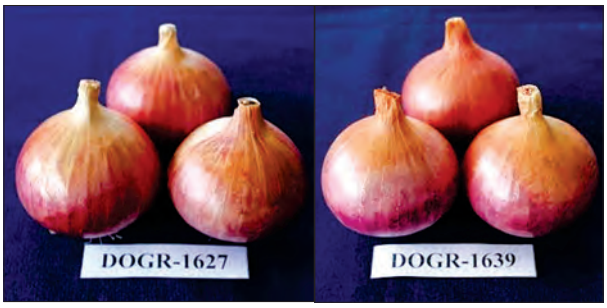
seedling population. It has deep pink fruit (22.56 g weight), 21.59 °Brix and high anthocyanin (96.56 mg/100 g) in peel. NRCL-88 has 16.22 g fruit weight, 76.38% pulp with small seed (7.63%).

Vegetable crops

Characterization of cow pea germplasm for micronutrient content in pods: There was a large variation in cowpea genotypes with respect to micronutrients contents in the pods. Copper contents ranged from 3.2 ppm in VRCP-112-4 to 14.45 ppm in VRCP-96-4, iron from 79 ppm in VRCP 71-1 to 229.6 ppm in VRCP 167-3, zinc from 51.45 ppm in VRCP 158-3 to 98.25 ppm in Kashi Shyamal; and manganese from 40.1 ppm in VRCP to 112.4 to 67.3 ppm in Kashi Unnati.

Onion

Two promising red onion lines identified: DOGR-1627 has medium red with globe shape bulbs weighing 67.4 g with thin neck and almost free from double bulbs and bolters. It has 27% more (34.62 t/ha) marketable bulb yield than check Bhima Super (27.25 t/ha). The line is early in maturity and harvested within 95 days after transplanting during *kharif*.



DOGR-1639 has medium red with flat-globe shaped bulbs with thin neck, weighing 62.8 g, free from doubles and bolters during *rabi*. It produces 37% more (36.81 t/ha) marketable bulb yield than check Bhima Kiran (26.83 t/ha). It attains harvestable bulb maturity at 111 days after transplanting.

Medicinal plants

***Cassia tora* accessions with high anthraquinone glycosides emodin and chrysophenol identified:** *Cassia tora* is a small shrub and grows as common weed in Asia. Many medicinal properties such as antimicrobial, antihepatotoxic and antimutagenic activities are attributed to *C. tora*. Two anthraquinone glycosides namely emodin and chrysophenol were

quantified in seed extracts of *Cassia tora* samples through reversed phase, high performance liquid chromatography method. Emodin (EM) content (%) ranged from 0.0015 to 0.0182% with a mean of 0.0079. Maximum EM content (%) was observed in DCT-2 (0.0182), followed by DCT-19 (0.0179), DCT-21 (0.0178) and DCT-1 (0.0152). Chrysophenol (CRYP) content (%) ranged from 0.0058–0.1002%. Maximum CRYP was observed in DCT-4 (0.1002), followed by DCT-14 (0.0538), DCT-10 (0.0458) and DCT-5 (0.0413). Minimum CRYP was recorded in DCT-41 and DCT-28 (0.0058), followed by DCT-36 (0.0082).

***Garcinia* species with high content of cytotoxic polyisoprenylated benzophenone identified**: A *Garcinia* species was identified which had higher content of xanthochymol in comparison to *G. spicata*. Further, a single step process was developed for isolation of xanthochymol.

Indian ginseng (*Withania somnifera*): Of the 327 pure lines of Indian ginseng evaluated, 10 lines such as, DWS-184, DWS-228, DWS-266, DWS-290, DWS-296, DWS-300 and DWS-315 were identified with higher (0.4%) anolides content.

Germplasm sharing: A total of 1,314 germplasm accessions in 18 different vegetable crops such as tomato (134), garden pea (42), cowpea (227), brinjal (139), Indian/Dolichos bean (16), muskmelon (45), French bean (26), cluster bean (50), watermelon (53), cucumber (77), chilli (165), winged bean (20), okra (234), bottle gourd (12), sponge gourd (22), bitter gourd (11), pumpkin (16), cauliflower (16) etc., were distributed to 40 organizations/institutes/universities through Material Transfer Agreement for use in demonstration and research.

Germplasm registration

Wood apple: Thar Gaurav, a new variety with large fruit (450.25 g), 124.36 kg/tree fruit yield in 12th year under rainfed conditions of western India was identified. The fruits are rich in pectin (1.76%), protein (pulp 18.13% and seed 24.38%), phosphorus (0.07%), potassium (1.73%), calcium (0.3%) and iron (16.72 mg) content.

Khejri: Thar Shobha and Selection-2 were registered with ICAR-NBPGR, New Delhi with IC number 632064 and 632065, respectively.

Date palm: One elite, male date palm promising for more pollen production (672.7 g/palm) and number of spathes (25–30/palm) was identified and registered (IC No. 0632315) with ICAR-NBPGR, New Delhi.

Drumstick: One medium-dwarf genotype (CHESD-40) with 2.74 m plant height, 248 pods, 218 g pod weight, 8–10 seed per pod and 8.9 °Brix was identified promising under rainfed conditions of semi-arid regions of Gujarat.

Garden pea: One unique genotype of garden pea 'VRPM-901-5' bearing 3–5 pods on one node was registered (INGR19077) with ICAR-NBPGR, New Delhi.

Watermelon: One stable, andromonoecious sex form in watermelon (AHW/BR-5) with ability to set fruits under net house conditions without pollinators and production of viable seeds was identified. It produces round, red fleshed fruits having light green rind (1.38–1.92 cm thick) devoid of stripes. It was registered (INGR 19081) with ICAR-NBPGR, New Delhi.

Ivy gourd: Accession (IC-632331) promising for fruit weight (29.4 g) and yield (38.96 kg/plant) under semi-arid conditions was identified.

Bottle gourd: The LS-4 × LS3-2 line was found superior with round fruits, maximum number of fruits (17.6/plant) and yield (13.2 kg/plant) with 750 g fruit weight.

Water melon: In water melon, one advance line, YF 5-2-7 with entire leaf (non-lobed), dark green rind with very narrow stripes and blackish brown seed coat was identified. The flesh contains carotenoid (3.92–4.14 µg/g fresh weight) and 0.25 mg AAE/g total antioxidant activity (TAA).

Onion: DOGR-1203-DR is a very dark red onion elite line registered as genetic stock for very early maturity (90 days after transplanting) with complete and uniform neck-fall during *rabi*. Average yield is 20–22 t/ha and 11–12% total soluble solids. Storability of bulbs is very good (5–6 months).

Ashwagandha: In ashwagandha, DWS-10 (IC0627268, INGR19027), a male sterile line was

registered with ICAR-NBPGR, New Delhi. It can reproduce itself by selfing under long-day condition (summer season; temperature >35°C), and becomes male sterile during winter; temperature 10–30°C and RH 40–50%. It is useful in commercial exploitation of hybrid vigour.

Isabgol: Two germplasm accessions, viz. DPO-185 (IC0627267, INGR19025) with Yellow leaf tip and Downy mildew resistance, and Tetraploid DTPO-6-6'(IC0627269, INGR19026) were registered with ICAR-NBPGR, New Delhi. DPO-185 is erect, with distinct yellow leaf tip coloration followed by tip drying during flowering, resistant to downy mildew (DM), late maturing (130–140 days).

Livestock

Registration of new breeds of indigenous farm animals: Thirteen new breeds of livestock and poultry and three breeds of dog were registered by ICAR-National Bureau of Animal Genetic Resources, Karnal (NBAGR) during the reporting period. These included seven breeds of cattle, two breeds of pig, and one breed each of buffalo, sheep, donkey and duck and three breeds of dog. The breeds of dog were first time registered by ICAR. Total number of indigenous breeds of livestock, poultry and dog are now 200.

Gazette Notification of livestock and poultry germplasm: All the 13 newly registered breeds were notified by the Government of India to provide statutory recognition of and claiming sovereignty over the native germplasm in May, 2020 [Gazette Notification: Ministry of Agriculture and Farmers' Welfare, No. 1420 (S.O.1583(E)) (May 22, 2020)] and 1421 (S.O.1584(E)) (May 22, 2020).

Identification and characterization of new livestock populations

Medini cattle of Jharkhand: It is a small size grey colour animal. Muzzle, eyelids, hooves and tail switch are black. Average herd size is 3.5 (1–8). Every village had 6 to 8 breeding bulls and natural service is practiced. Average adult weight is 265.94±2.68 kg in males; and 246.35±2.15 kg in females. Daily milk yield ranged from 0.7 to 2 kg with lactation length of 5 to 6 months. Bullocks are used for agricultural works.

New registered breeds of livestock and poultry

Breed	
Poda Thurpu cattle 	Poda Thurpu cattle from Nagarkurnool district of Telangana are migratory, medium size, having compact body and reared mainly for draught purposes. Daily milk yield ranges from 2 to 3 kg. Population size is approximately 15,000. Acce. No. INDIA_CATTLE_3600_PODATHURPU_03044
Nari cattle 	Nari cattle from Rajasthan and Gujrat are dual purpose, medium and have migratory nature. They survive well on grazing. Daily milk yield ranges from 5 to 9 kg. Population is approximately 55,000. Acc No. INDIA_CATTLE_1704_NARI_03045
Dagri cattle 	Dagri cattle from Gujrat are small size animal with compact body. Coat colour is predominantly white, sometimes with grey shade. Extensively used as draught animal with milk yield 1.5–3.0 kg/day. Population size is ~2.8 lakh. Acc No. INDIA_CATTLE_0400_DAGRI_03046
Thutho cattle 	Home tract Nagaland, medium in size, hardy, well-built, short horns, small hump and docile. Used mainly for draught, manure and meat; daily milk yield is 0.5 to 1.5 kg. Population is about 53,000. Acc No. INDIA_CATTLE_1400_THUTHO_03047
Shweta Kapila cattle 	Completely white coloured cattle from Goa, short to medium statured with straight and small horns. Daily milk yield ranges from 1.8 to 3.4 kg. Height ranges from 97 to 137 cm. Population size is approximately 22,000. Acc No. INDIA_CATTLE_3500_SHWETAKAPILA_03048
Himachali Pahari cattle 	These are small to medium in size with compact cylindrical body and short legs and black/ blackish brown coat from moderate to high altitude hills of HP. Daily milk yield ranges from 1 to 3 kg besides used for draught. Population is ~7.6 lakh. Acc No. INDIA_CATTLE_0600_HIMACHALIPAHARI_03049

(Contd...)

Breed	
Purnea cattle 	Small size animals from Bihar with grey, red and black coat colours. Daily milk yield 1 to 5 kg besides used for draught. Population is ~2.2 lakh. Acc No. INDIA_CATTLE_0300_PURNEA_03050
Gojri buffalo 	Well adapted to foot hills of HP and in areas of Punjab and reared by Gujjar community in pastoral system. Daily milk yield ranges from 3 to 8 kg. Acc No. 50000. INDIA_BUFFALO_1606_GOJRI_01017
Kajali sheep 	Large size sheep from Punjab. Black Kajali is complete black or black-brown coat. White Kajali have complete white coat with black or dark brown circle/patch around the eyes, and in face and ears with Roman nose. Adult male weighs 57 kg and female 43 kg. Population size is about 6,000. Acc No. INDIA_SHEEP_1600_KAJALI_14044
Mali pig 	Black color, medium size pig from Tripura with pot belly. Small to medium bristles on body, ears are short erect and snout concave. Adult male weighs 68 kg and females 71 kg. Litter size-3 to 7. Population size is about 45,000. Acc No. INDIA_PIG_1900_MALI_09009
Purnea pig 	Black color medium size pig from Bihar and Jharkhand. Ferocious in nature with thick line of bristle on topline from neck to shoulders. Small and thick snout and short, conical and erect ears are the characteristics. Adult males weigh from 41 to 50 kg. Litter size 4 to 6. Population is about 1 lakh. Acc No. INDIA_PIG_0325_PURNEA_09010
Kachchhi donkey 	Found in Kachchh of Gujarat. Mainly grey coat colour, followed by white, brown and black. Docile and used for agricultural and transportation. Population size is approximately 1,700. Acc No. INDIA_DONKEY_0400_KACHCHHI_05003
Maithili duck 	Light/dark brown plumaged duck from Bihar with circular spots on the feathers whereas drakes have dark brown to ash colour. Egg production ranges 33 to 71. Body weight at 6 month 1.12–1.24 kg. Population is ~46000. Acc No. INDIA_DUCK_0300_MAITHILI_11002
Rajapalayam dog 	Medium size dogs from Tamil Nadu with compact body and coat colour is white. Height at wither ranges from 55 to 72 cm in males. Adult body weight 14 to 32 kg. Utilized for guarding of farms and houses. Highly obedient and easily trainable. Estimated population is 3,000–4,000. Acc No. INDIA_DOG_1800_RAJAPALAYAM_19001
Chippiparai dog 	Chippiparai dogs from Tamil Nadu are also called as Kanni (virgin) or vettainaai (hunting dog). Medium in size, coat colour varies from fawn to dark brown, brownish black and black. Height at wither ranges from 60 to 76 cm in males. Utility is guarding and hunting. Estimated population is about 6,000. Acc No. INDIA_DOG_1800_CHIPPIPARAI_19002
Mudhol Hound dog 	Also known as Pissouri Hound or Lahori Hound from Karnataka, is having aerodynamic body with high stamina and endurance. Head is small, skull is long and narrow. Ears are medium, thin, triangular and set high. Abdomen is tucked. The tail is long and tapering. Height at wither ranges from 73 to 80 cm in males. Used for guarding and shepherding. Estimated population is ~1,500. Acc No. INDIA_DOG_0800_MUDHOL HOUND_19003

***Bawri* (*Garri*) *cattle of Chambal region* (*Madhya Pradesh*):** Unique population was identified in Sheopur and Morena districts of Madhya Pradesh. Reared

by Gurjars for milk under extensive system in ravine areas, characterized by medium size and moderate to wild in temperament. Milk production is 2–4 kg. Total population of Bawri cattle is about 20–25 thousand. These cattle are adapted to high temperature with less intake of water.

Kathani cattle of Maharashtra: The breed is mainly used for draught purpose. Animals are mostly white in colour with black muzzle, eyelids, hooves and tail switch. Average age at first mating in females is 42.8 months, lactation length 146 days and lactation yield 136.64±4.04 kg, respectively. Average herd size is 5.30. Average daily milk yield is 0.96±0.03.

Palamu goat of Jharkhand: Small size goat is also known as Medini. Its distribution area is Palamu, Latehar and Garhwa of Jharkhand. Average flock size is 5.36±0.19. Average age at first mating in males is 8.32±0.86 months; and in females 7.22±1.35 months.

Machrela sheep population of Andhra Pradesh: Macherla sheep is famous for meat production and distributed in Guntur, Krishna, Prakasham of Andhra Pradesh and Nalgonda district of Telangana state. More than 99% of females are polled and males are horned. Average adult body weight of males is 53.95±1.87 kg. The age at first lambing in ewes is about 18 months as reported by most of the farmers.

Balangir goat of Odisha: Goats are black or brown in colour with border on ears. Average age and weight at slaughter is 17.48±1.89 months and 20.56±1.15 kg. Average age at first kidding, kidding interval and kidding rate are 11.09 months, 218.16±0.09 days and 1.94, respectively. Average herd size is 8.02 and estimated population is 2 lakh.

Poonchi chicken of Kashmir: Landless or marginal farmers rear them for meat and egg. Adult body weight is 2.78±0.25 kg in males and 1.90±0.04 kg in females. Average age at first egg is 6 months and clutch size is 16.13±0.46 with 14 days clutch interval.

Genetic characterization of livestock populations: Five indigenous livestock populations of Kathani cattle, Balangir goat and Marwari, Sindhi and Kharai camel were characterized using a panel of 25 microsatellite markers, specific for each species.

Establishment of National Bovine Genomic Centre–Indigenous breeds: A total of 1,676 animals belonging to diverse breeds were sequenced at a coverage of 10x, yielding 60 GB of data per animal. The chips created and tested on 480 each of cattle and buffalo had given 99.8% call rate. Both the chips were validated for the informativeness of their markers. Total 14,006 animals belonging to CHRS Ajmer, CHRS Rohtak, CHRS Ahmedabad and BAIF were recorded for milk traits. About 4,000 animals have completed the lactation, their DNA was isolated.

Serum metabolome of animal germplasm of Ladakh region: Metabolic profile of serum samples (33) of livestock species in Ladakh (Ladakhi cattle, Jeresy cattle, Ladakhi donkey and Changathngi goat) adapted to high altitude was evaluated assessing a complementary systems-wide approach to elucidate the influence on these species. Such kind of analysis will help to delineate the metabolites that are making these species to naturally adapt and survive in harsh and hypobaric conditions.

Transcriptomic analysis of Bandur (Mandya) sheep meat: Among the meat type sheep breeds in India, organoleptic characteristics of meat of Bandur sheep are highly preferred by consumers. The differential expression of miRNAs in Bandur and Local sheep was elucidated using RNA sequencing. A total of 100 known, differentially expressed miRNAs were identified. Total 154 genes were predicted as targets of the differentially expressed miRNAs. The pathways were deciphered.

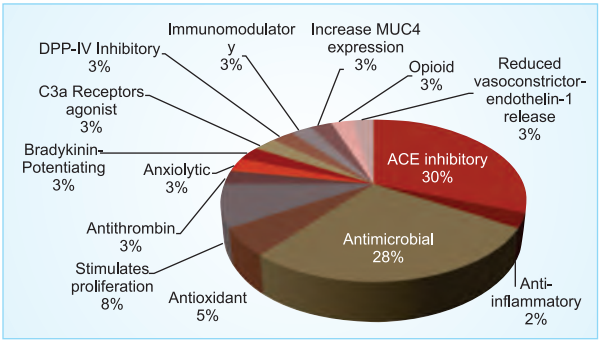
Skin transcriptome for Pashmina production in Changthangi goat: An attempt was made to unravel the gene networks and metabolic pathways that might contribute to fiber development in Changthangi goats in comparison of Barbari goats. Among these, 525 upregulated and 54 down-regulated genes. The down-regulated activities were mainly related to hair follicle development and hair shaft differentiation in Changthangi.

Identification of informative SNPs in buffalo breeds through HTP genomic tools: High throughput genotyping was done on 96 animals of 6 different breed of buffaloes for genome-wide SNPs mining. Phylogenetic tree showed that Pandharpuri formed a separate lineage to the rest of the breeds.

Generation of BMPR-IB gene edited goats using CRISPR/Cas technology: BMPR1B gene specific synthetic single guide RNA was produced and conditions for transfection of CRISPR components in to the *in vitro* produced caprine embryos were standardized. For the first time, BMPR1B gene edited viable caprine embryos were produced using CRISPR.

Genetic evaluation of traits of economic importance using pedigree information in SNPs marker in Murrah buffalo and crossbred cattle: Estimated breeding values of Vrindavani cattle and Murrah buffaloes were determined for sire ranking. The MUFA and PUFA content was significantly high in indigenous cows as compared to crossbred cattle and Murrah buffaloes. The concentration of iron and zinc were significantly high in indigenous cattle; whereas the content of Cu and Mn was high in Murrah.

Milk phospho-proteome analysis and association with geographical coordinates: The post translational modifications (phosphorylation, oxidation, acetylation, carbamido-methylation) were observed in low and high



Biological function of goat milk bioactive peptides

abundant proteins of genetically diverse goat breeds/genotypes. High levels of PTMs were observed in 120 goat milk proteins. The rare conserved peptide sequence of (SSSEE) was observed in αS1 and αS2 casein. The genotyping by SDS PAGE was carried out for more than 1,500 goat milk samples of 17 breeds/genotypes.

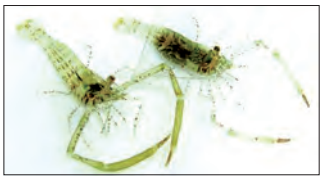
***Ex-situ* conservation of germplasm**: Conservation through somatic cells was initiated under CRP on Agro-biodiversity recently. Somatic cell bank was strengthened with Jaisalmeri and Bikaneri camel, Halari donkey and Zanskari horse fibroblast cell lines from at least five samples each. Somatic cells were cryo-preserved in 60 vials (1×10^6 cells/ml) for each breed.

Fisheries

First record of fish and shrimp species: Identified a new freshwater fish species, *Barilius torsai* (Teleostei: Cypriniformes: Cyprinidae), from Torsa River, Brahmaputra drainage (DOI: https://doi.org/10.11609/jott.4746.11.14.14808-14815). This fish is highly relished as food and fetches a high market price of ₹ 400–600/kg.

Holotype of *Barilius torsai* (ZSI FF5542; 71.41 mm SL)

Discovered for the first time, from Indian waters, three new species of marine ornamental shrimps, viz. *Periclimenella agatti, Urocaridella arabianensis* and *Actinimenes koyaii* from different islands of Lakshadweep. These species are new to science. Also discovered new distribution records of three marine ornamental shrimp species, viz. *Thor hainanensis, Lysmata hochi* and *Urocaridella antonbruunii*. Based on their ornamental value, attempts were made to breed three marine shrimp species, viz. *P. agatti, U. arabianensis* and *L. hochi* in captivity.

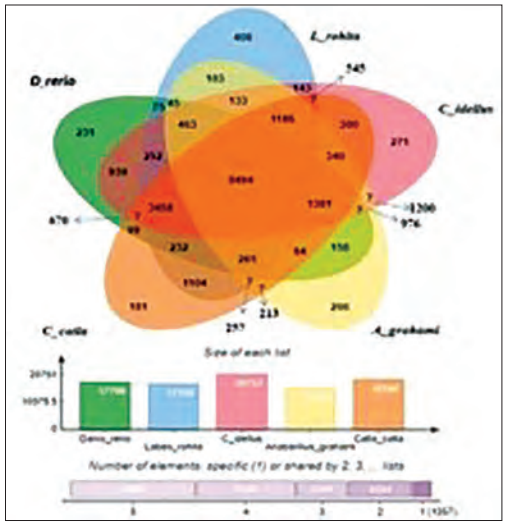


Periclimenella agatti

Urocaridella arabianensis

Isolation and characterization of a heterotrophic ammonia oxidising bacteria: A new species of *Pseudomonas* was isolated and identified from the aquatic environment, and further confirmatory identification by 16S rRNA revealed that isolated bacteria belong to *Pseudomonas aeruginosa*. The sequence analysis using the NCBI BLAST showed 99% identity with *P. aeruginosa*. The isolated bacteria are capable of conducting heterotrophic nitrification and aerobic denitrification and are also having a good ability to remove ammonia and nitrate without nitrite formation in the media.

Draft genome and associated genomics resources in *Labeo catla*: Accomplished *de-novo* genome assembly in Indian major carp, *Labeo catla*. Assembled genome size was 1.01 Gb against an *in silico* estimated



Orthologous relationship between *Labeo catla, Labeo rohita, Ctenopharyngodon idellus, Danio rerio* and *Anabarilius grahami*

genome size of 0.95 Gb, containing 5346 scaffolds (N50: 0.7 Gb; largest scaffold: 6.89 Mb). The evaluation of the genome revealed 92% complete, 87.9% complete and single copy, 4.1% complete and duplicated, 4.1% fragmented and 4.05% missing BUSCOs. The genome-wide simple sequence repeats were 391,331. Gene prediction revealed catla to contain 25,812 protein-coding genes. Orthologous relationships with diploid cyprinids such as *Labeo rohita, Ctenopharyngodoni idellus, Danio rerio* and *Anabarilius grahami* showed total of 8,494 orthologous gene clusters to be shared by all five species, with 1,357 species-specific gene clusters.

❑

5. Crop Improvement

Crop varieties released and notified

Since 1965, 5,334 improved field crops varieties have been developed which include 2,685 of cereals, 888 of oilseeds, 999 of pulses, 200 of forage crops, 395 of fibre crops, 129 of sugarcane and 38 of potential crops. During 2020–21, a total of 172 varieties/hybrids including 17 biofortified varieties were notified and released for commercial cultivation. Details are given below.

Cereals

Sixty two high yielding varieties/hybrids of cereals comprising 31 of rice, 2 of wheat, 13 of maize, 4 each of sorghum, pearl millet, finger millet and foxtail millet were released for cultivation in different agro-ecologies of the country.

List of released varieties/hybrids of cereals

Variety	Area of adoption	Characters
Cereals		
Rice (*Oryza sativa*)		
Chhattisgarh Rice Hybrid-2 (IRH 103) (IET 24956)	Chhattisgarh	Suitable for irrigated mid-early duration, average yield: 60.80 q/ha, maturity: 120–125 days, field tolerance against bacterial leaf blight (BLB), rice tungro and neck blast.
Rajendra Saraswati (IET 23423)	Bihar	Suitable for upland and midland ecology, high yielding, short duration rice variety, average yield: 50 q/ha, maturity 110–115 days, field tolerance to BLB, sheath rot, leaf blast, sheath blight and rice tungro virus.
Sukumar (IET 21261)	West Bengal	Suitable for irrigated, transplanted and mid-early duration, average yield: 39.98 q/ha, maturity 125–130 days, moderately tolerant to sheath rot, blast, leafblast and neck blast, moderately tolerant to stem borer, leaf folder, white backed plant hopper (WBPH) and green leafhopper (GLH).
KPH-471 (IET 25746)	Haryana, Punjab, Uttarakhand, Telangana, Kerala and Karnataka	Suitable for irrigated mid early duration condition, average yield: 59.70 q/ha, maturity: 124 days, moderately resistant to leaf blast.
CR Dhan 313 (IET 25489)	Maharashtra and Chhattisgarh	Suitable for rainfed mid land and irrigated ecology, semi dwarf variety (average plant height 115–125 cm), average yield: 47.25 q/ha, maturity: 130–135 days in both *kharif* and *rabi* season, resistant to false smut and moderately resistant to bacterial blight, neck and leaf blast diseases.
Pusa Basmati 1692 (IET 26995)	Delhi, Haryana and Uttar Pradesh (Basmati GI area)	Suitable for *kharif* irrigated, late transplanting and high fertility condition, semi-dwarf, non-lodging and non-shattering of grains at maturity, average yield: 52.58 q/ha, maturity: 110–115 days, moderately resistance blast, false smut sheath blight diseases, moderately resistant to brown plant hopper.
CR Dhan 602 (IET 26692)	Assam and Tripura	Suitable for irrigated high fertility condition in boro/ dry season, average yield: 57.52 q/ha, maturity: 154–163 days, moderate resistance to leaf blast, sheath blight and sheath rot, resistance to plant hopper and moderately resistant to stem borer.
CR Dhan 308 (IET 25523)	Chhatisgarh and Maharashtra	Suitable for rainfed mid land and irrigated ecology, semi dwarf variety (average plant height 110–120 cm),average yield: 50.30 q/ha, maturity: 130–135 days in both *kharif* and *rabi* season, resistant to neck blast and false smut, moderately resistant to rice tungro and glume discolouration.

List of released varieties/hybrids of cereals

Variety	Area of adoption	Characters
Teja (BPT 2595) (IET 25486)	Andhra Pradesh	Suitable for irrigated late condition, average yield: 62.93 q/ha, maturity: 150 days, moderate resistant to blast and BPH.
Nellore Dhanyarasi (NLR3354) (IET 26226)	Andhra Pradesh	Suitable for irrigated medium duration condition, average yield: 70.42 q/ha, maturity: 125–130 days, tolerant to leaf blast and neck blast.
Maruteru Sujatha (MTU 1210) (IET 25305)	Andhra Pradesh	Suitable for irrigated ecology, average yield: 71.67 q/ha, maturity: 135 days, resistant to blast and BPH.
Maruteru Mahsuri MTU 1262 (IET 27151)	Andhra Pradesh	Suitable for irrigated late condition, average yield: 64.32 q/ha, maturity: 150–155 days, resistant to blast and BPH.
Maruteru Samba MTU 1224 (IET 26225)	Andhra Pradesh	Suitable for irrigated medium duration condition, average yield: 65.59 q/ha, maturity: 135 days, resistant to blast and BPH.
Protezin (IET 25470) (R-RHZ-R-56)	Chhattisgarh	Suitable for irrigated medium duration condition, biofortified variety rich in protein (9.29%) and zinc (20.9 ppm), average yield: 45 q/ha, maturity: 126 days.
Jagtiala Rice-1 (JGL24423) (IET 25310)	Telangana	Suitable for irrigated mid-early duration condition, average yield: 69.90 q/ha, maturity: 120–125 days, tolerant to blast and brown spot diseases and to BPH and gall-midge biotypes 1 and 3.
Kunaram Rice-1 (KNM 733) (IET 27405)	Telangana	Suitable for irrigated ecology, average yield: 65.36 q/ha, maturity: 125–130 days, resistant to leaf blast and moderately resistant to neck blast and to BPH.
WGL-915 (IET 25284)	Telangana	Suitable for irrigated late condition, average yield: 75 q/ha, maturity: 135 days, moderately tolerant to blast, BLB, RTD and moderately tolerant to BPH.
Numali (IET 27405)	Assam	Suitable for irrigated medium ecology, average yield: 54.51 q/ha, maturity: 130–140 days.
IR 64-Sub 1 (IET 21247)	Uttar Pradesh	Submergence tolerant variety, developed through marker assisted backcross breeding, yield: 3–3.5 q/ha under submergence, maturity: 120–125 days, moderately tolerant to blast, RTV, stem borer, leaf folder.
Trombay Karjat Kolam (BARCKKV 13) (IET 27000)	Maharashtra	Suitable for irrigated ecology, compact panicle with high grain density, developed through radiation induced mutation breeding, average yield: 42.39 q/ha, maturity: 130–135 days, moderately resistant to BLB and blast, moderately resistant to stem borer, leaf folder and BPH.
Bastar Dhan-1 (IET 26624)	Chhattisgarh	Suitable for irrigated early direct sown condition, average yield: 44.9 q/ha, maturity: 105–110 days, moderately tolerant to stem borer and blast.
CR Dhan 102 (IET 25121)	Odisha	Suitable for direct seeded short duration condition, drought tolerant, maturity: 110 days, average yield: 3.9 t/ha (best check Sahabhagi Dhan produced 3.66 t/ha under direct seeded condition), moderately resistant to leaf blast, rice tungro virus, stem borer (dead heart), leaf folder and whorl maggot.
CR Dhan 410 (IET 24471)	Odisha	Suitable for rainfed shallow lowlands, long slender grain, photosensitive, flowering in 1st week of November, average yield: 43.53 q/ha, maturity: 160–165 days, resistant to stem borer (both dead heart and white ear heads) and leaf folder while moderately resistant to neck blast, bacterial blight, sheath rot and brown spot diseases.

List of released varieties/hybrids of cereals

Variety	Area of adoption	Characters
CR Dhan 210 (IET 23449)	Odisha	Suitable for aerobic cultivation, long slender grain,average yield: 31.63 q/ha, maturity: 110–115 days, moderately resistant to leaf blast, neck blast, brown spot and sheath rot, stem borer (both dead heart and white ear heads), leaf folder and green leaf hopper.
ADT 54 (AD 09493) (IET 24249)	Tamil Nadu	Suitable for irrigated medium duration condition,average yield: 63.07 q/ha, maturity: 130–137 days, resistant to leaf folder and moderately resistant to blast and yellow stem borer.
CO 53 (CB 06803 (IET 24057)	Tamil Nadu	Suitable for direct sown rainfed condition, short duration drought tolerant rice variety, average yield: 37.18 q/ha, maturity: 115–120 days, moderately resistant to leaf blast, neck blast, sheath rot, brown spot and *rice tungro* disease (RTD), moderately resistant to GLH.
Sasya (BPT-2411) (IET 23081)	Andhra Pradesh	Suitable for irrigated late duration condition, average yield: 67.38 q/ha, maturity: 140 days, moderately resistant to blast, brown spot, sheath rot and BLB.
Bhavathi (BPT-2782) (IET 27124)	Andhra Pradesh	Suitable for irrigated late duration condition, average yield: 66.90 q/ha, maturity: 140–145 days, resistant to leaf blast and brown plant hopper.
Nellore Siri (NLR 4001) (IET 25273)	Andhra Pradesh	Suitable for irrigated late duration condition, average yield: 66.91 q/ha, maturity: 140–145 days, tolerant to neck blast and brown planthopper (BPH).
Nellore Sugandha (NLR 40054) (IET 23194)	Andhra Pradesh	Suitable for irrigated mid-early duration ecology, aromatic, photo insensitive, fine grain rice variety, average yield: 63.18 q/ha, maturity: 130–135 days, tolerant to leaf blast and gall midge.
GR 17 (Sardar)	Gujarat	Suitable for irrigated early maturity condition, average yield: 55.66 q/ha, maturity: 113–115 days, moderately resistant to bacterial leaf blight, leaf blast, grain discoloration and sheath rot, moderately resistant to WBPH and leaf folder.
Wheat (*Triticum aestivum*)		
Phule Satwik (NIAW 3170)	Punjab, Haryana, Delhi, Rajasthan, (excluding Kota and Udaipur division), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu & Kashmir, Poanta Valley and Una district of Himachal Pradesh and Tarai Region Uttarakhand	Suitable for restricted irrigation, timely sown condition of NWPZ & PZ, average yield: NWPZ (50.8 q/ha) and PZ (33.7q/ha), maturity: NWPZ 148 days and PZ (107 days), resistant to leaf, stem and stripe rusts, Karnal bunt, powdery mildew and flag smut diseases, end product quality: soft grains with very good biscuit spread factor, viz. NWPZ (10.18) and PZ (9.34).
MACS 4058 (d)	Maharashtra and Karnataka	Suitable for restricted irrigation, timely sown condition of PZ, biofortified variety with high protein content (12.8%), average yield: 29.6 q/ha, maturity: 106 days, resistance to prevailing pathotypes of leaf and stem rust.
Maize (*Zea mays*)		
Ladhowal Baby Corn Hybrid 3 (LBCH 3) (DMRHB 1305) (Hybrid)	Jammu & Kashmir, Himachal Pradesh, Uttarakhand (Hill region), Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur, Arunachal Pradesh	Suitable for irrigated condition of *kharif* season, average yield: 12.58 q/ha without husk and 44.44 q/ha with husk, early maturity, resistant to moderate resistance response to multiple diseases, viz. turcicum leaf blight and maydis leaf blight under artificial epiphytotic conditions at hot spot of NWPZ, NEPZ and PZ, tolerant to *Chilo partellus*.

List of released varieties/hybrids of cereals

Variety	Area of adoption	Characters
Ladhowal Quality Maize Hybrid 1 (LQMH 1) (IMHQPM 1530) (Hybrid)	Jammu & Kashmir, Himachal Pradesh, Uttarakhand (Hill region), Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur, Arunachal Pradesh	Suitable for irrigated condition of *kharif* season, average yield: 84.56 q/ha at NHZ (Zone-1), early maturity: 100 days (NHZ) and less than 85 days in other zones, exhibited high tryptophan (0.80%) and lysine content (3.53%) in endospermic protein, moderately resistant response to turcicum leaf blight and banded leaf and sheath blight in northern hill zone (Z1), moderately tolerant to *C. partellus* in NWPZ.
ADV 759 (ADV 1390064) (Hybrid)	Karnataka, Andhra Pradesh, Telangana, Maharashtra and Tamil Nadu	Suitable for irrigated and rainfed areas of peninsular zone (PZ), average yield: 94.78 q/ha in peninsular zone (PZ), maturity: 120 days, resistance to sorghum downey mildew (SDM), curvularia leaf spot (CLS), Rajasthan downey mildew (RDM), and moderate resistance to turcicum leaf blight (TLB), banded leaf and sheath blight (BLSB), charcoal rot (CR) and bacterial stalk rot (BSR), moderate tolerant against *Chilo partellus*.
ADV 757 (ADV 7037) (Hybrid)	Karnataka, Andhra Pradesh, Telangana, Maharashtra and Tamil Nadu	Suitable for irrigated condition in peninsular zone (PZ) during Rabi season, average yield: 92.71 q/ha in peninsular zone (PZ), maturity: 120 days, resistance to sorghum downey mildew (SDM) and moderate resistance turcicum leaf blight (TLB) and charcoal rot (CR), moderate tolerant against *Chilo partellus* and *Sesamia inferens*.
ADV 764 (ADV 1390164) (Hybrid)	Punjab, Haryana, Uttarakhand (Plains) and Western Uttar Pradesh	Suitable for irrigated and rainfed conditions of north western plain zone (NWPZ), average yield: 97.57 q/ha in NWPZ, maturity: 120 days, moderate resistance to maydis leaf blight (MLB), turcicum leaf blight, banded leaf and sheath blight, charcoal rot, Rajasthan downey mildew (RDM), curvularia leaf spot (CLS), common rust and polysora rust, moderate tolerant against *Chilo partellus*.
Baby corn GAYMH-1 (GAYMH-1)	Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Telangana, Rajasthan, Madhya Pradesh, Chhattisgarh and Gujarat	Suitable for *kharif* season in PZ and CWZ, average yield: 14.36 q/ha in PZ and 22.99 q/ha in CWZ, moderate susceptible to moderate resistant against c. rust and turcicum leaf blight (TLB) in PZ, moderate resistant against c. rot, Rajasthan downey mildew (RDM) and curvularia leaf spot (CLS) diseases in CWZ, moderate resistant against *Chilo partellus* in both PZ and CWZ.
Ladhowal Popcorn Hybrid 2 (LPCH 2) (IMHP 1535) (Hybrid)	Rajasthan, Madhya Pradesh, Chhattisgarh and Gujarat	Suitable for irrigated condition during *kharif* season in CWZ, average yield: 26.68 q/ha in CWZ, maturity: early (84 days), moderate resistant to fusarium stalk rot (FSR) and curvularia leaf spot (CLS), moderate tolerant to *Chilo partellus.*
Ladhowal Popcorn Hybrid 3 (LPCH 3) IMHP 1540 (Hybrid)	Bihar, Jharkhand, Uttar Pradesh (Eastern region) , Odisha, West Bengal, Telangana, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Rajasthan, Madhya Pradesh, Chhattisgarh and Gujarat	Suitable for irrigated condition during *kharif* season, average yield: 31.61 q/ha in NEPZ; 43.93 q/ha in PZ and 26.62 q/ha in CWZ, maturity: early (85 days), moderate resistant to maydis leaf blight (MLB) diseases in NEPZ; moderately resistant to c. rot, fusarium stalk rot (FSR) and curvularia leaf spot (CLS), moderately tolerant to *Chilo partellus* in NEPZ, PZ and CWZ.
GAPCH-21 Mahashweta (IHPC-1203) (Hybrid)	Punjab, Haryana, Delhi, Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Telangana and Gujarat	Suitable for *kharif* season, average yield: 38.76 q/ha in NWPZ; 32.94 q/ha in NEPZ and 49.22 q/ha in PZ, maturity: medium (91 days), moderate resistant against MLB and charcoal rot diseases in NWPZ and moderate susceptible against MLB and TLB diseases in NEPZ, moderate resistant against C. Rot, P. Rust and TLB diseases in PZ, moderately resistant against *Chilo partellus* in both NWPZ, NEPZ and PZ.

List of released varieties/hybrids of cereals

Variety	Area of adoption	Characters
AH 7043	Bihar, Jharkhand, Odisha, UP (Eastern region), West Bengal, Maharashtra, Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, Jammu & Kashmir, Himachal Pradesh, Uttarakhand (Hill region), Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur and Arunachal Pradesh	Suitable for irrigated condition and high fertility during *kharif* season, average yield: 19.32 q/ha without husk and 52.49 q/ha with husk in NEPZ; 12.54 q/ha without husk and 56.61 q/ha with husk in PZ and 13.15 q/ha without husk and 49.42 q/ha with husk in NHZ, moderate susceptible reaction for maydis leaf blight in NEPZ; moderately resistant to TLB in NHZ, moderately resistant reaction to *Chilo partellus* in NEPZ, PZ and NHZ.
GPMH-1101	Karnataka	Suitable for Karnataka state (Zone:3) under irrigated condition during *kharif* season, orange grain colour, average yield: 74.88 q/ha, maturity: late (115 days), moderately resistant to turcicum leaf blight (TLB) and C. rust, moderately resistant reaction to *Chilo partellus*.
OMH 14-27 (Kalinga Raj)	Odisha	Suitable for Odisha state under irrigated as well as rainfed situation during *kharif* season, orange grain colour, average yield: 76.01 q/ha in irrigated and 54.03 q/ha under rainfed condition, maturity: medium (90–95 days), resistant to common rust (CR), Rajasthan downy mildew (RDM), moderately resistant to maydis leaf blight (MLB), turcicum leaf blight (TLB), charcoal rot, fusarium stalk, and cyst nematode, moderately resistant to *Chilo partellus.*
Gujarat Anand Sweet Corn Hybrid 11 (GASCH 11: Madhuram) (GSCH-0913)	Gujarat	Suitable for Gujarat state under irrigated condition during *rabi* season, yellow kernel single cross sweet corn hybrid, average fresh green cobs yield: 10.71 q/ha, TSS: 16.70–18.40%, maturity: medium (70–75 days—fresh green cobs harvest), moderately resistance to maydis leaf blight (MLB) disease and insect *Chilo partellus*.
Sorghum (*Sorghum bicolour*)		
CSV 42 (SPV 2423)	Karnataka, Maharashtra, Madhya Pradesh and Gujarat	Suitable for rainfed ecology during *kharif* season, average yield: 38–39 q/ha, maturity: 115–118 days, moderately tolerant to grain mold diseases, moderately tolerant to moisture stress.
Palem Pacha Jonna 1 (PYPS-2)	Telangana	Suitable for rainfed and irrigated ecologies during *kharif* and *rabi* season, yellow pericarp grains, good roti making and keeping quality and high protein content, average yield: 20–22 q/ha, maturity: 95–105 days, terminal drought tolerance.
GS-23 (Kanaka)	Karnataka	Suitable for *rabi* season, average yield: 11–15 q/ha, maturity: 105–112 days, moderately resistant to charcoal rot resistant to lodging and rust.
CO 32 (SPV 2369)	Tamil Nadu	Suitable for both rainfed and irrigated condition, grain yield: 24–29 q/ha, maturity: 105–110 days, moderately resistant to shoot fly and stem borer, moderately resistant to downy mildew and grain mould.
Pearl millet (*Pennisetum glaucum*)		
Central Pearl Millet Hybrid BHB-1602 (MH 2192)	Rajasthan, Gujarat and Haryana	Suitable for rainfed condition with high/low fertility conditions, average yield: 25.29 q/ha, maturity: 76 days, highly resistant to downy mildew and blast and resistant to smut, highly resistant to shoot fly, stem borer and grey weevil, biofortified variety (Fe 55 ppm and Zn 37 ppm).

List of released varieties/hybrids of cereals

Variety	Area of adoption	Characters
Jam Shakti (GHB 1129) (Hybrid)	Gujarat	Suitable for *kharif* and summer seasons, average seed yield: 29.57 q/ha (*kharif*) and 53.03 q/ha (Summer), maturity: 83 days, resistant to downy mildew, smut and ergot diseases, tolerant to shoot fly and stem borer, biofortified variety (Fe 72 ppm and Zn 43 ppm).
Moti Shakti (GHB 1225) (Hybrid)	Gujarat	Suitable for *kharif* season, average seed yield: 30.23 q/ha (*kharif*), maturity: 82 days, resistant to downy mildew, blast, smut, ergot and rust diseases, tolerant to shoot fly and stem borer, biofortified variety (Fe 76 ppm and Zn 46 ppm).
Proagro Marutej (XMT 1358)	Rajasthan	Suitable for low rainfall condition, average seed yield: 16.89 q/ha, maturity: 70 days, tolerant to downy mildew, rust and blast diseases, tolerant to shoot fly and stem borer, high iron and zinc content (Fe 43 ppm and Zn 35 ppm).
Finger millet (*Eleusine coracana*)		
Gowthami (PR 10-45)	Andhra Pradesh	Suitable for rainfed *kharif* and *rabi* season, average seed yield: 36–38 q/ha, maturity: 117 days, moderately resistant to leaf blight, banded blight, leaf blast and neck blast diseases, moderately resistant to grass hoppers and ear head caterpillar, high calcium (341.5 mg/100 g) and zinc (26.5 ppm).
KMR-630	Karnataka	Suitable for rainfed *kharif* and late *kharif* seasons, average seed yield: 35–40 q/ha, maturity: 95–100 days, resistant to neck and finger blast disease, tolerant to stem borer, aphids, grass hopper and ear head caterpillar.
VR 988	Andhra Pradesh	Suitable for rainfed condition in *kharif* and irrigated condition during *rabi* seasons, average seed yield: 30–32 q/ha, maturity: 105 days, resistant to leaf, finger and neck blast, foot rot and moderately resistant to blight diseases, resistant to grass hoppers and ear head caterpillars, high calcium (428.3 mg/100 g), iron (58 ppm) and zinc (44.5 ppm) content.
Kalua (OEB 532)	Odisha	Suitable for rainfed uplands during *kharif* and irrigated during summer seasons, average seed yield: 17–18 q/ha, maturity: 110 days, resistant to leaf and neck blast, moderately resistant to finger blast diseases, resistant to *myllocerus* weevil, ear head caterpillar, stem borer and grass hoppers.
Foxtail millet (*Setaria italica*)		
Garuda (SiA 3222)	Andhra Pradesh	Suitable for rainfed *kharif* and *rabi* seasons, average seed yield: 15–20 q/ha, maturity: 58–62 days, tolerant to blast and downy mildew, moderately tolerant to shoot fly and stem borer, high iron (34 ppm) and zinc (14 ppm) content.
Renadu (SiA 3223)	Andhra Pradesh	Suitable for rainfed *kharif* and *rabi* season, average seed yield: 28–30 q/ha, maturity: 86–90 days, tolerant to blast and downy mildew, moderately tolerant to shoot fly and stem borer, high iron (33 ppm) and zinc (18 ppm) content.
Hagari Navane-46 (HN-46)	Karnataka	Suitable for rainfed *kharif* season, average seed yield: 16–18 q/ha, maturity: 85–90 days, resistant to leaf blast, rust and leaf shredding diseases, resistant to shoot fly.
ATL 1 (TNSi 331)	Tamil Nadu	Suitable for rainfed condition, average seed yield: 20–22 q/ha, maturity: 80–85 days, tolerant to blast and rust diseases, tolerant to shoot fly.

Oilseeds: Twenty three high yielding oilseeds varieties comprising 03 of Indian mustard, 02 of yellow mustard, 06 of groundnut, 03 of linseed, 02 each of soybean, toria and safflower, 01 each of sunflower, caster and sesame were released for different agro-ecological regions.

List of improved released varieties/hybrids of oilseeds

Variety	Area of adoption	Characters
Indian mustard (*Brassica juncea*)		
Kesri 5111 (PRO 5111)	Uttar Pradesh, Madhya Pradesh, Uttarakhand and east Rajasthan	Suitable for early maturity sowing, dark brown mustard, short height (140–160 cm), high oil content (41–42%), widely adapted, yield: high yielding, 10–12 q/acre, maturity: 105–120 days, tolerance to white rust.
DRMR 1165-40	Jammu, Punjab, Haryana, Delhi and Rajasthan.	Suitable for timely sown rainfed condition, heat tolerant at seedling stage, moisture stress tolerant, average seed yield: 2,200–2,440 kg/ha, maturity: 133–151 days.
DRMR 150-35 (Bharat Sarson 7)	Bihar, Jharkhand, Odisha, West Bengal, Assam, Chhattisgarh, Manipur	Suitable for rainfed condition with protective irrigation during *Rabi* season, average yield: 12–18 q/ha, maturity 114 days, moderate resistance to *Alternaria* blight and powdery mildew, moderate resistance to aphid infestation.
Yellow sarson (*Brassica rapa*)		
Sanchita (YSWB-2014/2)	West Bengal	Suitable for medium maturity, timely sown irrigated condition, oil content (%): 44–45, maturity: 95–97 days, seed yield (under optimum date of sowing and ideal management): 1,400–1,600 kg/ha.
Anushka (YSWB-2011-10-1)	West Bengal	Suitable for early maturity, timely sown irrigated condition, oil content (%): 44–45, maturity: 85 days, seed yield (under optimum date of sowing and ideal management): 1,400–1,600 kg/ha.
Groundnut (*Arachis hypogaea*)		
Pratap Mungphali-3(UG 116)	Rajasthan	Suitable for irrigated and rainfed conditions, average pod yield: 33.88 q/ha (irrigated) and 20 (rainfed), maturity: 108 days; tolerant to early leaf spot, late leaf spot, rust, collar rot and dry rot diseases, moderately resistant to spodoptera, leaf miner, defoliators, jassids, thrips and leaf hopper.
Jagtiala Palli-1 (JCG-2141)	Telangana	Suitable for irrigated and rainfed conditions, average pod yield: 32 q/ha, maturity: 100 days (rainfed) and 115 days (irrigated), tolerance to early leaf spot, late leaf spot, rust, moderately tolerant to sucking pest complex and *Spodoptera.*
ICGV 06189	Karnataka	Suitable for rainfed conditions, HPS type, used in confectionary, average pod yield: 24.5 q/ha, maturity: 110 days, tolerance to *Spodoptera* defoliar insect and rust disease.
Gujarat Groundnut 41 (JPS 65) (Padma)	Gujarat	Suitable for rainfed condition, high oil and medium bold kernel, useful for oil industry and table purpose, average pod yield: 27.22 q/ha, maturity: 120 days, resistant to stem rot, collar rot, LLS and rust diseases, resistant to leaf defoliators and thrips.

List of improved released varieties/hybrids of oilseeds

Variety	Area of adoption	Characters
Girnar 4 (ICGV 15083)	Rajasthan, Karnataka, Gujarat, Tamil Nadu and Andhra Pradesh	Suitable for rainfed with protective irrigation during *kharif* season, high oleic containing healthy oil, direct consumption as healthy food, developed through marker aided back cross breeding, average yield: 32.18 q/ha (pod) and 21.33 q/ha (kernel), maturity: 112 days, moderate tolerance to late leaf spot, rust, stem rot and peanut bud necrosis diseases, moderate tolerant to leaf hopper, leaf miner, thrips and *Spodoptera.*
Girnar 5 (ICGV 15090)	Rajasthan, Karnataka, Gujarat, Tamil Nadu and Andhra Pradesh	Suitable for rainfed with protective irrigation during *kharif* season, high oleic containing healthy oil, direct consumption as healthy food, developed with marker aided back cross breeding, average yield: 31.24 q/ha (pod) and 21.33 q/ha (kernel); maturity: 113 days, moderate tolerance to late leaf spot, rust, stem rot and collar rot; moderate tolerant to leaf hopper, leaf miner, thrips and *Spodoptera.*
Soybean (*Glycine max*)		
KBS 23	Karnataka	Suitable for irrigated and rainfed conditions during *kharif* season, average seed yield: 25.04 q/ha, maturity: 95 days, resistant to leaf miner diseases.
Phule Kimaya (KDS 753)	West Bengal, Jharkhand, Chhattisgarh, Odisha, Assam and North Eastern states, Southern Maharashtra, Karnataka, Telangana, Andhra Pradesh and Tamil Nadu	Suitable for rainfed condition during *kharif* season, average yield: 23.62 q/ha, maturity: 95–100 days, resistance to rust and moderately resistance to stem fly, girdle beetle.
Toria (*Brassica campestris*)		
Raj Vijay Toria 3 (RVT 3) (RTM 08-6)	Madhya Pradesh	Suitable for irrigated and rainfed conditions, average seed yield: 13.88 q/ha, resistant to white rust, alternaria leaf blight, powdery mildew, downy mildew and sclerotinia stem diseases.
Jeuti (JT 90-1)	Assam	Suitable for normal condition during *Rabi* season, average seed yield: 4.76 q/ha, maturity: 91 days, moderately susceptible to *Alternaria* blight diseases, moderately susceptible to aphids.
Linseed (*Linum usitatissimum*)		
Kota Barani Alsi 5 (RL 29005)	Rajasthan	Suitable for rainfed and un-irrigated conditions, oil content 35–36%, average seed yield: 11.50 q/ha, maturity: 140 days, moderately resistant to wilt and alternaria blight diseases, moderately resistant to bud fly.
Jawahar Linseed-165 (PKDL-165)	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Punjab and Haryana	Suitable for irrigated condition, average yield: 13.92 q/ha, oil content 33.84%, maturity: 165 days, moderately resistant against most obnoxious pest i.e. budfly (dsyneuralini), high level of resistance to rust diseases, moderately resistant to wilt and powdery mildew.
RLC-161	Jammu, Himachal Pradesh, Punjab and Chhattisgarh	Suitable for rainfed condition, oil content 32.1%, average yield: 12.62 q/ha, maturity: 170 days, moderately resistant to bud fly.
Safflower (*Carthamus tinctorius*)		
Chhattisgarh Kusum-1 (RSS 2012-11)	Chhattisgarh	Suitable for irrigated conditions, average seed yield: 16.77 q/ha, maturity: 120 days, moderately resistant to *Alternaria* leaf spot.

List of improved released varieties/hybrids of oilseeds

Variety	Area of adoption	Characters
SSF-13-71	Maharashtra, Karnataka, Telangana and Andhra Pradesh	Suitable for rainfed and irrigated area of Zone-1, average yield: 19.99 q/ha, maturity: 125 days, moderately tolerant to aphid, tolerant reaction to *Alternaria* leaf spot.
Sunflower (*Helianthus annuus)*		
KBSH-78	Karnataka	Suitable for irrigated condition, average seed yield: 25.36 q/ha, maturity: 85 days (early maturing), moderately resistant to necrosis, alternaria leaf spot and powdery mildew diseases, resistant to sucking pests, thrips, leaf hoppers and caterpillars.
Castor (*Ricinus communis*)		
Gujarat Castor Hybrid 10 (GCH 10: Charutar Gold) (SCH 53)	Gujarat	Suitable for irrigated condition in Gujarat, hybrid has red stem, triple bloom, spiny capsules, 50% oil content, high seed yield: (38.98 q/ha), maturity: early duration (89–112 days), resistant to *Fusarium* wilt and leafhopper.
Sesame (*Sesamum indicum*)		
AST-1 (AAUDR 9304-14-4-1), Dikrut	Assam	Suitable for rainfed as well as irrigated condition, lodging tolerant; average seed yield: 850–1,000 kg/ha, maturity:75–78 days

Pulses: Thirty three high-yielding varieties of pulses comprising 07 of chickpea, 08 of urdbean, 05 of mungbean, 06 of urdbean, 03 each of lentil and field pea and 01 of rice bean were released for different agro-ecological regions.

List of improved released varieties/hybrids of pulses

Variety	Area of adoption	Characters
Chickpea (*Cicer arietinum*)		
Jawahar Gram 24 (JG 24) (JG 2016-24)	Madhya Pradesh, Maharashtra, Chhattisgarh, Gujarat, Rajasthan and Bundelkhand region of Uttar Pradesh	Suitable for irrigated areas of CZ, amenable to mechanical harvesting, 100 seed weight: 29.3 g, average yield: 22.37 q/ha, maturity: 115 days, resistant against *Fusarium* wilt.
IPC 2004-01	Uttar Pradesh	Suitable for rainfed and irrigated condition, average yield: 13.96 q/ha, maturity: 139 days, moderately resistant to wilt.
Kota Desi Chana-1 (RKG 13-515)	Rajasthan	Suitable for irrigated condition, 100 seed weight: 22.49 g, average yield: 24.55 q/ha, maturity: 116 days, moderately resistant to wilt.
Kota Kabuli Chana-1 (RKGK 13-271)	Rajasthan	Suitable for irrigated condition, 100 seed weight: 31.15 g, average yield: 24.70 q/ha, maturity: 110 days, moderately resistant to wilt.
IPC 2011-112	Uttar Pradesh	Suitable for timely sown condition, average yield: 12.96 q/ha, maturity: 137 days, moderately resistant to wilt.
Chhattisgarh Chana-2 (CG Chana-2)	Chhattisgarh	Suitable for rainfed and semi irrigated condition,100 seed weight: 23.5 g, average seed yield: 18.73 q/ha, maturity: 97 days, moderately resistant to *Fusarium* wilt.
Nandyal Gram 452 (NbeG 452)	Andhra Pradesh	Suitable for rainfed condition, 100 seed weight: 26.1 g, average yield: 20.24 q/ha, maturity: 95 days, moderately resistant to wilt diseases.

List of improved released varieties/hybrids of pulses

Variety	Area of adoption	Characters
Pigeon pea (*Cajanus cajan*)		
IPA 206	Uttar Pradesh	Suitable for rainfed and irrigated condition, average seed yield: 20.63 q/ha, maturity: 247 days, resistant to fusarium wilt and sterility mosaic diseases.
Chhattisgarh Arhar-1 (RPS 2007-10)	Chhattisgarh	Suitable for rainfed condition in *kharif* and irrigated condition during *rabi* seasons, average seed yield: 19.25 q/ha in *kharif* and 15.35 q/ha in *rabi* seasons, maturity: 175 days, moderately resistant to *Fusarium* wilt, sterility mosaic and phytopthora stem blight diseases, resistant to pod borer and sucking pests.
Warangal Kandi-1 (WRGE-97)	Telangana	Suitable for rainfed condition in *kharif* season, average seed yield: 17.80 q/ha, maturity: duration 160 days, moderately resistant to *Fusarium* wilt disease and tolerant to drought.
Krishna (LRG 105)	Andhra Pradesh	Suitable for rainfed condition during *kharif* season, average seed yield: 17.70 q/ha, maturity: 170 days, moderately resistant to Fusarium wilt and sterility mosaic diseases, tolerant to Maruca, pod borer and pod fly and tolerant to drought.
Tirupati Kandi 59 (TRG-59)	Andhra Pradesh	Suitable for rainfed condition during *kharif* season, average seed yield: 15.35 q/ha, maturity: 170 days, tolerant to Fusarium wilt and sterility mosaic diseases and tolerant to drought.
Gujarat Til 5 (GT-105: Janki)	Gujarat	Suitable for rainfed condition during *kharif* season, average seed yield: 16.06 q/ha, maturity: 140 days, moderately resistant to *Fusarium* wilt and sterility mosaic diseases and tolerant to drought.
Pusa Arhar-151 (Pusa 151)	Bihar, Uttar Pradesh, Jharkhand, West Bengal and Assam	Suitable for rainfed and late sown conditions, average yield: 20.82 q/ha, maturity: 240 days, resistance against sterility mosaic disease (SMD) and moderate resistance against *Fusarium* wilt, phytophthora blight and leaf spot diseases, tolerant to pod borer, pod fly, pod bug and bruchids, moderate resistance to root knot nematode (*M. javanica*).
Raj Vijay Arhar 19 (RVA 19) (RVSA-16-1)	Tamil Nadu, Karnataka, Andhra Pradesh, Telangana and Odisha	Suitable for rainfed/ irrigated condition, average yield: 15.62 q/ha, maturity: 185 days, moderately resistant to *Fusarium* wilt and sterility mosaic diseases, tolerant to *Helicoverpa armigera*, maruca and pod fly.
Mungbean (*Vigna radiata*)		
MH-1142	Uttar Pradesh, Bihar, Jharkhand, West Bengal and Assam and North West Punjab, Haryana, Delhi, Rajasthan, and Uttarakhand	Suitable for wider adaptability, green, shining, attractive and medium size seeds, average yield: 11.40 q/ha in NEPZ and 11.76 q/ha in NWPZ, maturity: 63–70 days, resistance to MYMV, ULCV and Leaf curl virus diseases, moderately resistant to anthracnose and powdery mildew diseases, lesser incidence of whitefly, thrips, pod bugs and pod borers.
IPM 512-1 (Soorya)	Uttar Pradesh, Bihar, Jharkhand, Assam and West Bengal	Suitable for cultivation in irrigated conditions during spring season, green, shining, attractive and medium-large seeds, average yield: 12.55 q/ha in NEPZ, maturity: 65 days, highly resistance to MYM diseases, cercospora leaf spot and anthracnose.
IPM 312-20	Uttar Pradesh	Suitable for irrigated condition during spring season, average seed yield: 6.59 q/ha, maturity: 72 days, resistant to yellow mosaic disease, cercospora leaf spot and powdery mildew diseases, resistant to whitefly and thrips.

List of improved released varieties/hybrids of pulses

Variety	Area of adoption	Characters
IPM 409-4	Uttar Pradesh	Suitable for irrigated condition during spring season, average seed yield: 8.11 q/ha, maturity: 70 days, resistant to yellow mosaic disease, cercospora leaf spot and resistant to leaf crinkle and leaf curl diseases, resistant to thrips.
Azad Moong 1 (KM 2342)	Uttar Pradesh	Suitable for *kharif* season of Uttar Pradesh, yield: 8–10 q/ha, maturity: 65–70 days, moderately resistant to MYMV.
Urdbean (*Vigna mungo*)		
Shashi (OBG 33)	Odisha	Suitable for rainfed upland during *kharif* and irrigated conditions during *rabi* seasons, average seed yield: 8.47 q/ha during *kharif* and 8.2 q/ha during *Rabi* season, maturity: 73 days, moderately resistant to yellow mosaic disease, cercospora leaf spot, anthracnose, powdery mildew and bacterial leaf leaf spot diseases, resistant to pod borer, sucking pests, whitefly and aphids.
VBN 11 (VBG 12-062)	Tamil Nadu	Suitable for rainfed and irrigated conditions, average seed yield: 9.4 q/ha under irrigated condition and 8.65 q/ha under rainfed conditions, maturity: 75 days, resistant to mungbean yellow mosaic virus, leaf crinkle virus and moderately resistant to powdery mildew diseases.
Kota Urd 3 (KPU 524-65)	Rajasthan	Suitable for rainfed normal sown conditions, average seed yield: 11.98 q/ha, maturity: 72 days, resistant to mungbean yellow mosaic virus, leaf spot and anthracnose diseases resistant to stem fly, white fly and thrips
Gujarat Urd 2 (GJU 1509)	Gujarat	Suitable for rainfed conditions, average seed yield: 10.79 q/ha, maturity: 82 days, resistant to yellow mosaic virus, powdery mildew and leaf curl diseases, resistant to pod borer, white fly, aphids and thrips.
Gujarat Urdbean 3 (GU-3: Anjani)	Gujarat	Suitable for rainfed conditions, average seed yield: 9.34 q/ha, maturity: 100 days, resistant to yellow mosaic virus, ULCV and cercospora diseases.
Kota Urd 4 (KPU 12-1735)	Uttar Pradesh, Bihar, Jharkhand, Assam and West Bengal	Suitable for spring season irrigated sown cultivation, average yield: 12.21 q/ha, maturity: 77 days, resistant to cercospora leaf spot and moderately resistant to MYMV, YMV, and web blight in NEPZ, less incidence of pod borer and maruca, tolerant to major biotic stresses.
Lentil (*Lens culinaris*)		
Chhattisgarh Masoor-1 (RL-3-5)	Chhattisgarh	Suitable for rainfed and semi irrigated condition of Chattisgarh, medium bold seed, yield: 1,187 kg/ha, maturity: 88–95 days, moderately tolerant to wilt.
PSL-9	Haryana and Uttar Pradesh	Suitable for moderate salinity stress conditions of NWPZ and NEPZ, average yield: 9.83 q/ha in NEPZ and NWPZ, maturity: 116 days, resistance to *Fusarium* wilt, rust, powdery mildew, stemphylium blight, aphids and pod borer.
PDL-1	Haryana and Uttar Pradesh	Suitable for moderate salinity stress conditions of NWPZ and NEPZ, average yield: 9.49 q/ha in NEPZ and NWPZ, maturity: 111 days, resistance to fusarium wilt, rust, powdery mildew, stemphylium blight, pod borer and aphid.

List of improved released varieties/hybrids of pulses

Variety	Area of adoption	Characters
Rice bean (*Vigna umbellata*) KBR-1	Karnataka	Suitable for rainfed and protective irrigation conditions, average seed yield: 15.23 q/ha, maturity: 75 days, resistant to leaf spot, leaf rust and MYMV diseases, resistant to aphids and pod borer.
Field pea (*Pisum sativum*) IPFD 12-8	Uttar Pradesh	Suitable for irrigated and rainfed conditions during *Rabi* season, average seed yield: 11.58 q/ha, maturity: 123 days,resistant to powdery mildew and rust diseases, moderately resistant to pod borer.
IPFD 13-2	Uttar Pradesh	Suitable for irrigated and rainfed conditions during *Rabi* season, average seed yield: 14.09 q/ha, maturity: 121 days, resistant to powdery mildew, downy mildew and rust diseases, moderately resistant to pod borer.
Kota Matar 1 (KPF 101)	Rajasthan	Suitable for rainfed condition, average seed yield: 18.11 q/ha, maturity: 124 days, resistant to powdery mildew, downy mildew, rust and rot knot nematodes diseases, moderately resistant to pod borer.

Commercial crops: Thirty nine high-yielding varieties/hybrids of commercial crops including 31 of cotton, 07 of sugarcane and 01 of jute were released for different agro-ecological regions.

List of improved released varieties/hybrids of commercial crops

Variety	Area of adoption	Characters
Cotton (*Gossypium* spp.) BGDS 1033	Karnataka, Tamil Nadu and Andhra Pradesh	Suitable for irrigated and high fertility ecology during *kharif* season, average yield: 23.51 q/ha, maturity: 160 days, light yellow petal colour with exerted stigma and yellow coloured pollen, moderately tolerant to leaf hopper.
GTHV 13/28	Gujarat, Maharashtra, Rajasthan and Madhya Pradesh	Suitable for irrigated conditions, average yield: 19.96 q/ha, maturity: 180 days, observed as better for reaction against different diseases of cotton, moderately resistant to leaf hopper.
Phule JLA-0906 (JLA-0906)	Maharashtra, Madhya Pradesh, Gujarat and Orissa	Suitable for rainfed conditions, average yield: 13.60 q/ha, maturity:180 days, moderately resistance reaction to bacterial leaf blight, *Alternaria* leaf blight and gray mildew, moderately resistant to sucking pests and bollworms.
PA 812	Maharashtra, Gujarat, Madhya Pradesh	Suitable for rainfed conditions, average yield: 12.49 q/ha, maturity: 160 days, tolerant to bacterial blight and alternaria leaf spot, tolerant to sucking pests.
RS 2814	North Western Rajasthan, Punjab, Haryana	Suitable for irrigated conditions, average yield: 26.83 q/ha, maturity: 175 days, tolerance against CLCuD, bacterial leaf blight and fungal foliar leaf spot, tolerant against whitefly, leaf hopper and boll worm.
Central Cotton CICR CNA 1028 (CNA 1028)	Maharashtra, Gujarat and Madhya Pradesh	Suitable for rainfed conditions, average yield: 13.24 q/ha, maturity:165 days, tolerant to major diseases of cotton tolerant to sucking pests.
Central Cotton CICR CNA 1032 (CNA 1032)	Maharashtra, Gujarat and Madhya Pradesh	Suitable for rainfed conditions, average yield: 13.174 q/ha, maturity: 160 days, tolerant to major diseases of cotton, tolerant to sucking pests.

List of improved released varieties/hybrids of commercial crops

Variety	Area of adoption	Characters
Gujarat Anand Desi Cotton 3 (GADC 3: Wagad Gaurav) (GVhu 767)	Gujarat	Suitable for rainfed condition, average cotton yield: 21.50 q/ha, maturity: 192 days, moderate tolerant to root rot, bacterial leaf blight, *Alternaria* leaf blight and fusarium wilt diseases, moderately tolerant to sucking pests and boll worm.
CO 17 (TCH 1819)	Tamil Nadu	Suitable for rainfed and irrigated conditions, average cotton yield: 16.04 q/ha, maturity: 135 days, moderately resistant to root rot and *Alternaria* blight diseases, moderately resistant to leaf hopper.
Adilabad Kapas-1 (ADB-542)	Telangana	Suitable for rainfed and irrigated conditions, average cotton yield: 25.75 q/ha, maturity: 170 days, resistant to bacterial leaf blight and tobacco streak virus diseases, tolerant to jassids and boll worm.
Bt cotton/hybrids		
ICAR-CICR Bt-6	Haryana and Punjab	Suitable for irrigated conditions, contains *Cry 1Ac* gene Maturity: 160–170; Yield: 26 q/ha.
ICAR-CICR 16 Bt	Maharashtra, Madhya Pradesh and Gujarat	Suitable for irrigated conditions, contains *Cry 1Ac* gene Maturity: 140–150; Yield: 13 q/ha.
ICAR-CICR 23 Bt	Tamil Nadu, Karnataka, Telangana and Andhra Pradesh	Suitable for rainfed conditions, contains *Cry 1Ac* gene Maturity: 150–160; Yield: 15 q/ha.
ICAR-CICR GJHV 374 Bt	Maharashtra	Suitable for rainfed conditions, contains *Cry 1Ac* gene Maturity: 160–170; Yield: 25 q/ha.
ICAR-CICR PKV 081 Bt	Maharashtra	Suitable for rainfed conditions, contains *Cry 1Ac* gene Maturity: 140–150; Yield: 25 q/ha.
ICAR-CICR Rajat Bt	Maharashtra	Suitable for irrigated conditions, contains *Cry 1Ac* gene Maturity: 160–170; Yield: 23 q/ha.
ICAR-CICR Suraj Bt	Central Zone	Suitable for irrigated conditions, contains *Cry 1Ac* gene Maturity: 160–170; Yield: 23 q/ha, Medium fertility, *Kharif* Season.
JKCH 15551 BGII	Karnataka, Andhra Pradesh, Telangana, and Tamil Nadu	Suitable for irrigated conditions, belong to MON 15985 containing *Cry 1Ac* and *Cry 2Ab* genes Maturity: 160–170; Yield: 20 q/ha.
YCH 7475 Bt 2	Gujarat, Maharashtra and Madhya Pradesh	Suitable for rainfed conditions, belongs to MON 15985 containing *Cry 1Ac* and *Cry 2Ab* genes Maturity: 140–150; Yield: 17 q/ha.
PRCH 2799 Bt 2	Gujarat, Maharashtra and Madhya Pradesh	Suitable for irrigated and rainfed conditions, belongs to MON 15985 containing *Cry 1*Ac and *Cry 2Ab* genes Maturity: 140–150; Yield: 22 q/ha (I); 18 q/ha (RF).
FBt 16-4 PAU Bt 3	Punjab, Haryana and Rajasthan	Suitable for irrigated conditions, contains Cry 1Ac gene Maturity: 160–180; Yield: 28 q/ha.
Indam-1642 BG II	Tamil Nadu, Karnataka, Telangana and Andhra Pradesh	Suitable for irrigated conditions, belong to MON 15985 containing *Cry 1Ac* and *Cry 2Ab* genes Maturity: 150–180; Yield: 15 q/ha.
Samir BG II	Andhra Pradesh, Telangana, Karnataka and Tamilnadu	Suitable for irrigated conditions, belong to MON 15985 containing *Cry 1Ac* and *Cry 2Ab* genes Maturity: 160–170; Yield: 20.91 q/ha.
Raghuvir BG II	Punjab, Haryana and Rajasthan	Suitable for irrigated conditions, belong to MON 15985 containing *Cry 1Ac* and *Cry 2Ab* genes Maturity: Medium; Yield: 35 q/ha.
Hemang BG II	Madhya Pradesh, Maharashtra and Gujarat	Suitable for rainfed conditions, belong to MON 15985 containing Cry 1Ac and Cry 2Ab genes Maturity: 150–160; Yield: 17 q/ha.

List of improved released varieties/hybrids of commercial crops

Variety	Area of adoption	Characters
Ajeet-1155-2 BG II	Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for irrigated conditions, belong to MON 15985 containing *Cry 1Ac* and *Cry 2Ab* genes Maturity: 150–16; Yield: 22 q/ha.
NBC-1103 BG II	Maharashtra, Madhya Pradesh and Gujarat	Suitable for rainfed conditions, belong to MON 15985 containing *Cry 1Ac* and *Cry 2Ab* genes Maturity: 150–155; Yield: 18 q/ha.
NBC-1111 BG II	Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for irrigated conditions, belong to MON 15985 containing *Cry 1Ac* and *Cry 2Ab* genes Maturity: 160–165; Yield: 26 q/ha.
NBHB 2205 BG II	Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for irrigated conditions, belong to MON 15985 containing *Cry 1Ac* and *Cry 2Ab* genes. Extra long staple cotton Maturity: 170–180; Yield: 14 q/ha.
NHH-44-BG II	Maharashtra	Suitable for rainfed conditions, belongs to MON 15985 containing *Cry 1Ac* and *Cry 2Ab* genes Maturity: 150–160; Yield: 25 q/ha.
DCH 32-BG II	Karnataka	Suitable for irrigated conditions, belong to MON 15985 containing *Cry 1Ac* and *Cry 2Ab* genes Maturity: 150–160; Yield: 22–25 q/ha.
Sugarcane (*Saccharum* sp. Hybrid)		
CoC 13339	Tamil Nadu, Andhra Pradesh and Odisha (Coastal areas)	Suitable for irrigated areas, average cane yield: 117.97 t/ha, moderately resistant to red rot and YLD, moderately resistant to smut.
Karan 14 (Co 13035)	Haryana, Rajasthan, Punjab, Uttarakhand and Central and Western Uttar Pradesh	Suitable for mid-late group for North-West zone, average cane yield 86.76 t/ha, Reaction to red rot is resistant to moderately resistant, least susceptible to shoot borer, top borer and stalk borer.
Sahaj-3 (CoS 12232)	Punjab, Haryana, Uttarakhand, Rajasthan and Central and Western Uttar Pradesh	Suitable for medium and high fertility soil under irrigated areas, average cane yield: 88.86 t/ha moderately resistant reaction to red rot and smut.
Sankalp (Co 12009)	Tamil Nadu, Kerala, Interior Andhra Pradesh, Telangana, Karnataka, Gujarat, Maharashtra, Madhya Pradesh and Chhattisgarh	Suitable for irrigated conditions, average cane yield: 119.65 t/ha, moderately resistant reaction to red rot, smut and YLD, less moderately susceptible to shoot fly and highly susceptible to internode borer.
Vasista/ Pampavathi [2009A 107 (CoA 14321)]	Andhra Pradesh	Suitable for irrigated and rainfed conditions, average cane yield: 131.07 t/ha, moderately resistant to red rot, smut, wilt and YLD diseases, moderately susceptible to early shoot borer, internode borer and scale insect pests.
Arundhati/ Naveen [2009 A 252 (Co A 14-323)]	Andhra Pradesh	Suitable for irrigated condition, average cane yield: 124.10 t/ha, moderately resistant to red rot, smut, wilt and YLD diseases, moderately susceptible to early shoot borer, internode borer and scale insect pests.
Rajendra Ganna-1 (CoP16437) × (Co 08139)	Bihar	Suitable for irrigated upland condition, average cane yield: 99.50 t/ha, moderately resistant to red rot, smut and wilt diseases, moderately susceptible to shoot and root borer, top borer and stalk borer.
Jute (*Corchorus olitorius*)		
NJ-7005	West Bengal, Assam, Bihar, Odisha, Uttar Pradesh and Tripura	Suitable for early March sowing, average fibre yield: 30 q/ha, potential yield: 35–37 q/ha, days to maturity: (fibre) 120–125 days, days to maturity: (seed) 140–150 days, resistant to pre-mature flowering and tolerant to insect pests (semi-looper and BHC) and stem rot disease, fibre strength (tenacity: 2,070 g/tex, fibre fineness: 2.70 tex.

Forage and other crops: Fifteen high yielding varieties/hybrids of forage crops comprising 04 of oat, 02 each of rye grass, bajara napier hybrid, lucerne and grain amaranth, 01 each of setaria grass, forage sorghum and Jawahar vicia were released for cultivation in different agro-ecologies.

List of improved released varieties/hybrids of forage and other crops

Variety	Area of adoption	Characters
Oats (*Avena sativa*)		
OL1869-1 OL 13	Punjab, Haryana, Rajasthan, Tarai Region of Uttarakhand, Western Uttar Pradesh, Gujarat, Maharashtra, Madhya Pradesh and Chhattisgarh	Suitable for normal fertility and irrigated conditions, annual *rabi* season cultivated fodder crop, average yield: 624.5 q/ha (green fodder) and 25.1 q/ha (seed), maturity: 155 days, moderately resistant to leaf blight.
Central Oat OS 405 (OS 405)	Maharashtra, Gujarat, Madhya Pradesh, Chhattisgarh and Central Uttar Pradesh	Suitable for normal fertility and irrigated conditions, annual *rabi* season cultivated fodder crop, average yield: 513.94 q/ha (green fodder), 114.73 q/ha (dry fodder) and 15.39 q/ha (seed), maturity: 155 days, moderately resistant to leaf blight diseases.
OL 1861	Punjab, Haryana, Rajasthan, Assam, Imphal, Kolkata, Jharkhand, Bihar, Odisha, Uttar Pradesh, Gujarat, Maharashtra, Madhya Pradesh, Chhattisgarh, Hyderabad, Karnataka and Tamil Nadu	Suitable for normal fertility and irrigated conditions, annual *rabi* season cultivated fodder crop, average yield: 4,487 q/ha (green fodder) and 19.6 q/ha (seed), maturity: 160 days, moderately resistant to leaf blight.
Central Fodder Oat 424 (OS 424)	Jammu and Kashmir, Himachal Pradesh and Uttarakhand	Suitable for normal fertility and irrigated conditions in hill zones, annual *rabi* season cultivated fodder crop, average yield: 296.5 q/ha (green fodder), 65.1 q/ha (dry fodder) and 13.5 q/ha (Seed), better nutritional quality, moderately resistant to leaf blight.
Ryegrass (*Lolium* spp.)		
Him Palam Ryegrass-1 (Palam Ryegrass 1)	Himachal Pradesh, Uttarakhand, Jammu and Kashmir and Punjab	Suitable for tropical, sub-tropical, sub-temperate and temperate climate under irrigated conditions, average yield: 355.39 q/ha (green fodder) and 72.30 q/ha (dry matter), maturity: 180 days, resistant to powdery mildew.
Punjab Ryegrass 2 (PBRG f2)	Jammu and Kashmir, Himachal Pradesh and Uttarakhand	Suitable for tropical, sub-tropical, sub-temperate and temperate climate under irrigated conditions, average yield: 463 q/ha (green fodder) and 76.8 q/ha (dry matter), maturity: 225 days, moderately resistant to resistant reaction to powdery mildew.
Setaria grass (*Setaria viridis*)		
Him Palam Setaria Grass 2 (S 25)	Uttarakhand and Himachal Pradesh	Suitable for cool sub-tropical and sub-temperate grasslands/pastures under rainfed conditions, perennial grass under rainfed condition, suitable for cut and carry as well as for grazing, high tillering ability and leaf stem ratio, average green fodder yield: 482.7 q/ha and dry matter yield: 89.73 q/ha, maturity: 235 days, tolerant to drought, cold and frost.
Bajra Napier Hybrid (*Pennisetum americanum*)		
BNH-14 (BAIF Napier Hybrid-14)	Punjab, Haryana, Rajasthan, Tamil Nadu, Karnataka, Kerala, Andhra Pradesh and Telangana	Suitable for irrigated conditions perennial crop under multicut system under high input condition, average green fodder yield: 1317.91 q/ha (SZ), 844.2 q/ha (NW); green matter yield: 301.49 q/ha (SZ) and 192.9 q/ha, dark green upper side midrib white and lower side midrib green, dark green foliage, thin stem, soft, long and narrow semi-erect leaves without pubescence.

List of improved released varieties/hybrids of forage and other crops

Variety	Area of adoption	Characters
BNH-11 (BAIF Napier Hybrid-11)	Punjab, Haryana, Rajasthan, Tamil Nadu, Karnataka, Kerala, Andhra Pradesh and Telangana, Maharashtra, Gujarat, Uttar Pradesh, Madhya Pradesh and Chhattisgarh	Suitable for irrigated areas, perennial crop under multicut system under high input condition, average green fodder yield: 1219.25 q/ha and dry matter yield: 276.79 q/ha, maturity: 55 days interval for quality green fooder, green foliage, thick elliptical stem, soft, long and broad leaves without pubescence.
Forage sorghum (*Sorghum bicolor*)		
CSV 44F (SPV 2445/ S713)	Maharashtra, Tamil Nadu and Karnataka	Suitable for low to medium fertility level, average green fodder yield: 407 q/ha, dry matter yield: 114.33 q/ha and seed yield: 13.58 q/ha, grain quality bold seeded, medium and grayed yellow, tolerance to Anthracnose, downy mildew and foliar, tolerance against stem borer and midge.
Jawahar vicia (*Vicia sativa*)		
JVS-1 (Jawahar Vicia 1)	Uttar Pradesh, Madhya Pradesh, Chhattisgarh and Maharashtra	Suitable for rainfed-irrigated under normal fertility conditions, average green fodder yield: 254.7 q/ha and dry matter yield: 57.8 q/ha, maturity: 135 days, susceptible reaction for aphids/tillers, higher leaf stem ratio.
Lucerne (*Medicago sativa*)		
Lucerne CO 4 (TNLC 15) (RCP 2-1)	Tamil Nadu, Karnataka, Andhra Pradesh and Telangana	Suitable for irrigated cultivated condition under perennial multicut system, average yield: 608.4 q/ha (green fodder) and 149.03 q/ha (dry matter), maturity: 130 days, resistant to downy mildew, resistant to aphids and weevils.
Alamdar-51	Karnataka, Tamil Nadu, Andhra Pradesh and Telangana	Suitable for high to low fertility and irrigated condition during *rabi* season. Suitable for perennial multicut system. average yield: 595.3 q/ha (Green fodder) and 129.5 q/ha (dry matter), seeds are yellowish, kidney shaped, bold and free from cuscuta weeds, moderately resistant to downy mildew, resistant to *H. armigera* and weevils.
Others (Grain amaranth) (*Amaranthus* spp.)		
BGA 4-9 (Suvadra)	Odisha, Chhattisgarh, Jharkhand, Maharashtra and Gujarat	Suitable for irrigated uplands, medium lands during Rabi season, average yield: 17 q/ha and potential yield during *rabi* season is 28.1 q/ha, maturity: 126 days, diseases reactions to stem rot.
KBGA-4	Karnataka	Suitable for *kharif* season, average seed yield: 22.05 q/ha, maturity: 95 days, resistant to leaf spot and leaf rust diseases, resistant to stem weevil, sucking pests and defoliators.

Identification of QTLs linked to wilt resistance in castor: Two SNP markers (Rc_28694-84511, Rc_30146-1103419) linked to wilt resistance in castor variety 48-1 were identified. These markers were validated in an independent F_2 population (JI-35×48-1) and found that these markers clearly differentiate plant population into resistant and susceptible category. Thus, these markers can be further used in MAS for development of wilt resistant castor varieties.

Development of genome edited lines for *IPA*1 gene in Swarna rice: The *miR156* binding site of the *Ideal Plant Architecture gene 1* (*IPA*1) was edited through CRISPR/Cas9 technique in rice variety Swarna. The edited lines showed ~40% increase in number of spikelets per panicle.

First lipoxygenase-2 free soybean variety NRC 132: Lipoxygenase-2 is the principal contributor to off-flavor associated with the soy products, and is one of the major deterrents in widespread consumption

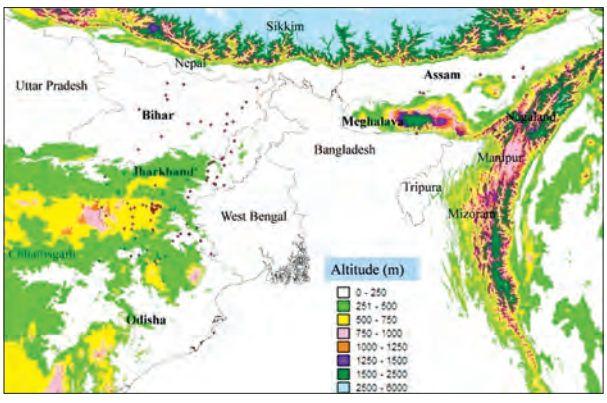
Lipoxygenase-2 free soybean variety NRC 132

of soybean in food use despite being a rich source of proteins. Using marker-assisted selection strategy, lipoxygenase-2 free soybean variety NRC 132 was developed, and identified for cultivation in Southern and Eastern zones. Soy products manufactured using this variety have reduced off-flavor. The plants of this variety flower in 40 days, and become ready for harvesting in 98 and 104 days in Southern and Eastern zone, respectively.

Identification and characterization of drought-responsive genes in wild chickpea: *Cicer microphyllum* is a wild relative of *C. arietinum*, which is naturally adapted to cold desert conditions of Ladakh, Lahaul and Spiti in India. Therefore, *C. microphyllum* may serve as a source of genes and other regulatory elements, responsible for stress tolerance. In order to identify the genes associated with drought tolerance, RNA-seq analysis of *C. microphyllum* was performed using high-throughput Illumina sequencing system. The *de novo* assembly of transcriptome data yielded >72000 transcripts, which were annotated using GO, EC and KEGG. The FPKM based expression profiling was performed and differentially expressed genes (DEGs) in response to drought were identified. Among DEGs, several transcription factors encoding genes were identified, which belong to various abiotic stress related TF families. The MIcroSAtellite identification tool (MISA) was employed to identify SSR markers from assembled transcriptome data. More than 8500 genic SSR markers were identified, which may be utilized for studying polymorphism in *C. microphyllum* genetic pool.

Identification of genes/QTLs for heat tolerance in lentil: Heat stress is one of the universal stresses faced by all organisms. To cope up with heat stress, plants have developed large heat shock factor (HSF) families and a complex transcriptional network composed of many transcription factors (TFs). Activation of HSFs is an important step for initiation of heat stress response. Many homologous HSF gene sequences were obtained through NCBI and Knowpulse database. The expression of nine HSFs (HSFA3, HSFA8, HSFA4a, HSFA1b, HSFB2, HSFB2a, HSF25, HSF33 and HSF34), was analyzed in heat stressed leaf samples of lentil. The genes were amplified from lentil and cloned in TA cloning vector. These partial fragments were sequenced and found homologous to corresponding HSF isoforms. In order to perform the functional characterization of HSF genes, full length gene sequences were determined using RACE (Rapid amplification of cDNA ends). Gene specific primers (GSPs) were prepared for nine HSFs. Seeds of lentil variety HUL 57, a locally grown and popular variety were germinated in pots. During vegetative stage, heat stress was imposed at various regimes: 1 h, 3 h, 6 h, 24 h and intermittent heat stress of 3 h for 3 days (3 h, 3d). The leaf samples were harvested and RNA was isolated. The RNA quality and quantity were screened through gel electrophoresis and Nano-drop spectrophotometer. All the samples were found to have satisfactory RNA quality.

Transcriptome resources for indigenous agri-horticultural crops: This study included 224 accessions of *heterophyllus* collected by the ICAR-National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Ranchi, Jharkhand from three agro-climatic zones comprising five different states of India. A total of 142 alleles at the 38 genic-SSR loci in 224 accessions of *A. heterophyllus* were detected. The number of alleles per locus ranged from 2 to 5, with a mean value of 3.74. The PIC values for the genic-SSR loci ranged from 0.25 to 0.69, with an average of 0.51. Analysis of distribution pattern of alleles among populations

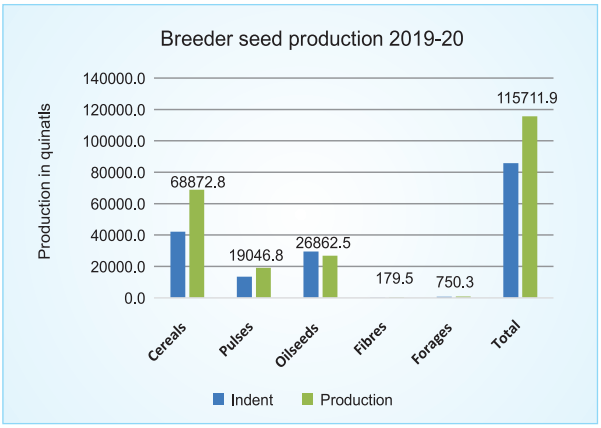


Sampling distribution of germplasm accessions of *A. heterophyllus* in Eastern and North-Eastern India

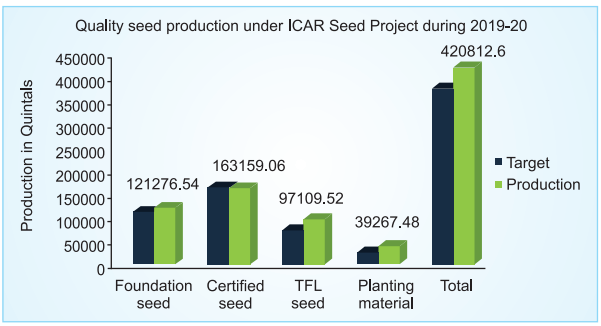
indicated that (*i*) 124 alleles were present in all the three populations, (*ii*) seven alleles were unique to Eastern Plateau and Hills population, (*iii*) seven alleles were present only in Eastern Plateau and Hills, and Middle Gangetic Plain Region populations, and (*iv*) four alleles were present only in Eastern Plateau and Hills, and Eastern Himalayan Region populations. Seven alleles unique to the Eastern Plateau and Hills population were those amplified by the primers JFSSR-4, JFSSR-18, JFSSR-20, JFSSR-101, JFSSR-134, JFSSR-135, and JFSSR-172. Out of these seven unique alleles of the Eastern Plateau and Hills population, five were specific to a small pocket near the Jharkhand-Odisha border area. The finding further suggests that the Jharkhand-Odisha border area is a priority site for the *in-situ* conservation of *A. heterophyllus*.

Seed production

Breeder seed production: During 2019–20, total breeder seed production in field crops was 1,15,711.9q against the indent of 85,752.8 q. The cereal crops had a major share in total breeder seed production, i.e. 68,872.8 q as against the indent of 42,152.1 q. Under pulse crops, a total of 19046.8 q breeder seed was produced against the indent of 13,476.1 q. In oilseeds, total breeder seed production was 26,862.5 q against the indent of 29,433 q. Breeder seed produced in the case of fibre crops was 179.5 q against the indent of 85.6 q and in forage crops, 750.3 q was produced against the indent of 605.8 q.



Quality seed production: During the year 2019–20, total production of quality seeds including all classes was 4,20,812.6 q against the target of 3,76,553 q. Seed production comprises of 1,21,276.54 q of foundation seed, 1,63,159.06 q of certified seeds, 97,109.52 q of truthfully labelled seed and 39,267.5 q of planting material of field crops. In addition, 169 lakh planting material and 8 lakh tissue culture plantlets were produced against the targets of 187 and 7 lakh, respectively.



HORTICULTURE

Crop Improvement

Fruit crops

Pummelo: Arka Chandra has high yield (35–40 kg/plant at 4 years) potential with 0.8–1 kg fruit weight, creamy white pulp (White group 155 A), 11–12°B TSS, 0.89% acidity, low (344.75 ng/ ml) bitter principle 'naringenin' and suitable for fresh consumption.

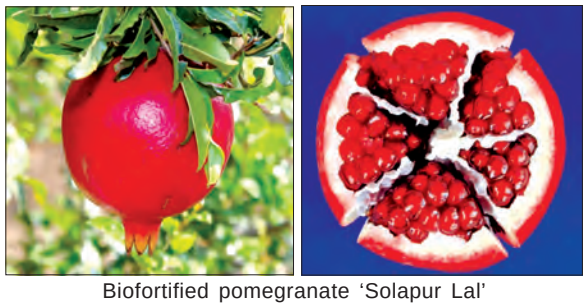
Arka Anantha: It has higher yield (45–50 kg/plant

at 4 years) potential with 0.9–1.2 kg fruit weight, pink pulp, 11–12°B TSS, 0.9% acidity, very low (156.64 ng/ml) bitter principle 'naringenin' and suitable for fresh consumption.

Avocado

Arka Supreme: A full grown tree yields 370–400 kg fruits, with 367–428 g fruit weight. The fruits are oblong, have 7.8°Brix in juice and 20% fat.

Pomegranate: Solapur Lal (NRCP H-6) is the first biofortified hybrid pomegranate, useful for juice or fresh consumption. This variety is of early maturity (160–165 days); higher yield (23–27 t/ha); higher TSS (17.5–17.7°B); vitamin-C (19.4–19.8 mg/ 100 g); anthocyanin (385–395 mg/100 g); iron (5.6–6.1 mg/100 g of fresh arils) and zinc (0.64–0.69 mg/



Biofortified pomegranate 'Solapur Lal'

100 g) in fresh arils.

Solapur Anardana (NRCP H-12) hybrid is useful for processing (anardana) with higher yield (22–24 t/ha); acidity (4.7–4.9%); anthocyanin (457–467 mg/100 g) and fruit size (250–300 g).

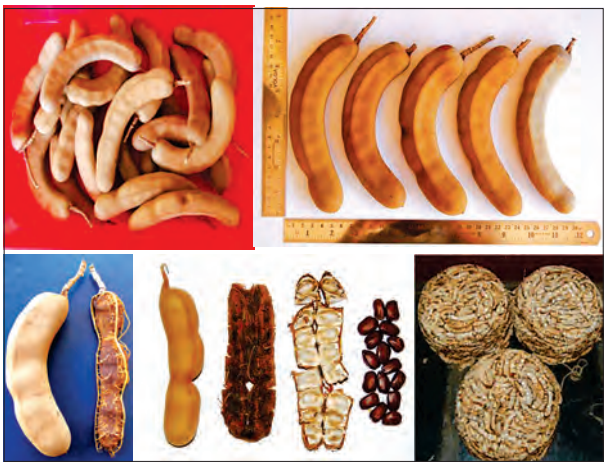
Grapes: ARI-516 (MACS 516) is high yielding

Solapur Anardana

(40–50 t/ha), early ripening (110–120 days after flowering), evenly maturing hybrid (*Vitis labrusca* L. × *V. vinifera* L.) with long, cylindrical, medium sized fruit bunches with 20–22°Brix and musky flavour. Juice content in berries varies from 65 to 70% and it is suitable mainly for processing. This variety is tolerant to downy and powdery mildew and resistant to anthracnose. It needs single pruning and has been identified for cultivation in Punjab, Maharashtra, Tamil Nadu and Telangana.

Grape hybrid 'ARI-516'

Tamarind: Thettu Amalika is selection from the variable seedling population of tamarind collected from Thettu village near Madanapalli, Chittoor, Andhra Pradesh. Pods are 15 to 20 cm long, slightly curved with rounded ends; pulp firm, soft and deep brown. Pod yield varies from 180 to 230 kg/tree. It has been identified for cultivation in semi-arid zones of Andhra Pradesh.



Tamarind 'Thettu Amalika' in various forms

Development and characterization of apple hybrids: Six apple hybrids with superior quality and/or scab resistance were developed, viz. Prima × Ambri, Ambri × Mollies Delicious, Prima × Red Delicious

Hybrid apple progenies

and Ambri × Top Red. Of these, two hybrid (Prima and Pride) progenies are scab resistant.

Plantation crops

Coconut: Following coconut varieties were notified by the Central Subcommittee on Crop Standards, Notification and Release of Varieties for Horticultural Crops, Govt. of India.

Kalpa Haritha, is selection from Accession IND 045, yields 118 nuts/palm (20,886 nuts/ha/year). It is tall palm and green nut variety. It is suitable for copra (3.72 t/ha) production or tender nut (440 ml nut water)

Kalpa Haritha

Kalpa Jyothi

Kalpa Surya

Kalpa Sreshta

production with 5.85°Brix, 17.5 ppm Na and 2,100 ppm K. This variety has been notified for cultivation in Kerala and Karnataka.

Kalpa Jyothi, is selection from accession IND 058, 114 nuts/palm yield (20,178 nuts/ha/year), yellow tender nut (380 ml water) with 5°Brix, 36 ppm Na and 1,988 ppm K. This variety has been notified for cultivation in Assam, Kerala and Karnataka.

Kalpa Surya, is selection from accession IND 048, yields 123 nuts/palm (21,771 nuts/ha), orange tender nut with 400 ml nut water having 6.2°Brix, 35 ppm Na and 2,142 ppm K. This variety has been notified for cultivation under irrigated conditions in Karnataka, Kerala and Tamil Nadu.

Dwarf × tall hybrid Kalpa Srestha (IND 058 × IND 125) has high yield (167 nuts/palm equivalent to 29,227 nuts/ha/year), copra production (216 g/nut equivalent to 6.28 t copra/ha/year) with 64% oil yield and notified for cultivation under irrigated conditions of Kerala and Karnataka.

Cocoa

VTLCP-9: It is a promising hybrid (I-56 × III-35) with 3 kg dry beans/tree/year yield. The hybrid is suitable for chocolate industry with 12–13% shelling, 87–88% nib recovery and 50% fat content. It is tolerant to black pod rot and tea mosquito bug.

Coco hybrid 'VTLCP-9'

Oil palm: Godavari Ratna, has average bunch yield of 158.67 kg/palm/year, Fresh Fruit Bunch (FFB) yield of 22.69 t/ha and recommended for cultivation in Maharashtra.

Godavari Swarna, has higher bunch yield (210.56 kg/palm/year), FFB yield (30.11 t/ha) and identified for cultivation in Andhra Pradesh.

Godavari Gold, has medium bunch yield (198.39 kg/palm/year), FFB yield (28.37 t/ha) and identified for cultivation in Tamil Nadu.

Vegetable crops

Registration of varieties

Onion and garlic: Two onion varieties viz. Bhima Shubhra (Reg. No. 120 of 2019 dated 10 Oct, 2019) and Bhima Safed (Reg. No. 115 of 2019 dated 10 Oct, 2019) were registered with PPV&FRA, New Delhi under extant category for their protection.

In addition, two new onion varieties (Bhima Dark Red and Bhima Light Red) and one extant garlic variety Bhima Purple have been registered with PPV&FRA, New Delhi.

Identification/notification of improved varieties of vegetable crops

Brinjal Long

Punjab Raunak (PBL-232): Plants medium tall and thorn-less with green foliage, flowers are purple, borne in cluster and solitary; fruits are medium long (16.3 cm) and thin (3.72 cm), deep purple and shining, yield 368 q/ha; indentified for cultivation in Zone VI (Delhi, Haryana, Gujarat) and Zone VII (MP. Maharashtra and Goa).

Vaibhav (DBPR-23): It is suitable for growing in *kharif* in zone IV (Punjab, Uttar Pradesh, Bihar, Jharkhand); plants are tall (105–110 cm) with light purple pigmentation on stem. Fruits are round (15 cm length, 7.5 cm diameter), shiny purple, borne solitary with 250 g weight. It takes 55–60 days from transplanting to first picking (harvest) with 410 q/ha yield having potential of 580 q/ha. It has good culinary attributes, i.e. suitable for *Bharta*. It is resistant to *Fusarium* wilt, virus and little leaf complex under field condition in Delhi.

Kashi Vijay (IVBL-23): Plants are bushy with sturdy stems, fruits medium long, purplish pink, potential yield 470–530 q/ha, tolerant to *Phomopsis* blight and *Fusarium* wilt under field conditions; identified for cultivation in Uttar Pradesh, Bihar, Jharkhand and Punjab.

Tomato

Hybrid CTH 1: Fruits are flat, round, thick pericarp (5.84 mm) with extended shelf life (10 days at room temperature). Fruits are borne in clusters of 5–6, with an average fruit weight of 75.3 g. The hybrid has

long harvesting period (20–22 harvests) in 150 days with a yield of 2.94 kg/plant (92.3 t/ha) and moderately resistant to leaf curl virus.

Arka Aditya (H-331): Plants are semi-determinate with dark green foliage, jointed pedicel with triple resistance to leaf curl (*Ty2+Ty3*) virus, bacterial wilt and early blight. Fruits are firm, deep red, oblate round, medium large (90–100 g), suitable for cultivation during summer, *kharif* and *rabi* and bred for fresh market and yield potential 60 to 70 t/ha in 140–150 days.

BT19-1-1-1, is a selection from the Cross of LE-79 × Sel-22 with plant height of 95.7–100.2 cm, round to oval fruits yielding 338 to 490 q/ha, resistant to bacterial wilt and identified for cultivation in Jammu and Kashmir, Himachal Pradesh and Uttarakhand.

Kashi Chayan (Kashi Tamatar-8): It is indeterminate in vegetative growth, high yielding (950 to 60 t/ha), tolerant to Tomato Leaf Curl Virus (ToLCV) carrying Ty3 gene; identified for cultivation in Uttar Pradesh, Bihar, Jharkhand, Punjab, Madhya Pradesh, Maharashtra and Goa.

Cherry Tomato

VL Cherry Tomato 1 (VT 95): It has been identified and recommended for cultivation in Zone I, III and VII. It has fruit yield of 250–300 q/ha in open and 400–450 q/ha in polyhouse. Fruits are smooth, oval, attractive red, firm (15 to 25 g), rich in Vitamin C (86 mg/ 100 g).

Chilli

CH-27 (IC 613996): Hybrid CH-27 (MS-12 × S-343) bears medium long (7.6 cm) fruits, thin skinned, light green when immature and deep red when mature. Fruits are pungent (0.8% capsaicin), high in dry matter (26%) and rich in colouring matter (242 ASTA units). It is resistant to leaf curl virus, fruit rot and root knot nematodes, tolerant to thrips and mites. Fruit weight is 4.2 g and yield of red ripe fruits is 146 q/ha.

Capsicum

KTC-1: Identified and recommended for cultivation in Zone-I. It is an open pollinated variety of capsicum with non-pungent, bell shape with attractive green fruits having 5–6 lobes at marketable stage and turn orange at maturity. It has potential fruit yield of 21.3 t/ha under open field conditions.

Radish

UHF R-12-1 (IC 0598463): It has been developed through Half-sib Recurrent Selection from a round-rooted landrace 'Doonagiri mooli'. The roots have sweet pungent taste with peculiar aroma. The roots are round to slightly tapering, 10–12 cm long, white, weighing 180–200 g at edible maturity. Roots attain harvestable size in 55–60 days after sowing. As compared to long rooted varieties, it is 15–20 days late in maturity. It has 418.5 q/ha root yield and identified for cultivation in Zone-I (Jammu and Kashmir, Himachal Pradesh and Uttarakhand).

Kashi Aardra (VRRAD-150): It has attractive dark-green & soft leaves. Roots are white, tapered, 22–24 cm long weighing 150–225 g. First harvesting starts at 40–45 days after sowing. Root yield ranges from 240 to 400 q/ha; identified for cultivation in Tamil Nadu, Kerala, Puducherry, West Bengal and Assam.

Pea (Early)

Matar Ageta-7 (IC 611572): It is an early maturing variety, first picking in 65–70 days after sowing with pods having 7–9 seeds/pod. Pods are of medium length (9 cm), slightly curved from tip, borne singly or in doubles, shelling out turn is 45% with 91.5 q/ha green pod yield.

VL Sabji Matar 16 (VP 1305): It is early in maturity, identified for cultivation in Zone I (Jammu and Kashmir,

Ladakh, Uttarakhand and Himachal Pradesh). It has 97.4 q/ha green pod yield with early maturity, therefore, escapes powdery mildew. It has attractive dark green, medium-long, slightly curved pods, 8–9 seeds/pod and high shelling per cent (>50%). It has less incidence of pests like pod borer under mid hills conditions.

French bean

Kashi Baingani (VRFBP-14): It flowers at 70–80 days after sowing. Pods are initially green for 5–7 days and subsequently turn purple in the next 8–10 days. Pods are 14–15 cm long and potential yield is 160 q/ha. It has been identified for cultivation in Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Madhya Pradesh, Maharashtra, Goa and Karnataka.

Cabbage

F1 hybrid 'KTCBH-822' has been identified for release for zone I (Humid Western Himalayan Region, i.e. Jammu and Kashmir, Himachal Pradesh and Uttarakhand) and Zone-VI (Arid Western Plains: Rajasthan, Gujarat, Haryana and Delhi). It has dark green and waxy leaves, flat and very compact head covered with outer leaf. It matures in 70–75 days after transplanting and has very good field staying capacity after head formation. It has field tolerance to black rot disease. Average yield is 41.4 t/ha.

Okra

AOL 12-52: The fruits are dark green with attractive shape and size and recommended for cultivation in Zone V.

Cucumber

Pusa Gynoecious Cucumber Hybrid-18 (DGCH-18): It has been identified for cultivation in Zone I (Jammu and Kashmir, Himachal Pradesh and Uttarakhand). Fruits are attractive green, 18–20 cm long, 200–210 g weight with mild whitish green stripes originating from the blossom end and brownish green blotchy patches near the stem end. Fruits become ready for first harvesting in 40–45 days after sowing during spring-summer and *kharif*. It has 24.52 t/ha yield potential.

Bottle gourd

Arka Ganga: It has the yield potential of 60 t/ ha, resistant to Gummy Stem Blight (GSB). Fruits are green, oblong/oval, retain firmness and colour up to 10 days at room temperature.

Arka Shreyas: It has the yield potential of 48 t/ha and resistant to Gummy Stem Blight (GSB). Fruits are green, club shaped and retain firmness and colour up to 10 days at room temperature.

Arka Nutan: It has the yield potential of 46 t/ha and resistant to Gummy Stem Blight (GSB). Fruits are green, cylindrical and retain firmness and colour up to 10 days at room temperature.

Teasel gourd

Arka Bharath: It is robust, vigorous growing with up to 6 m long vines. Fruits are attractive, dark green, long-oval, weighing 110 g/fruit with 10 t/ha potential fruit yield. It has been observed suitable for cultivation in high altitude areas such as, Kodagu district (1,200 m above MSL), Karnataka.

Onion

Promising hybrids of onion identified are described below.

DOGR Hy-73: It has uniform globe shaped, attractive dark red bulbs, and is suitable for cultivation during *kharif*. It has 11.2% higher marketable bulb yield (33.7 t/ha) than check Bhima Super (30.31 t/ha) with 61.3 g bulb weight and thin neck. It is free from double bulbs and bolters. The hybrid attains early maturity and harvested in 91

days after transplanting.

DOGR Hy-173: It has global and medium red bulbs suitable for cultivation during *rabi*. It produces uniform bulbs of 91 g with thin neck and free from doubles and bolters. It has 30.6% higher (40.6 t/ha) marketable yield than the best check Bhima Kiran (31.05 t/ha). It attains harvestable bulb maturity in 111 days after transplanting.

DOGR Hy-179: It has global and medium red bulbs suitable for cultivation during *rabi*. It produces 16.5% more (36.17 t/ha) marketable bulbs than best check Bhima Kiran (31.05 t/ha) with uniform bulbs of 60.8 g with thin neck, free from doubles and bolters. It attains harvestable bulb maturity at 108 days after transplanting.

JWO-11-5-7 (GJWO-3): White onion variety GJWO-3 has been identified for cultivation during *rabi* in Zone-II & IV (Rajasthan, Jammu and Kashmir, Haryana, Punjab, Madhya Pradesh, Chattisgarh, Odisha, Karnataka and Maharashtra) under irrigated conditions. Average yield is 230 q/ha, good in storage (up to 4 months) with about 30% storage losses, has 11.07% TSS. It is has field tolerance to thrips.

Garlic

Yamuna Purple-10 (G-404): Bulbs are compact, attractive light purple with creamy flesh. Diameter of bulb varies from 4.8 to 5.5 cm, 25–30 elongated cloves/bulb. Bulbs contain 39–40% Total Soluble Solids, 42.9%

dry matter and 26.8 micro mole pyruvic acid/g. Crop matures in 160–170 days after sowing. The productivity ranges between 165–175 q/ha. It has been identified for growing in Zone II (Delhi, Rajasthan, Haryana, Jammu & Kashmir and Punjab) and Zone IV (Punjab, *Tarai* region of Uttar Pradesh, Uttarakhand, Bihar and Jharkhand).

Potato

Kufri FryoM, is medium maturity (90–100 days) with 300–350 q/ha productivity and field resistant to late blight. It is suitable for cultivation in North West and Central plains and similar agro-ecologies. It is suitable for French fries.

Kufri Karan, has high resistance to late blight, viruses and moderate resistance to PCN with high dry matter (18.8%) and good keeping quality of tubers. It has 270–290 q/ha yield potential in 100–120 days, suitable for both table purpose and processing. It has been identified for cultivation in Indian hills and Plateau region.

Kufri Manik, has field resistance to late blight, produces attractive, deep red, ovoid tubers with shallow eyes and whitish pulp. The variety has high levels of anthocyanin (0. 68 µ/g FW), carotenoids (33 µ/100 g fresh weight), micro nutrients (Zn, Fe, Cu and Mn), waxy texture with good flavours and taste. It has 300–320 q/ha yield potential and identified for cultivation in Eastern plains of India.

Kufri Sahyadri, has combined resistance to potato cyst nematode (PCN) and late blight with 280–350 q/ha yield potential. Tubers are oval with light yellow peel and yellowish pulp and shallow deep eyes, suitable for table purpose and processing. It has been identified for cultivation in Nilgiri Hills of India.

Kufri Thar-1, has been identified for cultivation in East coast plains & hills and Middle Gangetic plains. It has high dry matter (19%) in tuber, medium maturity (90–100 days) with production potential of 300–350 q/ha.

Kufri Thar-2, has been identified for cultivation in western dry regions, Central plateau and hills with 300–350 q/ha yield potential in 90–100 days with high dry matter (20–21%) in tubers. It is resistant to late blight.

Kufri Thar-3, has white tubers suitable for table purpose, identified for cultivation in trans-gangetic plains, upper gangetic plains and Eastern plateau and hills region. It has medium maturity with 300–350 q/ha potential productivity.

Kufri Sangam, is dual purpose (processing into French fries & table potatoes) hybrid identified for cultivation in central plains for both table and processing purposes. It has medium maturity (90–100 days) with 350–400 q/ha production potential.

Hybrid Kufri Chipsona-4, is suitable for processing into chips owing to its round tubers and high dry matter (>20%), identified for cultivation in southern plateau and hills region, lower gangetic plains, central plateau and hills region and Gujarat plains and hillls. It has medium maturity (90–100 days) with 300–350 q/ha productivity potential.

Sweet potato

Promising sweet potato accessions identified: Accession No. 47 and 52 were the high yielders (1 kg/plant) followed by accession No. 73 (900 g/plant) and accession 56 (700 g/plant). Two accessions, viz. Accession 80 and 88 had good tuber shape with potential for processing into fried chips making.

Promising elite lines of sweet potato

Yam bean

High yielding elite lines of Yam bean identified: Accession No. 39 was the highest yielder (1.25 kg/plant) followed by Accession no. 9 (1.2 kg/plant), Accession No. 10 (1 kg/plant) and Accessions No. 54 and 57 (900 g/plant).

Promising elite lines of yam bean

Elite sweet potato lines for processing: Four accessions with white flesh and productivity (SPH 65, SPH 19, SPH 61 and SPH 60; yield ranged from 22–25 t/ha) and another four hybrid accessions with orange flesh (SPH 44, SPH 21, SPH 52 and SPH 40; yield ranged from 20–22 t/ha) were identified.

White flesh sweet potato hybrid SPH 65

Orange flesh sweet potato hybrid SPH 44

Similarly, five purple fleshed, promising hybrid lines (SPH 31, SPH 30, SPH 29, SPH 15 and SPH 14: yield ranged from 22–24 t/ha) having very less (>5%)

weevil infestation were identified. SPH 29 had no weevil infestation whereas, SPH 30 had good shape and may be used for fried chips making. It also showed deep purple colour and could be used for anthocyanin extraction. Hybrid progenies such as, SPH 14, 15 and 31 had less amount of latex which are good for table purpose.

Promising elite line of yam: A promising line of yam 'SD-15' with significantly higher yield (36 t/ha), good tuber shape and culinary quality than the check variety Sree Dhanya (23.5 t/ha) was identified.

Tubers of white yam 'SD-15'

Greater yam: Sree Hima, has been identified for cultivation in Kerala with higher productivity (38 t/ha), medium sized, digitate, fused tubers with dark brown skin, purple rind and white flesh. It has medium starch (21%) and crude protein content (4.8%).

Greater yam var. Sree Hima

FLOWERS AND OTHER ORNAMENTAL PLANTS

Gerbera

Arka Red: Flowers are double and bright red, yielding 360 flowers/m^2/ year. Under Bengaluru conditions, it is suitable for growing outdoors throughout the year for display in beds or cut flower production.

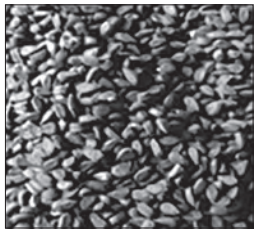
Spices

Nutmeg: IISR-Keralashree, is a high yielding (75.6 q nut/ha and 15.12 q mace/ha), high quality nutmeg variety developed through farmer's participatory breeding, suitable for growing in Kerala and Tamil Nadu.

Seed spices

Ajmer Ajwain-73, is medium maturing (165–170 days) and high yielding (10.7 kg/ha) variety with seeds containing 9.15% total oil and 6.38% essential oil.

Ajmer Nigella-1 (AN-1) has 9.09 q/ha potential seed yield. It is medium maturity (145–150 days) and the seeds contain 19.7% total oil. Total oil fraction contains 21.14% 9-Octadecenoic Acid (Oleic Acid), 3.32% Octadecenoic Acid (Oleic Acid), Cis-11, 14-Eicosadienoic Acid (3.14%). This variety is tolerant to root rot.



Medicinal plants

Isabgol: A stable tetraploid (2n=4x=16) (DTPO6-6) line of isabgol was developed from the variety GI 2 using colchicine (0.1 to 0.5%) seed treatment. The tetraploidy was confirmed through flow cytometry, root anatomy, phenotypic observation and cytology. The tetraploid was fertile and stable over the years (2010–2017). Morphologically the tetraploids were more vigorous than the diploids but late maturing. The anatomical comparison revealed that the size of xylem and phloem of stem and inflorescence stalk were larger in tetraploids than diploids. The seed yield was higher in tetraploids than the diploids.

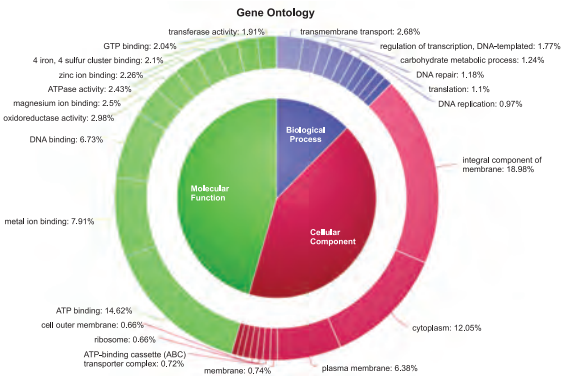
Bach (*Acorus calamus*): A new, high yielding variety, of bach (*Acorus calamus*) namely, Swarna Swara (APAc-5) was identified for cultivation in Andhra Pradesh, Kerala, Karnataka, Assam, Chhattisgarh, West Bengal, Himachal Pradesh, Uttar Pradesh, Odisha and North Eastern States. It has higher (69.05%) rhizome yield (27.8 q/ha) as compared to check Symbolia. The beta-asarone content in APAc-5 is 15.9 mg/g.

Mushrooms: A total of three strains, two in Button and one in Milky mushroom were released.

DMR-button-14 and DMR-button-59 giving average yields of 23–25 kg and 22–24 kg/100 kg compost. The

Cashew

Cashew genome assembly and annotation: For the first time, a draft genome sequence of the popular Indian cashew cv. Bhaskara was generated using the hybrid genome assembly approaches. The total genome assembled is about 385 Mb arranged in 4,981 scaffolds, with N50 value of 2.55 Mb. The gene prediction and annotation of the assembled genome revealed a total of 40,264 protein coding genes, of which 32,194 were annotated and 8,070 were un-annotated. Further, a total of 47,646 microsatellites were detected comprising of 59% of di-repeats followed by 24.4% tri-nucleotide, 3.6% of tetra-nucleotide, 1% of penta-nucleotide, and 0.8% of hexa-nucleotide repeats and 11.1% complex microsatellite motifs. The decoding of cashew genome forms the basis for genomics assisted breeding in cashew to improve yield, biotic and abiotic stress tolerance, altered plant stature, quality traits and other useful traits.



Graphical annotation of draft genome sequence of cashew cv. Bhaskara

two strains gave 15% and 9% yield increase over control.

DMR Milky-985 has spherical pileus and long stipe, and higher average fruit body weight (47 g). The higher biological efficiency (55.7%) and 5.6% yield increase was observed in DMR Milky-985 as compared to control (52.6% BE).

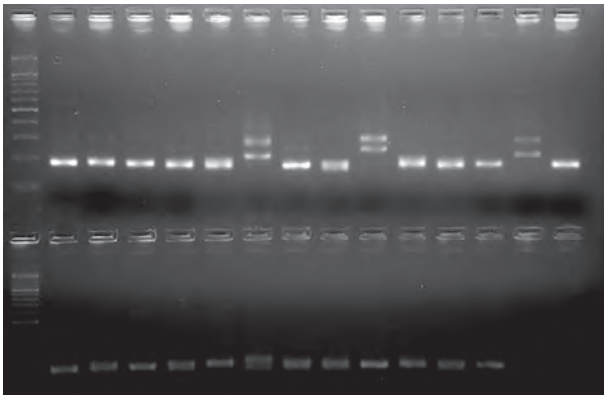
Biotechnology

Plantation crops

Medicinal plants

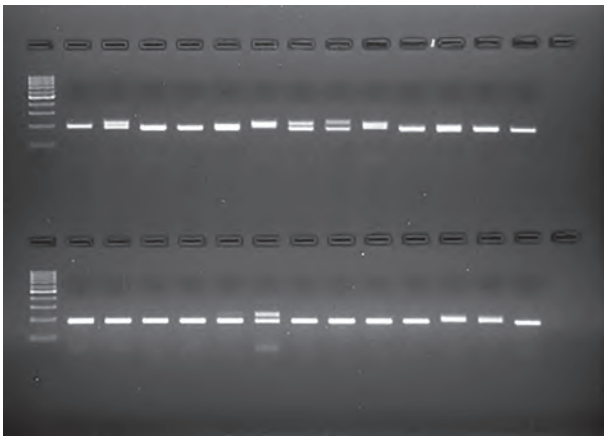
Assessment of genetic diversity of *madhunashinee* (*Gymnema sylvestre*) germplasm by SSR markers: Of the 100 SSR markers used for screening of 26 genotypes of madhunashinee (*Gymnema sylvestre*), 58 primers produced alleles ranging from 1 to 6; with maximum number of alleles (6) being in XDAGSM10 showing maximum (0.602) polymorphic information content (PIC) and allelic diversity (0.662). It was followed by the XDAGSM55 having maximum PIC (0.607) and allelic diversity (0.671). These two are highly efficient polymorphic markers and can be used to distinguish the germplasm of *G. Sylvester.*

Maximum genetic similarity value (0.968) was observed between genotypes DGS-21 and DGS-5 and minimum (0.384) between genotype DGS- 26 and DGS-17.



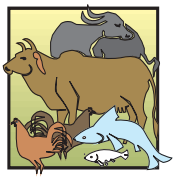
Profile of XDAGSM10 primer with 26 germplasm of *Gymnema sylvestre*

New genomic SSR markers for Isabgol developed: Raw reads (24.3 gb) of the isabgol genome were downloaded from the SRA-NCBI database and *de novo* assembled using CLC software. There were 2,43,681 contigs sequences of 292,141,447 bp obtained with



Profile of XDAGSM69 primer with 26 germplasm of *Gymnema sylvestre*

an N50 of 2,912 bp. SSR search using MISA yielded 3,14,206 SSRs with a frequency of 1.08/kb. Over 2,00,000 genomic SSR markers were developed of which 100 SSR markers validated by PCR amplification. ❑



6. Livestock Improvement

Cattle

Development of a crossbred strain of cattle Frieswal: On 3 November 2019, DG declared Frieswal as a breed and subsequently obtained a trademark Frieswal™ (Indian Patent Office No. 4361504 dated 28-11-2019). Established a bull mother farm of Frieswal cattle at ICAR-NDRI, Karnal by selecting 208 Frieswal cows/heifers from 850 elite cows belonging to 18 Military Farms for production of young male calves for Field Progeny Testing Programme.

Total 65,543 doses of Frieswal bull semen were produced cumulating to 4,695,266 doses since the inception of the project. At present, a total of 2,055,322 semen doses are available in the stock. During the period, 7,319 semen doses were distributed to Military Farms, and 22,829 doses were sold to para-vets, state AH Departments, LDBs, and SAUs.

Genetic improvement of crossbred cattle under-Field Progeny Testing Project (FPT): Under the Field Progeny Testing (FPT) project, the increase since 1995 to 2019 in average first lactation 305 days milk yields of the Frieswal progenies was recorded as 67.77% in KVASU (3285.69 kg vs 1958.4 kg), 41.95% in GADVASU (3829.6 kg vs 2697.8 kg), 12.41% in BAIF (3294.3 kg vs 2930.4 kg) and 36.07% in GBPUA&T unit (3394.8 kg vs 2494.8 kg). Also, the average age at first calving (AFC) of Frieswal progenies in corresponding period decreased by 15.77% in KVASU (957.1 days vs 1136.4 days), 31.91% in GADVASU (811.6 days vs 1192 days), 18.79% in BAIF (793 days vs 976.5 days), and 14.2% in GBPUA&T unit (985.8 days vs 1149 days).

Genetic improvement of indigenous cattle breeds through Progeny Testing: Under the Indigenous Breeds Project (IBP), genetic improvements of three breeds, viz. Gir, Kankrej and Sahiwal were carried out through the selection of elite animals maintained at the Germplasm (GP) unit and also at Associated herds (AH) maintained by different agencies including farmer herds in the respective breeding tract.

Release of Frieswal

Dr Trilochan Mohapatra, Secretary (DARE) & DG (ICAR) released 'Frieswal' a national milch crossbred cattle variety on 03-11-2019 during the inaugural function of 'National Conference on Livelihood Improvement through Sustainable Livestock Production' and IV Annual Convention of Pashu Poshan Kalyan Samittee (PPKS) organized on the occasion of the 33rd Foundation day celebrations of ICAR-Central Institute for Research on Cattle, Meerut. The average milk production potential of Frieswal cows based on 300 day milk yield is more than 3,335 kg. The mature lactation milk yield of Frieswal cows is 3,628 kg.

Network Project on Buffalo Improvement

All India Coordinated Research Project on buffaloes was initiated in the year 1970–71 and the main thrust was to test the sires with a view to produce proven bulls for enhancing milk production. In 1993, this was changed to Network Project on Buffalo Improvement and running at ICAR-Central Institute for Research on Buffalo, Hisar. Progeny testing in Murrah Breed is carried out at six participating institutional /SVU centres, viz. CIRB Hisar, NDRI Karnal, IVRI Izatnagar, GADVASU Ludhiana, LUVAS Hisar and ICAR Research Complex for Eastern Region Patna. About 17,200 artificial inseminations were carried out in 2019–20 at farmer's doorstep in the village to produce daughters. The milk yields of daughters are being recorded for use in sire evaluation.

At present, 5 important breeds of buffaloes namely Murrah, Nili Ravi, Jafrabadi, Surti and Bhadawari are being addressed under the Network Project. About 1,044 breedable buffaloes are being maintained at institutional Murrah centres for production of high genetic merit male and female calves. There are 15 superior Murrah bulls (3 bulls from CIRB Hisar, 4 bulls from GADVASU Ludhiana, 4 bulls from LUVAS Hisar and 4 bulls from NDRI Karnal are in the XVIII set being used since 01-01-2019 onwards till June 2020). So far, 234 superior bulls have been test-mated in 17 sets. Data of 581 daughters born from the 13th set of bulls which completed 1st lactation was compiled and bulls were evaluated. Bull no. 2234 and 2269 from GADVASU, Ludhiana ranked first and second with sire index value of 2,688 and 2,619 kg, respectively. The percent superiority over their contemporary daughters was 14.80 and 13.86%, respectively.

Elite herds of Jaffarabadi, Surti, Bhadawari and Nili Ravi breeds of buffaloes have been established in their respective breeding tracts. Semen freezing laboratories have been established at all the centres. Nili-Ravi and Bhadawari breed centres are functioning as conservation and improvement units, and Jaffarabadi and Surti breed centre are concentrating on field progeny testing along with maintaining the elite herd for bull production and testing. A breedable herd of 682 of four breeds (Nili-Ravi-355, Jaffarabadi-213, Surti-66 and Bhadawari-48) is being maintained. A total of 404,827 semen doses produced and 450,262 semen doses were sold/used.

Murrah breeding bull's 327,997 semen doses production and 40,813 dissemination of Murrah breeding bulls was there, in other breeds 76,830 semen doses produced and 42,131 disseminated i.e sold/used in farm herd/ field under field progeny testing program.

Sheep

The project includes farm and field based cooperating centres located in various ICAR Institutes and SAUs/ SVUs. Presently, there are six ongoing cooperating centres with its coordinating unit at ICAR-CSWRI, Avikanagar. Four of these units are farm based units while two of them are field based units. The body weight at 12 months in Muzzafarnagri, Deccani and Nellore were 37.73±0.52, 29.57±0.34 and 25.00±0.48 kg, respectively. In field units, Madras Red and Mgra had 20.72±0.17 and 28.94±0.13 kg body weight, respecyively at 20 weeks.

Mega Sheep Seed Project (MSSP): There are four cooperating units, viz. KVAFSU, Bidar for Mandya Sheep; TANUVAS, Chennai for Mecheri Sheep; RAJUVAS, Bikaner for Sonadi Sheep and ICAR-CSWRI, Avikanagar for Malpura sheep with project coordinating (PC) unit at ICAR-CSWRI, Avikanagar. The major objective of the project is improvement of indigenous sheep breeds by propagation of superior germplasm in the farmers' flock by each unit.

Mecheri sheep flock

Distribution/sale of superior breeding rams and ewe covered

Unit (Breed) sold	Rams distributed/ coverage by rams	Breedable ewes
Mandya	75	2,058
Mecheri	134	2,050
Sonadi	62	1,610
Malpura	75	2,873
Total	346	8,591

Goat

A total of 345 improved goats germplasm of different breeds were supplied to farmers and different developmental agencies for improving production performance in field conditions. The institutional flock of Jakhrana goats exhibited an average milk production of 147.72±3.66 liters in 90 days and 192.40±5.58 liters in 120 days.

Body weight gain and lactation performance of goats

Barbari: The overall least squares means of part lactation milk yield in 90 and 140 days were 84.52±2.08 and 117.69±4.16 liters. Year of kidding had significant influence on all the lactation traits.

Jamunapari: The least squares means of body weight of kids at birth, 9, and 12 month were 18.86±0.34 and 22.69±0.23 kg, respectively. Least square means for total lactation yield and lactation length were 82.46±1.13 litres and 113.61±2.13 liters, respectively.

Developed database of goat milk proteins and peptides: A database of more than 2,000 proteins and peptides in milk samples collected from various tropical goat breeds was developed which would potentially be used for multiple human health benefits.

Camel

The PCR products (TLR 4 exon 2) were sequenced, submitted to NCBI (accession no: MT365024) and analyzed. One polymorphic SNP at the positions in 5' UTR region of TLR4 gene was identified, whereas no SNPs were found in exons. The phylogenetic analysis was also performed.

Mithun

Follicular dynamics studies in pubertal mithun animals: The follicular dynamics concerning the changes in concentrations of hormones during the estrous cycle in pubertal mithun was evaluated.

Pig

Generation-wise genetic evaluation of Rani pig crosses: A high producing crossbred pig variety Rani was developed and released by ICAR-NRC on Pig. The breed characters of Rani crossbred was stabilized. Top 3 and 8% of male and female were selected for producing subsequent generation based on performance traits.

Poultry

Improvement of germplasm

Rural poultry germplasm: Two male lines, PD-1 (Vanaraja male line) and PD-6 (Gramapriya male line) and two female lines, PD-2 (Vanaraja female line) and PD-3 (Brown egg layer line) were improved. The genetic and phenotypic response to selection for higher shank length at 6th wk in PD-6 was 2.39 and 1.44 mm, respectively, over the last 9 generations. In PD-3 line (S-8), the direct selection response over the last seven generations was 151.5 g on genetic scale and 79.7 g on phenotypic scale for egg mass at 40 wks, the primary trait of selection.

PD-6 adult birds

Native chicken populations: In Vanashree (PD-4) population (S-10), the shank length improved at 8 wks of age by 1.1 mm, while the egg production up to 40 wks of age (80.16) improved by 6.15 eggs compared to S_0. In Ghagus native population, body weight at 8 wks (471.7 g) increased by 36.5 g in the S-2 generation.

The hen housed egg production (73.0 eggs) up to 40 wks of age in Nicobari breed increased by 10.5 eggs compared to S_0. Body weight at 4 (211.4 g) and 8 (492.3 g) wks of age in the next (G-7) generation increased by 110 and 90.6 g, respectively, compared to S_0. In the Kadaknath population, procured from Jabalpur Centre, body weight at 8 wks was 376.3 g.

A pair of Vanashree

Nicobari male

Evaluation of crosses for rural poultry farming: A total of five crosses were produced by crossing Aseel males with females of PD-1, PD-2, PD-6, PB-1 and PB-2 lines and evaluated up to 12 wks of age. Aseel crosses with coloured broiler lines (PB-1 and PB-2) had higher body weights, while Aseel × PD-1 cross recorded higher shank length at all the ages. Aseel crosses with PD-1 and PD-6 had suitable body weight, and optimum meat quality traits with overall acceptability like native chicken meat.

Kadaknath chickens

A two-way cross (PD-1 × PD-4) was evaluated under farm and field conditions. The sixth week body weight was 578.2 in male and 548 g in females. Under field evaluation in Thatiguda village, Adilabad district, the body weight at 12 weeks was 1.3 kg in cocks and 1.0 kg in hens, and the hens produced 39 eggs up to 40 wks of age with 50 g egg weight.

Aseel × PD-1 cross

2-way cross birds in the rural backyard

Broiler populations: In the PB-1 line (S-28), the egg production increased by 5.7 eggs as compared to the last generation. In PB-2 line (S-28), the phenotypic and genetic response to selection for the 40 wks egg production over last 15 generations was 0.29 and 0.78 eggs per generation, respectively. To increase the variability and improve the juvenile growth traits of PB-2 line, settable eggs were obtained from Bengaluru centre of AICRP. The body weight and breast angle at 5 wks of age in this new population were 1,042 g and 80.7°, respectively.

Layer populations: Three layer lines, viz. IWH, IWI and IWK are under selection for higher egg numbers up to 64 wks of age, whereas IWD, IWF and Layer Control (LC) are under random breeding programme. The ASM increased across all the lines during the year. The annual egg production of IWH was 297 eggs. The egg weight of IWH, IWI and IWK at 64 wks was 56.9, 55.3 and 56.9 g, respectively.

Poultry breeding

At Mannuthy centre, the egg production up to 40 wks was 79.0 eggs in the native chickens (S-4) with egg weight of 43.0 g. The genetic response per generation was 4.58 eggs in IWN. At the Anand centre, the egg production of Ankleshwar chicken up to 40 wks was 71.1 eggs. Egg production up to 72 weeks (EP 72 wk) was 324.5 in IWN and 306.3 eggs in IWP strain, whereas EP 40 wks was 116.7 in IWD and 114.7 in IWF strain. At the Bengaluru centre, the 5 wk body weight was 1,247 and 1,093 g in PB-1 and PB-2, respectively, and the EP 40 wks in PB-1 and PB-2 lines were 55 and 53 eggs, respectively.

At the Ludhiana centre, the 5 wk body weight was 1,237 and 1,156 g in PB-1 and PB-2, respectively. In Punjab Brown, the 8 wk body weight was 767.1 g. The EP 40 wks of age was 56.12 eggs. At the ICAR-CARI, Izatnagar centre, the 40 wk egg production was 68 and 69 eggs in CSML and CSFL, respectively. At the Bhubaneswar centre, Hansli birds matured at 176 days and laid 34 eggs up to 52 wks of age. The phenotypic response for 5 wk body weight in CSFL and CSML over the last eight generations was 38.4 and 59.6 g, respectively. At the Tripura centre, the body weight at 20 wks was 1,821 and 1,378 g in male and females of 3-way cross under farmer's backyards. The annual egg production (AEP) was 133 under field conditions and 162 in farm conditions. At Jabalpur centre, the body weight at 40 wks was 2,130 and 1,570 g in Jabalpur colour and Kadaknath, respectively. The egg production up to 52 wks was 161 eggs in Jabalpur coloured population and 94 eggs in Kadaknath. The Narmadanidhi variety produced 94 eggs under field conditions up to 52 wks. At the Guwahati centre, the body weight at 20 and 40 wks was 1,021 and 1,681 g, respectively in Daothigir indigenous breed of Assam. The EP 52 wks was 76 eggs with an egg weight of 44 g in Kamrupa variety.

At the Ranchi centre, the body weight of native chicken at 20 wks was 1,476 g in males and 1,181 g in females, while the 64 wk egg production was 71 eggs. The body weight of Jharsim at 20 wks was 1,830 and 1,670 g in males and females, respectively, and AEP was 148 eggs under field conditions. The AEP of Himsamridhi was 146 eggs under field

conditions. At Udaipur centre, the body weight at 40 wks was 1,700 and 2,300 g in female and male birds of Mewari, respectively. The annual egg production was 160 eggs in Pratapdhan under field conditions. A total of 8,75,866 chicken germplasm was distributed to the farmers from different centres with a total revenue generation of ₹ 222.01 lakhs.

Poultry Seed Project

The Poultry Seed Project was operated at 12 centres across the country. A total of 417,813 improved chicken varieties were distributed by different centres in their respective regions/states with a revenue receipt of ₹ 133.12 lakh during the year 2019.

The Vanaraja chick were supplied by Kolkata (11,053), Patna (71,700) and ICAR-NOFRI Gangtok (96,815) centres. Jharnapani centre distributed 79,375 improved chicken germplasm to farmers of Nagaland and neighbouring states. Manipur Centre distributed 38,709 improved chicken germplasm to the farmers. Hosur, Tamil Nadu Centre distributed 127,327 improved rural chicken (Vanaraja and Gramapriya) germplasm. Goa centre supplied 39,893 improved chicken germplasm. Port Blair centre distributed 22,063 improved chicken germplasm (Vanaraja and Srinidhi) to farmers in Andaman and Nicobar Islands. ICAR-RC for NEH Region, Umiam, Barapani, centre distributed 12,606 improved chicken germplasm. SVVU, Tirupati supplied 31,858 chicks to the farmers. PVNRTVU, Warangal distributed 24,794 improved rural chicken germplasm was distributed to the farmers.

Genetic improvement of elite germplasm of Japanese quails: Genetic improvement in different elite germplasms of J. quail was continued. Feed conversion ratio (FCR) from 0 to 5 weeks in different crosses ranged from 2.81±0.02 to 3.22±0.02.

Genetic improvement of guinea fowl germplasm: Average body weight at 12 weeks in pearl, lavender and white varieties were 1145±1.5, 1130±7.0 and 875.8±7.25 g, respectively.

Conservation and utilization of indigenous chicken: A total of 13,614 good chicks of different pure breeds of chicken were produced with pooled fertility % as 64.04 and hatchability on total egg set as 71.44. Gain of 5.6% in 20 week body in Aseel was achieved in third generation of selection.

Farm evaluation of new crosses -CARI Dhawal and CARI Neera Safed: Average liveability in corresponding crosses were 95.31 and 92.30. Overall 20-week body weights were 1499.64±14.31 and 1655.18±24.86 g, 52-week egg production were 184.78±1.53 and 183.05±1.47 with an egg weight (52 week) as 61.02±1.21 and 59.61±1.87 g.

Genetic improvement of turkey

- **Higher body weight turkey**: Average body weight at 12, 18 and 26 weeks of age were 1,549.7, 2,915.3 and 3,908.1 g, respectively. Average age at first egg was 241.8±6.81 d with peak egg production (17.46±3.30) during 53–56 weeks of age.
- **Small size turkey**: The overall body weight of Black and Multicoloured turkey birds at 36 weeks was 3,298.9 and 3,384.5 g, respectively.
- **Germplasm supplied**: Approximately 50,000 diversified poultry germplasm was supplied to more than 150 beneficiaries belonging to more than 9 states.

Fisheries

Breeding of ornamental and food fishes: *Channa stewartii*, commonly known as the Assamese snakehead or golden snakehead, is an indigenous ornamental fish. The species collected from beels of Assam were raised to broodstock in concrete tanks. Upon attaining maturity, the males (160–190 g) and females (250–300 g) were selected and kept in breeding tanks for natural spawning. After spawning, hatchlings were allowed to be with the parents as this fish exhibit parental care. After three weeks, the hatchlings (25–29 mm/0.18–0.29 g) were reared separately.

Channa stewartii

Silver moony, *Monodactylus argenteus*

Silver moony, *Monodactylus argenteus*, is a brackish water ornamental fish, which can be adopted to freshwater. The complete technology of breeding and seed production of silver moony was developed and is ready for transfer and entrepreneurship development.

Captive breeding and seed production of an important food fish, Mangrove red snapper, *Lutjanus argentima culatus*, was successfully undertaken, which not only

Mangrove red snapper, *Lutjanus argentima culatus* and its different stages of development

is a suitable species for farming in brackish water ponds and open cages, but it also grows fast, tolerates a wide range of salinities and accepts pelleted feed.

Three rare and endemic fish species from Western Ghats, viz. Nilgiri Mystus *Hemibagrus punctatus*, *Clarias dussumieri* and Peninsular carp *Puntius kolus*

Male *Puntius kolus*

Female *Puntius kolus*

(also called *Hypselobarbus kolus*) were collected from the wild, developed to broodstock and successfully bred in captivity.

Hemibagrus punctatus

Maze rabbit fish/ vermiculated spine foot, *Siganus vermiculatus*, a marine herbivore fish was successfully induced bred and further successful larval rearing was undertaken with manipulation of water quality parameters and feeding protocols. For breeding, the wild-captured fishes were reared in the sea-cage farm. On attaining maturity, brooders were transferred to the hatchery complex and induced bred. The estimated fecundity was about 1.8 lakh eggs. Eggs were demersal and adhesive which hatched after 24 h, with >80% hatching rate. The green-water technique was used for egg incubation and larval rearing. Copepod, *Parvocalanus crassirostris*, rotifers (S type and L type), *Artemia* and artificial pellet were used during larviculture. The larvae attained metamorphosis at 2.5–2.8 cm total length after 36 days of rearing and survival of 12% was recorded after 60 days.

Adult maze rabbit fish

Juveniles of maze rabbit fish

Developed portable FRP pabda hatchery: Designed and fabricated a portable fiber glass reinforced plastics (FRP) hatchery for pabda (*Ompok bimaculatus)*. The hatchery consists of three cylindro-vertical hatching/incubation pools placed one above other on a triangular iron frame and three rearing tanks of a specific design. It possesses the capacity to accommodate 45,000–50,000 fertilized eggs, which produce 10,000–15,000 early fry in a single cycle. After successful evaluation and validation, the hatchery was released.

Multiple stocking and multiple harvesting (MSMH) model for milkfish farming: Milkfish, *Chanos chanos*, a herbivorous fish, is an ideal species for low input based brackish water fish farming. By adopting multiple stocking and multiple harvesting (MSMH) farming models with milkfish, the productivity could be increased in small and traditional ponds.

Haul of milk fish

Stocked with the fingerlings of 10–12 g at the stocking density of 7,500–15,000/ha and fed with formulated feed (CP 30%) @ 3–4% of body weight, the fish attained a size of 120 g after 90 days of culture period. After partial harvesting, the ponds were stocked with advanced fingerlings to maintain the initial stocking density. In 180 days, this model yielded a production of 3.0–3.8 tonnes/ha with a benefit cost ratio of 1.50–1.66.

❑

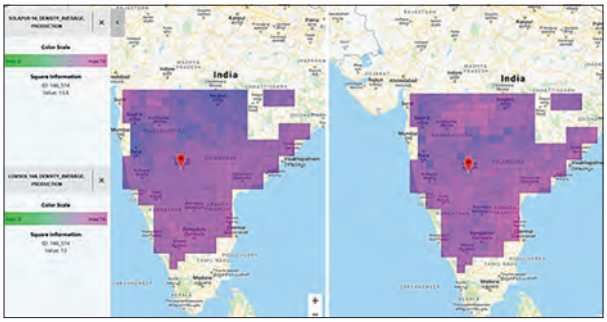
“We must enable farmers to feed Indian and the world; and earn a good livelihood.”

— Narendra Modi

7. Crop Management

Crop Production

Decision support tool (APSIM) to design suitable crop management in sorghum: A decision support tool (APSIM) to design suitable crop management in sorghum interventions for locations and to optimize *rabi* sorghum systems productivity is being developed. Simulation study indicated that refined APSIM setup with gridded NASA data could be successfully used to simulate yields of *rabi* sorghum across different parts of India. The support system allows its practical use by farmers/researchers for taking decisions on site specific management options for optimizing the G×E management for augmenting grain yield.



Overview of interactive map - Variation in average plant density of *rabi* sorghum for Gulbarga region.

Organic farming in pigeon pea: Work on organic farming (OF) in pulses especially in long duration pigeon pea (LDP) showed that higher crop performance could be realized with OF vis-à-vis inorganic or recommended practice. Highest productivity in LDP was observed when relatively narrow plant density (75×20 cm v/s 90×20 cm recommended for LDP) was maintained especially under low soil fertility/lighter soils under IGPs. Similarly, significantly higher grain yield in chickpea was recorded with organic practice alone [FYM 5 t/ha + biofertilizers (Biozinc + Biophos)].

Performance of IPM 205-7 mungbean under conservation agriculture (CA): Under CA-practices extra early summer mungbean variety IPM 205-7 (Virat) performed better and can be recommended under CA in rice–wheat–mungbean system for cropping system intensification.

Performance of Virat—An early mungbean variety with 55 days extra in IGP.

Cropping system in Peninsular region: Intercropping of maize +cowpea (1:1) was most effective with higher grain yield of maize (66 q/ha) compared to that in maize–chickpea system (63.90 q/ha). On liquid fertilizer supplementation, highest grain yield of cowpea DC-15 was recorded in water soluble complex fertilizer applied (1%) at flowering stage (60 DAS) in the peninsular India.

Maize+ cowpea (1:1) intercropping at Dharwad (Peninsular India).

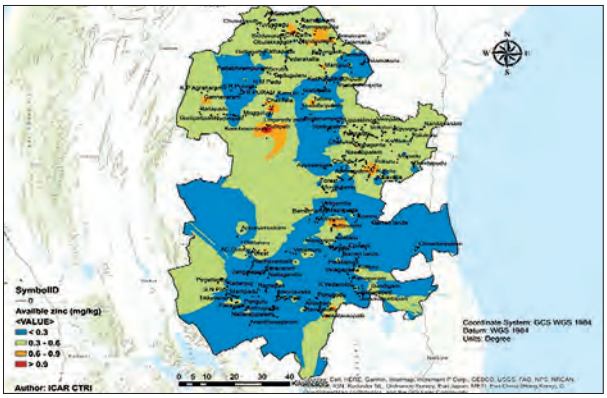
Cropping intensity enhancement: Crop intensification with fox tail millet (*korra*) as pre-*rabi* crop, is recommended in rainfed *Alfisols* of Prakasam district for additional net income of ₹ 10,000 to 25,000/ha, where farmers normally grow tobacco and Bengal gram in *rabi* season.

Tail millet in rainfed *Alfisols* of Prakasam district.

Efficient cropping system: Maize-tobacco cropping system is recommended as remunerative cropping system in terms of tobacco leaf equivalent yield (2,380 kg/ha) and net returns (₹ 139,285) for enhancing the farmers' income in FCV tobacco growing *Vertisols* of Andhra Pradesh.

Maize–tobacco cropping system in Vertisols of Andhra Pradesh.

Soil fertility maps for FCV tobacco area: Soil fertility thematic maps were developed for FCV tobacco growing Southern Light Soils of Andhra Pradesh. These fertility maps used to rationalize fertilizer use and ensure balanced nutrition for obtaining higher yields and quality of FCV tobacco.



Available zinc in southern light soils of FCV tobacco.

System efficiency enhancement through conservation technologies

Tillage systems: The maximum soybean yield was recorded under conventional tillage carried out after two years (CR-RR-RR-CR) and remained at par with sub soiling once in four years (SS) and conventional tillage carried out every year. The minimum yield was associated with single cultivator (SR-SR-SR-SR). The highest *rabi* yield was recorded with conventional tillage carried out after two years (CR-RR-RR-CR) and remained at par with reduced tillage every year (RR-RR-RR-RR) and conventional tillage alternate year (CR-RR-CR-RR). The lowest yield was noted with sub-soiling once in four years. The maximum soybean equivalent yield was associated with conventional tillage carried out after two years (CR-RR-RR-CR) and remained at par with conventional tillage carried out either once in four years (CR-RR-RR-RR) or alternate year (CR-RR-CR-RR) or every year (CR-CR-CR-CR). The reduced tillage and sub-soiling yielded lower than conventional tillage. The highest net returns were associated with conventional tillage carried out either once in four year (CR-RR-RR-RR) and remained at par with all the treatments except single cultivator (SR-SR-SR-SR). The maximum B : C ratio was with sub-soiling (SS). Similar trend was also observed in net energy and energy use efficiency. The highest carbon input, output and carbon use efficiency (CUE) was incurred under conventional tillage carried out every year (CR-CR-CR-CR). The highest carbon productivity was recorded with conventional tillage carried out after every two years. The carbon sustainability index was with conventional tillage carried out every year or alternate years and remained at par with reaming treatments of conventional tillage.

Cropping systems: The soybean yield remained unaffected due to preceding crops like wheat, chickpea and mustard. However, the soybean yield was marginally higher to the tune of 2.57 and 0.95% when preceding was mustard and wheat. When comparing the *rabi* crops yield, the maximum tonnage was recorded with wheat followed by chickpea and mustard. Similar was the case with reference to soybean equivalent yield (SEY). Soybean–wheat cropping system was found to be the most remunerative, energy and carbon efficient than soybean–chickpea and soybean-mustard.

Effect of organic and inorganic management on productivity of soybean-based cropping systems: Three management systems (organic, inorganic and integrated) and two cropping systems, i.e. soybean–wheat and soybean–chickpea were tested. Soybean yielded higher (2.32%) when grown after chickpea crop than wheat. Soybean–wheat cropping system was more productive with less variability over years, remunerative and sustainable than soybean–chickpea cropping system. Among the management systems, the integrated management system showed their superiority over inorganic and organic management systems with regards to production with less variability over the years, economic gain and sustainability. While organic management system was more stable than integrated and inorganic systems. Soybean-chickpea cropping system was the most viable system under organic management system.

A novel *Rhizobium* recovered for Indian soybean rhizosphere—*Bradyrhizobium daqingense*: A novel rhizobial strain *Bradyrhizobium daqingense* (NCBI Accession No. KX230052) was isolated for the first time from root nodules of soybean (drought-tolerant line PK-472). This strain along with other strains was evaluated on soybean under simulated moisture stress

Field evaluation of novel *Bradyrhizobium daqingense* on soybean (JS 95-60).

conditions to enhance soybean nodulation, growth and physiological status of plants under stress conditions under ICAR-NBAIM-AMAAS Network sub-project. The application of *B. daqingense* in soybean improved plant fitness against stress and performed better, which signify the role of this inoculant in stress tolerance of soybean plants. The co-inoculation of *Rhizobium* with arbuscular mycorrhizal fungi at 75% RDF, produced significantly higher yield than control (100% RDF) and saved 25% use of N fertilizers without compromising productivity.

Role of ethylene during fibre development in cotton: Tissue specific expression of ACS (1-aminocyclopropane-1-carboxylic acid synthase) and ACO (1-aminocyclopropane-1-carboxylic acid oxidase) in six medium long to long-linted desi cotton (*Gossypium arboreum*), viz. PA812, PA 760, PA 528, PA 402, DLSa 17, CNA 1041 genotypes and a short staple check- Phule Dhanwantary was planted under high density planting system. Results showed higher expression of both these enzymes in ovules as compared to subtending leaves of bolls. Temporal expression analysis of the same revealed their involvement in early fibre elongation stage than fibre initiation stage. A positive correlation was established between the amount of ethylene and fibre length of respective genotypes, wherein, genotypic variation of ethylene may be accredited as responsible factor to decide final fibre length. Further, role of two candidate genes; BONZAI and PEX1 involved in H_2O_2 and other ROS (Reactive Oxygen Species) homeostasis during fibre development was confirmed and re-validated in *G. arboreum*.

Development of phosphate solubilizing bio-fertilizers for fodder crops: Identified and characterized 20 PSM (phosphate solubilizing microbes) for salt, acid and drought tolerance capabilities. Seed priming with carrier-based inoculants of PSM produced fodder cowpea and oat yield with only 50% P fertilizer which was at par with 100% P as per RDF in normal poor soil, acid soil and salt affected soil. Two efficient strains (*Burkholderia cepacia* and *Talaromyces pinophilous*) genomes were sequenced to understand stress tolerance and phosphate solubilizing mechanism. These inoculants were also tested in > 50 farmers' fields of Jhansi, Niwari and Datia districts of Bundelkhand region and got similar results. This can be a major breakthrough in integrated nutrient management and would be cost effective and safer for soil environment.

Integrated nutrient management in bajra × Napier hybrid-based system: Application of 50% nutrients through chemical fertilizers (38 kg N, 55 kg P_2O_5 and 30 kg K_2O/ha), 25% through vermicompost (4.38 Mg/ha/vermicompost) + bio-fertilizer in BN hybrid + (cowpea – berseem) cropping system recorded 12.6% higher green fodder yield over 100% RDF. *Parthenium* (locally available weeds) enriched compost (4.1 Mg/ha) has also recorded similar results instead of vermicompost. Furthermore, the integrated use of inorganic (50%), organic (25%) and biofertilizers (Consortia of *Rhizobium* + *Azotobacter* + PSB) has also significantly moderated physical properties; increased SOC, soil available nutrients, microbial and enzymatic activities.

Bajra × Napier – Cowpea intercropping with INM

Evaluation of PSB in fodder oats

Evaluation of PSB in fodder cowpea

Livestock based integrated farming systems for semi-arid Bundelkhand farmers: Five resources based and farmer specific IFS models (2 for rainfed and 3 for irrigated farmers) each of 1 ha size were developed and demonstrated by IGFRI, Jhansi to enhance the livelihood of Bundelkhand farmers. The models are irrigated intensive IFS with balanced enterprise combinations (for resource rich farmers), irrigated dairy based IFS with greater emphasis on milch animals and fodder (for dairy farmers), high value IFS with greater emphasis on high value crops like vegetables and fruits (for peri-urban and farmers near cities/ market), rain-fed crop dominated IFS with greater emphasis on rainfed crops and water harvesting (rainfed crop based farmers) and rainfed livestock dominated IFS with focus on livestock, rainfed fodder and crops and water harvesting (for rainfed livestock based farmers). Among the irrigated IFS models, dairy based IFS resulted in the highest net return (₹ 162,593), employment (431 man-days/year) and resource recycling followed by intensive IFS with balanced enterprises (₹ 108,638 and 336 man-days/year, respectively) while the B:C ratio was the highest in intensive IFS with balanced enterprises (1.58) followed by dairy based IFS (1.52). On the other hand, among the rainfed models, highest net return (₹ 37,424) and B:C ratio (2.03) was observed in rainfed crop dominated IFS as compared to rainfed forage dominated IFS. The average annual income of irrigated and rainfed farmers in Bundelkhand region is ₹ 80,000 to 10,000 and ₹ 25,000 to 30,000, respectively, which can be enhanced to ₹ 160,000 and ₹ 40,000 by adopting dairy and rainfed IFS models, respectively. IGFRI is also simultaneously promoting above IFS models on fields of representative farmers in the area and planning for further up-scaling on larger scale through other inter-institutional programmes.

View of water harvesting pond and rainfed IFS model.

Integrated Farming System: **A step towards doubling farm income**: Integrated farming system (IFS) model was developed with the concept of integration of multiple enterprises (crops, livestock's, beekeeping, fisheries etc.) in a single farm unit to ensure year-round income and employment for a farm family having 1 ha irrigated land. Net income of model was ₹ 3.87 lakh/year along with 628 man days engaged throughout the years. The highest net income (₹ 1.68 lakh/year) was obtained from livestock (3 crossbreed cows) enterprise followed by crop (₹ 1.06 lakh). Model depicted that the total carbon assimilation by the crop enterprises was 4,448 kg/annum. Carbon cycle assessed using farm design tool showed that total input of carbon from the crop enterprises to household and animal was 603 and 5,555 kg/annum respectively. The addition of carbon from crop and livestock manure to the soil was 256 and 1,698 kg/annum respectively. Overall accumulation of carbon in the soil was 1,955 kg per annum which ultimately enriches the organic matter pool of the soil.

Net income though IFS model.

Integration of different IFS enterprises

An android based nitrogen fertilizer recommendation app for riceNxpert: ICAR-NRRI developed '**riceNxpert**' an android based mobile application to monitor the leaf N content based on leaf greenness and determine real time N fertilizer requirements to synchronize the demand and supply. The N application using riceNxpert produced higher yield in rice compared to the blanket recommendation. Farmers can download riceNxpert to their smart phone from google play store or ICAR-NRRI website or

Graphical user interface of riceNxpert; riceNxpert being used by a farmer in his field

resilienceindia.org. By using this application, images of 10 fully expanded healthy leaves are taken by mobile phone placing a white sheet on the back of the leaf during 8–10 AM from 14 days after sowing or 21 days after transplanting at 3–5 days interval. On basis of leaf colour analysis riceNxpert makes real time N recommendation in terms of urea for top dressing in different rice ecologies.

Crop Protection

Multi-trait *Trichoderma* based formulation for soil-borne diseases of pulse crops: Several species of *Trichoderma* were identified from pulses rhizosphere and characterized for their antagonistic potential against soil-borne and root rots diseases and plant growth (germination percentage, plant height, shoot and root length) promoting ability in major pulse crops. Among the *Trichoderma* isolates tested under *in-vitro* and green house condition at ICAR-Indian Institute of Pulses Research, Kanpur, one isolate, IIPRTh-31 (*Trichoderma asperellum*) was identified for maximum inhibition of mycelial growth (>80%) of wilt pathogens, promoted root length, shoot length, and tolerated temperature up to 50°C. Three formulations were developed using different carrier materials (Talc, parafin oil, glycerol) and tested for their shelf-life up to 6 months at room

Preparation of DALHANDERMA

temperature. Maximum inoculums viability (4.2×10^8/ cfu/g) was observed in talc-based formulation DALHANDERMA. This talc-based formulation DALHANDERMA, a *Trichoderma asperellum* strain of IIPRTh-31 (MK968811), will be very useful for the management of soil-borne diseases and promoting growth of pulse crops such as chickpea, pigeon pea and lentil through seed treatment and soil application.

***Sclerotinia sclerotiorum* associated with *Rhynchosia bracteata* of wild derivatives of pigeonpea from India–First Report**: Out of total 79 accessions of wild relatives of pigeonpea (*Cajanus cajan*), one accession of *Rhynchosia bracteata* was found to be affected by leaf and stem blight symptoms. Presence of water-soaked lesions on leaves and stem which later turn chalky in appearance, cottony white mycelium on the affected plant parts along with black coloured irregularly circular sclerotia resembled those of white mold fungus, *Sclerotinia sclerotiorum*. Pathogenicity of the fungus was proved using detached leaf/twig inoculation. Morphological characters and the sequences of internal transcribed spacer (ITS) region (MK828202) of the fungus confirmed the causal agent of the disease to be *Sclerotinia sclerotiorum*. This is the first report of *Sclerotinia sclerotiorum* on *Rhynchosia bracteata* not only in India but in the world also.

Leaf and stem blight symptoms

Detection and diagnosis of inner boll rot of cotton: During 2019–20, higher incidences of inner cotton boll rot were reported from farmers' fields from major cotton growing regions of Maharashtra. This unusual emerging problem in cotton has been associated with reduced boll development, quality of fibres and total yield. On detail investigation, bacterial species belonging to members of *Enterobacteriaceae* family (facultative anaerobe) were predominately isolated from rot affected green cotton bolls. On basis of polyphasic characterization and Koch's postulates study, association of phytopathogenic bacteria *Pantoea dispersa* was identified as a potential and principal pathogenic agent causing inner cotton (*Gossypium hirsutum*) boll rots in Maharashtra state, India.

Inner boll rot of cotton

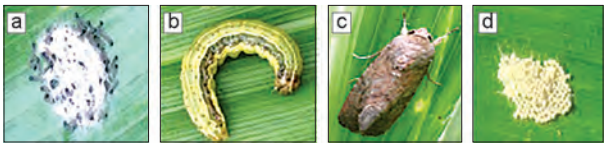
Effect of blast on grain size of finger millet: Blast pathogen *Pyricularia grisea* infect the spike or finger at flowering stage. Yield loss due this disease varies from 28–36% and may go up under favourable conditions for disease. Twenty-six finger millet accessions were tested for effect of finger blast on grain size, which affects yield. Various types of symptoms were recorded on finger and neck. Healthy looking and blasted fingers were sampled from each accession, at the time of harvest, and threshed separately. It was observed that the pathogen can infect a finger at a single or multiple site along its length. Lesion size gradually increases and reaches the base of the spikelet. Such spikelet generally fails to form seed. Spikelets away from the lesion may form seed but

Various stages of finger and neck blast infection and severity: (*a*) initial infection, one or more small lesion(s) on finger, (*b*) increase in lesion size, spikelets close to the lesion are affected, (*c*) drying of finger, proximal part of finger from the point of infection dries up, (*d*) initial infection on neck, (*e*) infection close to finger base, one or more fingers are affected, and (*f*) whole neck blasted, all fingers dead with unfilled grains.

Change of seed color and shape due to blast infection: (*a*) healthy seed, (*b*) discolored and deformed infected seed, and (*c*) growth of pathogen on styler end.

become chaffy up due to cut-off of nutrient supply from the mother plant. Sometimes neck of peduncle is infected and fingers in such plant dried up either partially or completely. Infected seeds were deformed and darker in colour. On incubation such seeds often develop pathogen growth. Grain size (weight/1000) varied from 1.81–3.38 g/1,000 in healthy and 0.23–2.20 in blasted fingers. Fifteen accessions recoded >2.5 g grain size in healthy fingers of which GPU28, GE48 and GE64 showed >3.0 g/1,000. Grain size reduction varied from 2–91%. In majority of the acc. (15 Nos), there was more than 40% reduction. Accession GE140, 147, 168 and 416 showed least reduction of grain size due to finger blast.

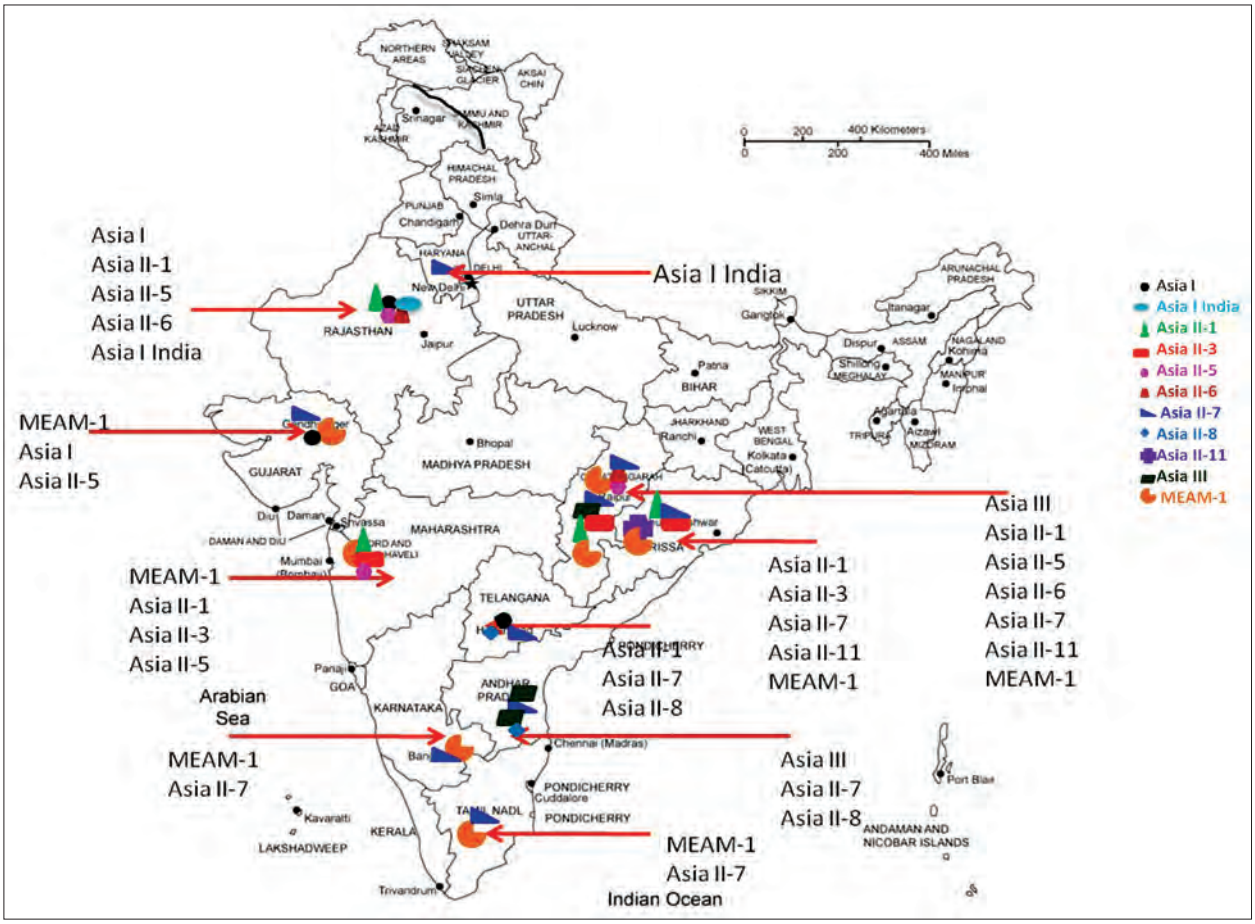
Determination of life-table parameters of fall armyworm fed on maize: Thorough knowledge of life-table traits is essential for the development of



Life-table parameters of FAW
(*a*) Neonates; (*b*) Larva; (*c*) Female adult; (*d*) Egg mass

sustainable integrated pest management strategies. Therefore, life-table parameters for FAW were worked out on maize starting from a cohort of 100 neonate larvae under laboratory conditions. The survival fraction among larval stages remained highest (0.98) at fifth instar and lowest (0.92) at first instar of FAW, while the maximum Mortality Survivor Ratio (MSR) (0.09) was observed at first instar and minimum MSR (0.01) was obtained at fifth instar. The adult female had the highest number of progeny (number of eggs per female, m_x=100.5) in life cycle on the 30th day of pivotal age. The net reproductive rate was 96.2 females/day. The intrinsic rate of natural increase was 0.15 female/day and the population of FAW would be able to multiply 2.88 times/week on maize. The mean length time required for completing one generation was 30.17 days. The finite rate of increase in number was 1.16 females/day.

Mapping of genetic groups of white fly in India: Whitefly, *Bemisia tabaci* is a polyhagous pest infesting wide variety of crop plants, weeds, ornamental plants etc. in India. It causes significant direct damage to crops and indirectly by transmitting several important plant viruses belonging to Geminiviruses. The host preference and plant virus transmission efficiencies of various genetic groups of *B. tabaci* were reported to be varying significantly. Therefore, it is essential to determine the distribution of various genetic groups of *B. tabaci* and their efficiencies in transmitting begomoviruses in various crops across India. A total of 1,005 whitefly samples were collected from 12 different host plants in 72 sites of 14 states including Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, Goa, Maharashtra, Odisha, Chhattisgarh, Jharkhand, Gujarat, Rajasthan, Uttar Pradesh, Delhi and Arunachal Pradesh. Total genomic DNA was isolated from 330 individual whiteflies following PCR protocol. Eleven distinct genetic groups of *B. tabaci* were identified in south, central and few north Indian states from which four genetic groups, Asia I, Asia II-1, Asia II-7 and MEAM-1 were the predominant. Asia I mostly recorded in central and northern states while Asia II-7 widely distributed in South and Central India. Two new genetic

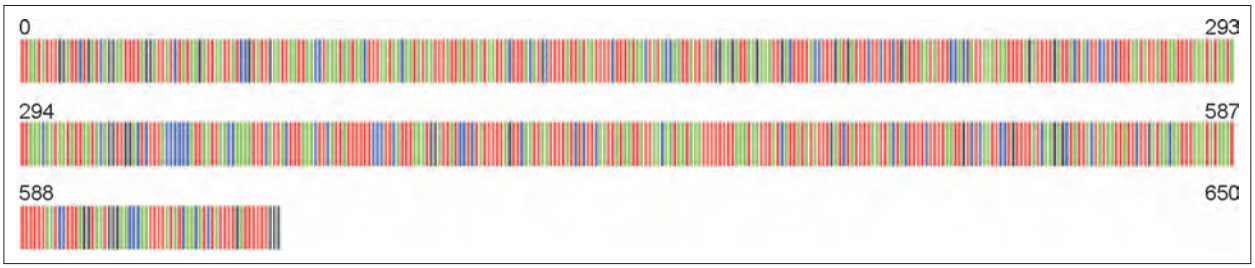


Mapping of genetic groups of white fly Bemisia tabaci in India

groups, Asia II-6 and Asia III were recorded in Chhattisgarh and Andhra Pradesh while another new group, Asia II-3 was recorded in Odisha and Maharashtra for the first time.

Barcoding of mealybug: Different populations of mealybugs were collected on cassava from Namakkal and Salem Districts of Tamil Nadu during August 2020 and were subjected to molecular identification using cytochrome oxidase –I gene (CO-1). Furthermore, the mealybug sequences were compared with already available sequences in National Centre for Biotechnology Information (NCBI) database. The sequences were matching 100% as *Phenacoccus manihoti* with GenBank Acc. Nos. KY611349; KY611348; KY611347; KY611346 (deposited from China) and were confirmed as *P. manihoti* and Genbank Acc No: MT895817 was obtained for the first time in India.

Natural enemy complex of invasive fall armyworm identified: Multiple parasitoid species for biological control of FAW *Spodoptera frugiperda* - *Glyptapanteles creatonoti*, *Campoletis chlorideae*, *Cotesia ruficrus*, *Coccygidium transcaspicum*, *Chelonus formosanus* Sonanand *Phanerotoma* sp. were identified. *Spodoptera frugiperda* is the first host record for *G. creatonoti* and *C. transcaspicum* across the globe. A strain of *S. frugiperda* nucleopolyhedrovirus (SpfrNPV NBAIR1) infected *S. frugiperda* was isolated from the diseased larvae and in morphological biological characteristics were studied . Electron shaped SpfrNPV occlusion bodies (OBs) of size 1.64 µm. Dose–mortality bioassays revealed that first, second and third instar larvae were equally susceptible (LC50 3.71–5.02 OBs/mm^2) to SpfrNPV infection. A PCR technique for detection of viral DNA in *S. frugiperda* NPV was developed by employing the polyhedrin gene (polh)-



DNA Barcode of *Phenacoccus manihoti*

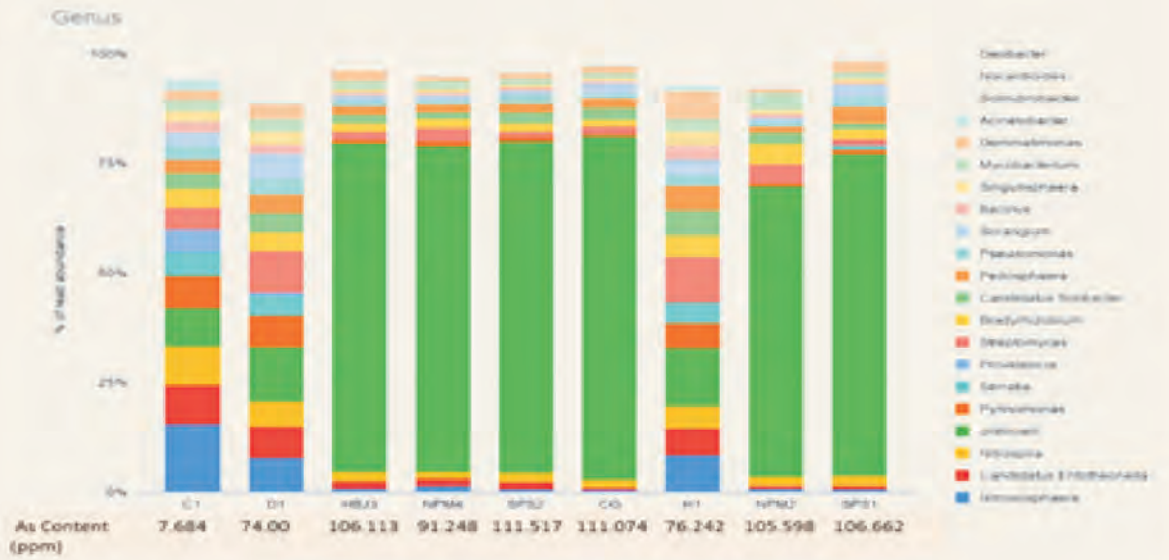
Diseased larvae of S*podoptera frugiperda* showing characteristic viral infection symptoms.

specific primers. The amplicon of 618 bp was amplified, sequenced and NCBI GenBank accession number was obtained (MT422725). Blast analysis revealed that SpfrNPV conserved polh gene sequence matched 100% with the reference sequence (J04333) from the NCBI database, which confirmed the identity of the SpfrNPV. Maize field experiments data revealed that application of aqueous suspension (2%) of *Spodoptera frugiperda nucleopolyhedrovirus* through three foliar sprays @ 1.5×10^{12} POBs/ha during 20, 35 and 45 days after sowing during 2018–19 and 2019–20 showed 66.24% and 67.46% reduction in plant damage caused by FAW and 53% and 38% increase in yield over control respectively.

Sulphur oxidizers for improved mustard yield and oil content: Sulphur (S) is one of the essential plant nutrients that account for about 10% of the total N content. Sulphur undergoes several chemical alterations in soil which are exclusively operated by microorganisms. Oxidation of sulphur is the most important step as it leads to sulphate ions which are readily absorbed by plants. S is required in quantities equal to phosphorus in oil seed crops, especially mustard. In this context, it is required to develop microbes that can oxidize sulphur in soil and make them available to crop plants. Fourteen heterorophic sulphur oxidizing bacteria were identified and two isolates S 14 and Ca7 releasea 6 µg SO^{4-}/ mg of sulphur. Inoculation with SS1 (*Bacillus flexus*) for chickpea and BS104 (*Alcaligens* sp.) for mustard significantly improved the growth and yield in pot and field experiments. *Alcaligens* sp. BS104, a

Microbial indicators for arsenic pollution

In pursuit to identify effective, cheap and easily interpretable microbe-based indicator of arsenic pollution, survey of Ballia district of Uttar Pradesh and 5 districts of West Bengal, viz. Howrah, North 24 Pargana, South 24 Pargana, Nadia and Kolkata which are known high as contaminated belt in India was done and rough estimation of As pollution was assessed. It was found that level of arsenic pollution level was higher in West Bengal samples as compared to that of Ballia. The lowest record of arsenic contamination in West Bengal sample was 82.25 ppm which was higher than highest record of arsenic contamination (76.242 ppm) from Ballia district. Based on arsenic contamination and geographical location, three samples from Uttar Pradesh and six samples from West Bengal were selected for met genomic studies. The comparative data analysis from samples from various locations of two arsenic contaminated regions (Ballia district and 5 districts of West Bengal) will possibly throw light on microbial indicator for arsenic contamination. (Comparative met genome analysis between control and arsenic contaminated samples from regions under test, revealed that samples from same geographic location but different in arsenic contamination, change the relative abundance of bacterial community at various taxonomic levels as well as read counts for various functions like arsenic related pathways and many xenobiotics biodegradation and metabolism pathways). From analysis genus like *Nitrososphaera, Candidatus entotheonella*, *Nitrospira*, *Pyrinomonas, Pseudomonas*, and *Bacillus* were affected with increase in arsenic contamination in soil and appeared to be suitable choice of indicator for arsenic pollution.



Relative abundance of genus along with the arsenic contamination from soils from Ballia and 5 districts of West Bengal.

facultative autotroph was identified as the most potent S-oxidizing bacteria in two years field experiment on mustard var. Pusa Bold. Application of gypsum alone at S equivalent of 20 kg/ha recorded the highest yield (1,992 kg/ha) and was at par with treatment with inoculation of BS104 along with S amendment (1,875 kg/ha). With regards to oil content highest oil content was recorded with BS104 + sulphur (41.78%) treatment closely followed by gypsum treatment (41.72%). The application of the sulphur oxidizers may be excellent eco-friendly choice for increasing sulphur uptake by mustard crop and thereby increasing seed yield and oil content.

HORTICULTURE

Crop Management

Fruit crops

Integrated nutrient management in custard apple Arka Sahan: Application (10 kg/tree) of FYM incubated (for 48 h) with Arka Microbial Consortium (10^9 to 10^{10} CFU/g of *Azatobacter tropicalis*, *Bacillus aryabhattai* and *Pseudomonas taiwanensis*) along with 100 g AM fungi (mixture of three *Glomus* spp. @ 100 spores/g of substrate), was observed effective in replacement of 25% of recommended (250:125:125 g N, P_2O_5 and K_2O/tree) dose of fertilizers in custard apple Arka Sahan. This way, there was saving of 25 kg N and 12.5 kg each of P_2O_5 and K_2O/ha (400 trees/ha) without any adverse effect on fruit size (334.7 g/fruit), productivity (15.61 kg/tree) or quality (32.72 °Brix), when compared to 100% RDF along with 10 kg FYM/tree (13.72 kg/tree, 320.2 g/fruit, 31.65 °Brix) either under rainfed or fertigated situations.

Precision farming technology in banana: Fertigation of 75% N, P_2O_5, K_2O (derived from STCR equation) along with irrigation at 80% ER and polyethylene mulching (100 µ thickness) in combination with foliar spray of (2%) micronutrient Banana Shakti (at fourth, fifth and sixth MAP) and bunch spraying with 2% potassium sulphate (once at male bud removal and again 30 days later) significantly enhanced the yield of banana cv. Grand Naine in Karnataka, Odisha and Andhra Pradesh. The yield enhancement was to a tune of 22 to 44% with B:C ratio of 2.78 to 3.37. The treatment can also significantly advance the harvest by 28 to 40 days, besides improving the fruit quality with respect to TSS and shelf life.

Organic farming in banana: In Grande Naine banana, the application of poultry manure + groundnut cake + rural compost + wood ash + VAM + PSB + KSB yielded bunches (23.5 kg) which were on par with with 100% inorganically fertilized banana plants. The nutrient uptakes (g/plant) and the leaf nutrient concentrations of organically grown banana were also on-par with 100% inorganically fertilized crop. The organic inputs caused decline in soil pH from 8.2 to 7.2, increased EC (dS/m) from 0.21 to 0.23 and organic matter from 0.12 to 0.72%, at harvesting. The organic banana grown soil had good number of CFUs of Actinomycetes (713×10^1), fungi (45×10^2) and bacteria (153×10^3). The B/C of this best treatment was 1.9 against 2.8 that of inorganic fertilizer alone. The 'r' values for soil available nutrients indicated a significant matching of nutrient releasing and uptake patterns in organic banana farming.

DRIS norms for oil palm: The Diagnosis and Recommendation Integrated System (DRIS) indices for oil palm in two districts of Andhra Pradesh, viz. Srikakulam (–1.78, 1.23, –0.87, –0.9 and 2.32 for N, P, K, Mg and B respectively. N>Mg>K>P>B is the order of importance of nutrients) and Vizianagaram (the order of importance of nutrients is K>P>N>B>Mg and their corresponding DRIS indices are –2.4, –0.7, 0.39, 1.64, 3.98, respectively) were developed.

The critical leaf nutrient concentrations were worked out for both the districts separately using Beaufills method. The optimal ranges for N, P, K, Mg and B in leaf samples of Srikakulam District were 0.84–1.31, 0.13–0.23, 0.61–1.03, 0.47–0.77% and 49–92 ppm, respectively. In Vizianagaram district the critical leaf concentrations ranged at 0.98–1.53, 0.13–0.20, 0.73–1.11, 1.81–2.82, 0.50–0.63, 0.66–1.58 (%) and 57–103 ppm for N, P, K, Ca, Mg, S and B respectively.

Vegetable crops

Indian good agricultural practices (GAP) for production of potato: Indian GAP for the potato production as per the guidelines of Quality Council of India (QCI) was documented. The requirements of both basic GAP as well as INDGAP were taken into account for production of seed, ware and processing potatoes. Compliance criteria of different control points were ensured for potato production. All modules of GAP developed by QCI were included in the final document. It is expected that adoption of GAP norms shall help Indian potato growers in getting higher net returns and sustained productivity by conserving the individual farms and the environment. It will also be very useful for other stakeholders in potato supply chain as they shall be aware about production environment of this crop, thus, there will be drastic reduction in the rejection of inland and offshore consignments.

Phosphorus management in potato in acid soils: The sole and synergistic effects of rock phosphate (RP) and phosphorus solubilising bacteria (PSB) on potato yield were studied in acidic soils of Meghalaya. At Shillong, application of 75% of recommended–P (RDP) as rock phosphate along with PSB inoculation exhibited potato tuber yield at par with the treatment receiving 100% RDP (140 kg P_2O_5/ha through RP), indicating a saving of about 25% RDP. Hence, the application of 75% RDP through rock phosphate along with seed inoculation with PSB could be recommended for higher yield of potato in the acidic soils of Meghalaya.

In another study at Ooty, application of 100% RDP as RP + PSB inoculation exhibited highest potato tuber

First crop of rice (var. Manu Ratna)

Short-duration cassava + cluster bean

Short-duration cassava + French bean

Short-duration cassava + groundnut

View of the field experiment on rice-short-duration cassava + legumes

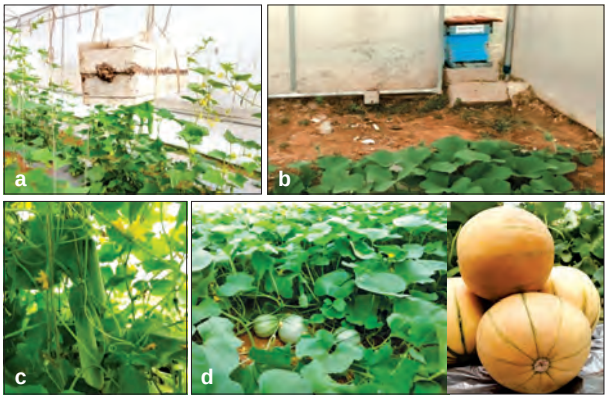
yield over other treatments, which again indicated that rock phosphate in combination with PSB can prove a suitable source of P in acid soils of Ooty. In another study at Ooty, 50% P + PSB + lime @ 5 t/ha gave potato yield equivalent to application of 100% P + PSB. Overall, application of phosphatic fertilizers along with PSB and lime proved beneficial for P-management in potato under acid soils with a saving of 25 to 50% P.

Intercropping short-duration cassava and legumes in rice-based cropping system: Intercropping short-duration cassava with cluster bean, irrespective of fertility level was productive due to cassava tuber yield (22 t/ha; yield reduction of 7%) on par with sole cassava (23.5 t/ha) and saving of nutrients. Nutrient saving to cassava to the extent of half FYM and N and full P was possible.

Use of native honey bees for pollination of cucurbits grown under polyhouse conditions: Hand pollination to achieve satisfactory fruit set in cucurbitaceous vegetables, such as, cucumber and muskmelon under polyhouse conditions for want of pollinating insect visitors is laborious. A protocol for using two native bee species, viz. Indian honey bee, *Apis cerana* and stingless bee, *Tetragonula iridipennis* for pollination of muskmelon (var. Arka Siri) and cucumber grown under polyhouse was standardized. The technology involves placing a honey bee hive (of eight frames size) at the border of polyhouse in such a way that half of box remains with main entrance facing inside polyhouse and other half (back of box) remains outside polyhouse. This box is provided with two exits at front and back of the hive so that bees can move in either of directions. The hive has to be placed when crops are about to flower. In stingless bee, two hives of *T. iridipennis* are hung from top at crop canopy level. Observations revealed both pollinator species foraging efficiently on both male and female flowers of muskmelon and cucumber and thus effecting pollen transfer to stigma.

(*a*) Stingless bee foraging on muskmelon flower; (*b, c*) Indian honey bee foraging on cucumber and muskmelon flowers.

There was no fruit set in plants excluded from bees whereas, fruit set, number of fruits per plant and fruit weight due to bee pollination were 92.5%, 1.85 and 1.6 kg, respectively, in musk melon, and 88.6%, 21.4 and 375.5 g, respectively, in cucumber; and comparable with hand pollination. The estimated yield was 50 t/ha for muskmelon and 80 t/ha for cucumber with honey bee assisted pollination. This technology has potential in overcoming the pollination problem of cross pollinated vegetables under polyhouse without need of exotic pollinator insect species.



(*a*) Hive of stingless bee inside polyhouse; (*b*) honey bee hive placed in polyhouse; (*c*) cucumbers grown with bee pollination; (*d*) muskmelon grown under polyhouse with honey bee pollination.

Vegetable based cropping system for eastern Uttar Pradesh: Two years observation proved cowpea-tomato-okra to be the best vegetable cropping sequence for productivity (275.83 q/ha) in terms of Rice Equivalent Yield followed by okra-tomato-cowpea (258.07 q/ha). However, bottle gourd-wheat-amaranth cropping system was observed most profitable with maximum (2.36) B:C.

Production of vegetables through organic sources of nutrient management: Application of FYM (25 t/ha) in green manure tomato–mung bean cropping system recorded 12.16% higher rice equivalent yield (REY) over inorganic system. In green manuring - vegetable pea–okra sequence combined application of FYM (10 t/ha) and NADEP compost (10 t/ha) increased yield by 10.14% over conventional system. The organic carbon content of the soil improved by 17.63 and 22.42%, respectively, with the application of NADEP compost and FYM (25 t/ha) over the inorganic system. The ascorbic acid, total phenol and anti-oxidant content increased by 18.2, 13.6 and 9.2% in cowpea and 21.8, 16.6 and 12.4% in okra over the inorganic system.

Harnessing the synergistic benefits of interspecific grafting in solanum: The novel steonic combination obtained by inter-specific grafting of two solanaceous vegetables, i.e. potato (as rootstock) and tomato (as scion) is termed as Pomato. The innovative technology on Pomato was developed and finetuned by harvesting both potato tubers and tomato fruits from Pomato. Field experiments have proved Pomato (indeterminate tomato hybrid NS42-66 grafted on potato Kufri Pukhraj) producing 74.25 t tomato and 17.65 t of potato/ha with a net profit of ₹ 6.27 lakh/ha and benefit-cost ratio of 3.46.

Back bulbs as source of planting materials in orchids: Back bulbs are previously flowered or unflowered pseudobulbs. A back bulb having roots are pulled or rhizomes are cut just beyond it and are inserted at one side of a pot filled with orchid compost or sharp sand or grit keeping the cut surface of the bulb nearest the edge of the pot. The shoots emerge from these bulbs within two or three months which

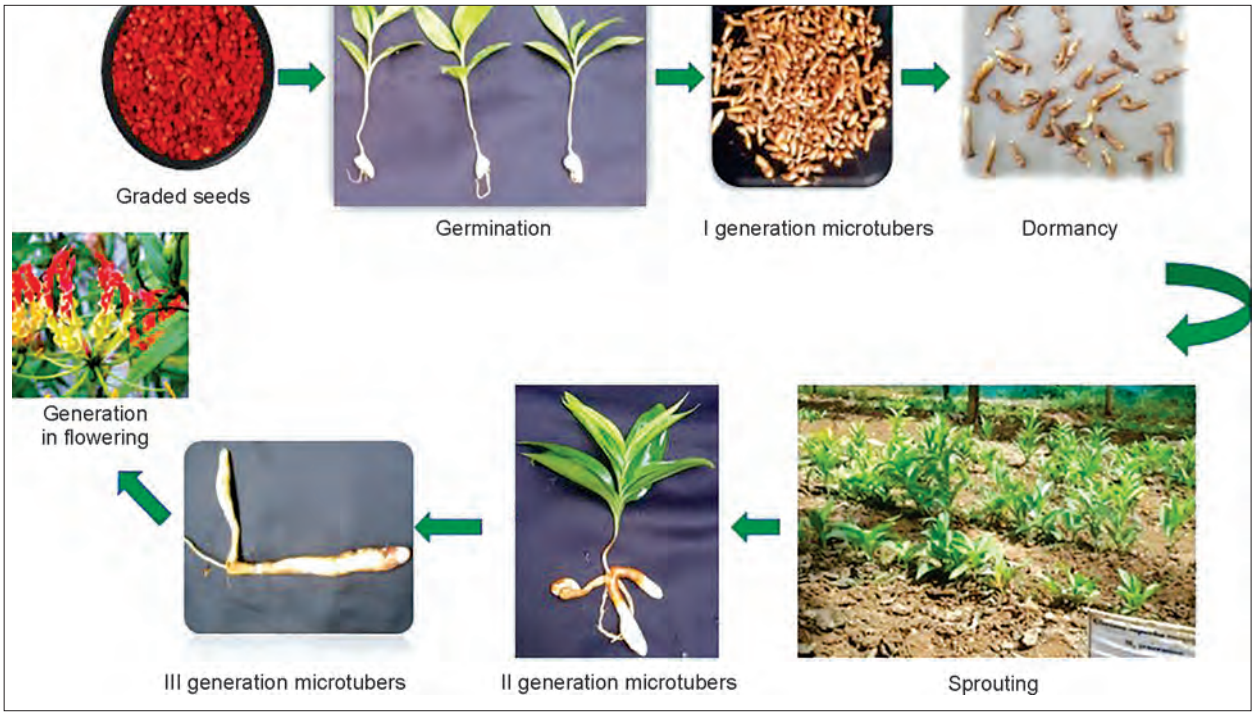
Backbulbs in Cymbidium | Backbulbs in Oncidium

can be potted in orchid compost. C*ymbidium*, *Cattleya*, *Coelogyne* and *Oncidium* are propagated through this method. In *Cymbidium*, it was observed that both saw dust and cocopeat are effective media for generation of plants through backbulbs. Germination takes place in 90–99 days during spring and 42–48 days during summer.

Zygopetalum orchid based cropping system: In *Zygopetalum* based farming systems, 10 to 12 spikes of *Zygopetalum*/m^2/year with 7 number of pseudobulbs/plant, 3 number of spikes/plant having 70 cm spike length, 6.5 flowers/spike measuring 7.75 cm can be produced along with anthurium bearing 8 to 12 number of spikes/m^2/season, 2 to 3 spikes/plant having 6.96 cm × 9.17 cm spathe size, 32–40 cm peduncle length, 0.5 cm × 6.15 cm spadix size. In bed culture of anthurium, a dose of 10–20 kg FYM/m^2 was sufficient for production of quality flower with a vase life of 90 days.

Glory lily (*Gloriosa superba*)

Development of protocol for cost effective micro-tuber production: The protocol for cost effective multiplication of micro tubers from seeds of glory lily was standardised including pollination, maturity indices, grading, and methods to induce seed germination. The micro tubers evolved were advanced for two more generations and bulked to 40–45 g weight tested at farmers field. Results indicated that this technology is successful in reducing the tuber cost to as low as ₹ 1.25 lakh/ha as compared to ₹ 3.75 lakh/ha in conventional practice of using wild traded tubers. By using these microtubers evolved



from this technology, nearly 20% increased seed yield could be obtained.

Mushrooms

Substrate prepararion and cultivation technology for mushroom: A total of four compost formula using wheat straw, paddy straw, mustard straw and sugarcane baggasse were evaluated and successful results were obtained in all the formulations with a maximum yield in wheat straw (18.30 kg/100 kg compost) followed by sugarcane baggasse (17.77 kg/100 kg compost) further followed by paddy straw (16.31 kg/100 kg compost).

Cultivation technologies for *Panus velutipes* and *Lentinus tigrinus* were developed. Both these mushrooms were cultivated on sterilized saw dust substrate supplemented with 20% wheat bran. *P. velutipes* gave 50% BE and *Lentinus tigrinus* gave 18% BE.

Substrate preparation technique was standardized for cultivation of Morchella mushroom (guchchhi) using wheat (46%), cotton seed cake (18%), gypsum (1%), calcium carbonate (1%), forest soil (8%), saw dust (10%) and coir pith (16%). Under *in vitro* studies on induction of ascoma in *Morchella* spp strain ANG, three small ascomata of 5–10 mm were obtained. Under

Panus velutipes *Lentinus tigrinus*

first seasonal cultivation trial *Morchella* spp strain ANG, conidial stage (asexual stage) and a mature ascoma of total 13 cm length was produced under green house for the first time in India.

Crop protection

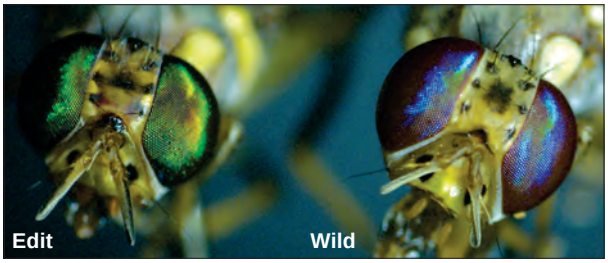
Taxonomy of banana scarring beetle: The correct names of banana leaf and fruit feeding beetles of the Indian region were clarified for future phytosanitary, quarantine and management purposes and *Basilepta subcostata* was found to be the economically most important pest species in northern and north-eastern India.

Management of banana scarring beetle, *Basilepta subcostata*: Soil application of liquid formulation of *Beauveria bassiana* (1×10^7 cfu/ml -200 ml/plant) @ 3 ml/l during October along with bunch spraying with

Banana Scarring beetle *Basilepta subcostata*

acephate 75 WP (0.1125%) just after opening of first hand followed by bunch covering with polypropylene sleeve after shoot initiation, reduced the number of scar on leaf and improved quality of banana fruits.

CRISPR/Cas9 mediated genome editing of mango fruit fly, *Bactrocera dorsalis*: Utility of genome editing of mango fruit fly, *Bactrocera dorsalis* mediated by CRISPR/Cas9 was demonstrated by disrupting the white gene, spermatogenesis pathway genes such as *topi*, *per*. Editing was achieved by delivering single guide RNAs (sgRNAs) along with Cas9 protein through embryonic microinjection and by electroporation. Disruption of white gene produced greenish metallic eye color and variation in pigmentation in cephalothorasic region. This successful lead could be useful for developing male only strains by disrupting oogenesis and speramatozoa production pathway genes. This will enable future environmental release of sterile males for area wide pest management of *B. dorsalis*.



Management of whitefly in coconut: A Neotropical palm whitefly, *Aleurotrachelus atratus* was observed on coconut from Mandya, Karnataka. Spraying azadirachtin based botanical pesticide 'neemazal' (1%) caused highest mortality of whitefly complex (40 to 50%) and no new colony formation was noticed on the treated leaves. Entomopathogenic fungus, *Simplicillium* sp., exhibited effective biocontrol against spiralling white fly in coconut and was produced at large scale in soild and liquid formulations.

Management of potato tuber moth in stores using biological control agents: Tuber dip treatment with *Bacillus thuringiensis* formulation @ 2% for 20 min is recommended for management of potato tuber moth under ambient storage condition of Maharashtra and Karnataka.

Disease management and diagnostics

Banana bunchy top virus (BBTV) resistant diploid bananas: Diploid banana germplasm accessions (AA and BB) were screened for resistance against BBTV using viruliferous aphids in an insect proof screen house. Thirteen AA diploids expressed typical symptoms of bunchy top viral infection, but BB diploids did not show symptoms except one accession. The time taken to express the symptoms varied between 30 and 120 days. The control (susceptible triploid) varieties, viz. Virupakshi (Hill banana) and Grand Naine, expressed BBTV symptoms within 30 days of inoculation. Some of the *Musa* species like *M. flaviflora* and *M. burmannicoides* were also observed to be susceptible to BBTV.

Reaction of diploid banana accessions to BBTV inoculation. (*Left:* BB genotypes, and *Right:* AA diploids expressing typical bunchy top symptoms)

Characterization of pathogen causing rhizome rot of banana: Based on pectin utilization on specific medium and PCR with 16s rDNA, the major bacterial species associated with rhizome rot of banana were characterized as *Pectobacterium* sp., *Achromobacter* sp., and *Klebsiella* sp. For quick bioassay of rhizome rot (10–20 days), a soil heating unit was developed using locally available materials.

Management of leaf curl virus in chilli: Integrated management of leaf curl virus in chilli 'Pusa Jwala' was standardized with reduced incidence of leaf curl disease to 62.96% as compared to untreated control with increased yield of green chilli by 78.61% as compared to untreated control. The schedule comprised seed disinfection using Virkon-S followed by seed treatment with imidacloprid; raising seedlings under insect proof net; soil application (5 g/kg) with talk based formulation of *Bacillus subtilis* (BS-2); seedling dip in imidacloprid (0.5 ml/l) followed by carbendazim + mancozeb (2.5 g/l for 20 min) before transplanting; installation of yellow sticky traps (50 nos/ha); bicolour (black/silver) silver polythene mulching; growing two rows of bajra along the borders; soil application (2.5 kg/ha) of *Bacillus subtilis* (BS-2) enriched FYM bio-formulation; soil application (5 g/plant) of neem cake; spraying (2 ml/l) of micronutrient mixture and salicylic acid (2 mM) to improve resistance of plant; soil drenching (5 ml/l) with humic acid; and need based rotational application of insecticides for vector control.

Nursery disease management using bio-agents and new fungicides in tomato: Application of talc based formulations (minimum cfu of 2.5×10^8) of *Bacillus subtilis* (BS2-IIVR strain) as seed treatment @ 4 g/kg seed, soil application (10 g/m^2) and soil drenching @ 5%, has recorded reduced damping off incidence on tomato var. Kashi Aman (15.22%) and brinjal var. Kashi Taru (33.18%) with maximum cost benefit ratio (CBR) 1 : 79.98 and 1 : 36.69, respectively.

Integrated management of vector-borne virus diseases of chilli: Application of neem cake (1 kg/m^2) in the seed bed, spraying (1.8 ml/l) of Cyazpyr 2–3 three days before transplanting, seed treatment with imidacloprid (8 g/kg), seedling dip (imidacloprid 0.5 ml/l) and growing of two rows of maize/sorghum (jowar) as border crop in the main field along with sliver agrimulch sheet + rotational spray of insecticides

(Acephate @ 1.5 g/l + neem oil @ 2 ml/l) + (Fipronil @ 1.0 ml/l + neem oil @ 2 ml/l) + (imidacloprid @ 2 g/151 + neem oil @ 2 ml/l) + (Cyzpyr @ 1.8 ml/l) at 7 days interval till fruit formation significantly reduced the incidence of vector-borne viral diseases in chilli. Residual analysis of pesticides used in the best treatment indicated that the acephate @ 1.5 g/l, fipronil @1.0 ml/l imidacloprid @ 2 g/15 l and cyzpyr @ 1.8 ml/l were not detected in HPLC/GLC testing. The CB ratio varied from 1:1.92 to 1:3.07.

Management of late blight in potato: Following spray recommendation were made for management of late blight in potato in different agro-climatic conditions.

Prophylactic spray with mancozeb @ 0.25% followed by cymoxanil + mancozeb @ 0.3% at the time of disease appearance and one more spray with mancozeb @ 0.25% after 8–10 days of second spray in Kanpur, Uttar Pradesh.

Prophylactic spray with mancozeb @ 0.25% followed by amectoctradin + dimethomorph @ 0.2% or azoxystrobin + tebuconazole @ 0.1% at the time of disease appearance and one more spray with mancozeb @ 0.25% after 8–10 days of second spray in Hassan, Karnataka.

Prophylactic spray with chlorothalonil @ 0.25% followed by dimethomorph + mancozeb @ 0.3% at the time of disease appearance and one more spray with chlorothalonil @ 0.25% after 8–10 days of second spray in Srinagar, Jammu and Kashmir.

Characterization of viruses infecting vegetable crops: Newly emerging yellowing disease on cucurbitaceous crops such as, squash, watermelon, pumpkin, sponge gourd and ivy gourd were documented as *Polerovirus* transmitted by aphids. On the basis of gene sequence analysis, these were identified as cucurbit aphid-borne yellows virus (CABYV), melon aphid-borne yellows virus (MABYV) and luffa aphid-borne yellows virus (LABYV).

Bitter gourd

Watermelon

Squash

Pumpkin

Disease management in mushrooms: Denovo based whole genome sequencing (WGS) of *Mycogone perniciosa* was completed and a draft genome of 39 Mb obtained. These studies revealed its maximum similarity with *Trichoderma* spp. Two botanical pesticides namely, Dorisom (*Pongamia glabra/ Pongamia pinnata* (Karanj tree) and Prabal (*Opuntia* sp + *Oryza sativa*) @ 0.1–0.3% concentration were identified for the management of wet bubble disease of button mushroom.

❑

“We walk together, we move together, we think together, we resolve together and together we take this country forward.”

— Narendra Modi

8. Livestock Management

Nutrition

New variety of sorghum fodder, CSV-43 BMR (JAICAR NUTRIGRAZE/SPV 2018) improves performance of growing and lactating buffaloes (IIMR, Hyderabad and CIRB, Hisar collaborative programme): A *brown midrib* (*bmr*) sorghum, CSV-43 BMR (JAICAR NUTRIGRAZE/SPV 2018) was developed through pedigree method of breeding at ICAR-Indian Institute of Millets Research, Hyderabad and was evaluated for feeding value at ICAR-Central Institute for Research on Buffaloes, Hisar was superior in various nutritional qualities. The variety contains less lignin (4.12% ADL), promotes early ruminal fermentation with higher truly degradable dry matter and ruminal fibrolytic enzymes production, and lowers methanogenic archaeal population with reduced methane production as compared to popular MP Chari and MFSH-4 varieties. The buffalo calves fed SPV 2018 fodder had 14% more body weight gain with significant increase in feed efficiency compared to calves fed with CSH 24MF and MP Chari. Feeding trial on lactating buffaloes demonstrated increased daily milk yield (9.64%), 6% fat corrected milk (18.55%) and fat protein corrected milk (11.53%) in comparison to buffaloes fed with MFSH-4 sorghum fodder. The *in vivo* digestibility of DM, OM, NDF and ADF were higher in buffaloes fed this variety than MFSH-4 fed buffaloes, suggesting better nutrient availability, which was reflected in milk production. The variety has been released and commercialized for the widespread fodder cultivation throughout the country.

Feed additives supplementation for reducing enteric methane production and enhancing performance in lactating Murrah buffaloes: A 90 days trial in early lactating buffaloes was conducted with supplementation of a composite feed additive which contained an ideal combination of methane inhibitors, alternate hydrogen sinks and rumen stimulating agents along with basal feed of green fodder, wheat straw and concentrate mixture. The results showed a decrease (44.6%) in methane concentration in exhaled air of supplemented buffaloes with increase in digestibility of feed in comparison to control. Total digestible nutrient (TDN) content of the ration fed to the supplemented buffaloes increased. The daily milk yield, 6% fat corrected milk (FCM) yield and immune response also increased in buffaloes. The study suggests that the supplementation of composite feed additive was effective to reduce enteric methane emissions and improvement in production performance and health status of buffaloes.

Improved feeding and shelter management to reduce age at puberty in Murrah bulls: The study was undertaken at ICAR-NDRI to evaluate the effect of dietary energy and linseed on growth performance, age at first ejaculation, semen quality and to study the behaviour, physiological responses, hormones and blood biochemicals of Murrah buffalo males under different shelter management conditions. It was concluded that Murrah buffalo males can grow faster, attain early puberty and AFE with better semen quality when provided with improved feeding and management.

Comparative probiotic potential of faecal lactic acid bacteria isolated from crossbred and indigenous dairy calves: A total of 69 lactic acid bacteria (LAB) strains were isolated from faeces of newborn calves. Carbohydrate fermentation ability was similar in both the genetic groups. However, Tharparkar isolates exhibited the ability to ferment esculin indicating their greater ability to survive in the presence of bile.

Dietary supplementation of *Tinospora cordifolia* stem can prevent sub-acute lactic acidosis in goats: Effect of dietary supplementation of *T. cordifolia* for reducing the risk of lactic acidosis in goats was investigated in Jamunapari goats. Supplementation of *T. cordifolia* stem powder at the rate of 2% in

Birth of cloned calves

Treatment of cloned embryos with Dickkopf-1: The low live birth rate obtained with cloned embryos limits the application of this technology on a large scale. Studies conducted at ICAR-NDRI revealed that treatment of cloned embryos with Dickkopf-1 improved their developmental competence, quality and live birth rate.

Three cloned calves produced using donor cells of an elite bull

concentrate feed for 14 days could prevent sub-acute lactic acidosis in small ruminants.

Moringa based complete feed is highly economic and productive for sheep and goats: Intensive cultivation of *Moringa oleifera* can be a sustainable animal diet to meet out the challenge, growing demand of livestock feed and to replace conventional concentrate components of animal diet with prominent fodder resources.

The growing goats and sheep fed with moringa based complete feed for long duration attained considerably higher body weight gain and appreciably higher efficiency of feed conversion in comparison to the other group of animals of similar age and breed fed traditional ration. The cost of complete feed (₹/kg) was found drastically low in comparison to the sheep and goat fed traditionally. Moringa fed goats produced higher weight of carcass and contained low fat (3.5% vs 4.8%), higher protein (20.37% vs 18.42%) and low concentration of saturated fatty acids. The vision of doubling farmers' income through moringa cultivation and its feeding to livestock seems to be viable and sustainable.

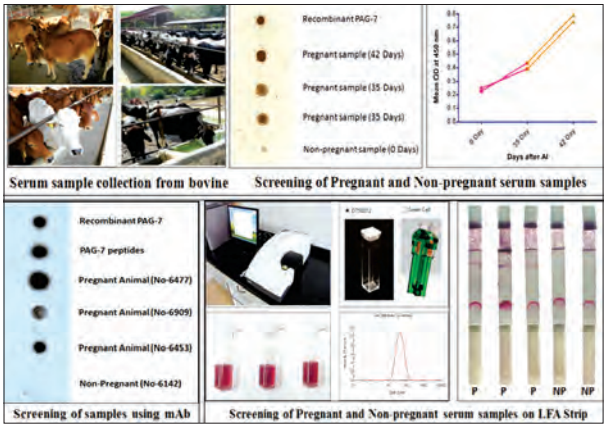
Vegetable waste/fruit waste based pig feeds: Vegetable waste based silage was prepared using locally available vegetable wastes namely cabbage, cauliflower, carrot, tomato etc. Feed cost per kg gain was reduced by ₹ 9.76 and ₹ 12.69 at 10% and 15% supplementation of vegetable silage by replacing whole concentrate in crossbred finisher pigs.

Nutritional strategies for augmenting production: Supplementation of moderate amount of lysine to QPM based diets favourably influenced egg quality in PD-2 hens. Availability of feed ingredients was surveyed in Palampur (Himachal Pradesh), Agartala (Tripura), Udaipur (Rajasthan) and Mahabunagar (Telangana) for formulating region specific diets for rural poultry germplasm. The highest egg iron concentration was obtained by feeding the hens with 150 mg iron/kg diet along with 70 ppm zinc and 25 ppm copper. Rice-DDGS (15% in diet) depressed body weight of Srinidhi chicks, which could be countered by methionine supplementation at 110% level.

Nutrition for health and welfare: A 42 days biological trial conducted to study the effect of graded levels of aflatoxin B1 (AFB1) and ochratoxin (OTA) combination indicated no adverse effect on growth performance, immune response and blood biochemical parameters in broiler chicken.

Physiology

Development of pregnancy-associated glycoprotein (PAG)-based diagnostic assay: A pregnancy-associated glycoproteins-based diagnostic assay was developed at ICAR-NDRI for early detection of pregnancy in bovine. The polyclonal and monoclonal antibodies produced against PAGs were examined for their suitability as diagnostic markers of early pregnancy. Best interacting antibodies were further used for development of ELISA and LFA assay. A proof-of-concept was developed for early diagnosis of pregnancy in bovine.



Development of PAG based proof of concept for early detection of bovine pregnancy

Mitigation of spermatozoa cryodamages and fertility assessment using different additives: Cryodamage to the spermatozoa occurs invariably during the process of cryopreservation of semen. In order to minimise such injuries during freezing, glutathione (2.5, 5.0 and 10 mM) and alfa-tocopherol (1.0, 3.0 and 5.0 mM) were added as antioxidants and results showed that glutathione at 10 mM concentration had better cryo-protection during freezing and thawing process with respect to sperm motility, HOST and acrosome reactions.

Multiplication of Sahiwal cow through multiple ovulation and embryo transfer: Five embryo transfer calves (3 female and 2 male) were born from four Vrindavani recipients, which include twin males due to embryo splitting. The embryo recovery per flushing was 5.5 and average conception rate was 42.7%.

Development of early pregnancy diagnostic assay through discovery of biomarkers in cattle and buffalo: An ELISA was developed for detection of PR-2 protein in the test sample using MAP-1738 as capture and HRP linked MAP-1739 as detector antibodies. The sensitivity and specificity achieved

on gestation days 17–20 and 30 of cattle were 61.54, 92.39 and 72.22, 92.39%, respectively.

Climate resilience of native Indian cattle: Study under controlled thermal stress conditions in psychrometric chambers and in different seasons (under different THI) revealed that crossbred cattle are under more immune stress than indigenous cattle.

Semi-intensive mithun rearing units: The Institute developed an alternative package of practices of mithun rearing under a semi-intensive rearing system. Under this system, the mithun can be monitored by the owner regularly for growth, reproduction, health care, and breeding.

Phytogenics: Phytogenics reported to improve health and growth of poultry, are considered as safe and residue free. A novel phytogenic blend was developed to replace antibiotic growth promoters (AGP) in broiler production. Dietary supplementation of the blend (@ 1% level) significantly improved body weight gain and feed conversion ratio and reduced the *Salmonella* and coliform counts in the caecum.

Livestock protection

Disease informatics: The National Animal Disease Referral Expert System v2 (NADRESv2) developed and maintained by ICAR-NIVEDI was updated with 4,986 district wise livestock disease outbreaks data from November 2019 to September 2020. The prediction results, risk maps, post prediction maps were disseminated through forecasting bulletin to all the State Animal Husbandry Departments and DAHD, GoI for initiating preventive action. A bluetongue forewarning Mobile App was developed and launched to provide forewarning of bluetongue two months in advance for all Taluks of Karnataka. The mobile app can be downloaded from Google play store. The maintenance and updation of National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) with 28,756 baseline, biological, disease outbreak and hatcheries data was done. Nation-wide Sampling plan for sero-surveillance and sero-monitoring of FMD, brucellosis and PPR in India was formulated and provided to DAHD, GoI.

Sero-epidemiology

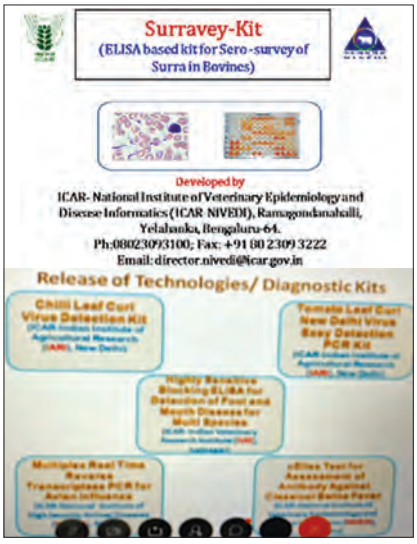
Sero-prevalence of economically important bacterial disease: The burden of economically important diseases or diseases of public health importance was estimated by sero-survey. The seroprevalence of porcine brucellosis at national level was estimated to be 4.4% (n-5431). The disease burden in bovine population from Chhattisgarh (159 blocks in 22 districts) showed 4.64% seropositivity (n-3144). A total of 1,583 serum samples (sheep 272, goat 868, cattle 164, swine 126 and human 153) collected from more than 10 states were screened for *Leptospira* and provided the diagnostic reports. Of the 1,167 samples from South India screened for leptospirosis, the seropositivity of 46.32% in sheep and 38.13% in goats was estimated, whereas 9% (14/153) in cattle and 38.5% (59/153) in human from Gujarat was observed.

Sero-prevalence of economically important viral disease: The national serosurvey was carried out to estimate the burden of porcine reproductive and respiratory syndrome (PRRS), an emerging viral disease of pig in India. The mean sero-positivity was 22.1% (1346/6089). The seroprevalence of the disease was 24.17% in NE region of the country. Similarly, the burden of CSF was estimated to be 36.6% nationally. A total of 15,812 samples of sheep and goat serum collected from 18 states were screened for PPRV antibodies which showed that the population immunity was high in the states with regular vaccination programme. The burden of emerging zoonotic disease, Crimean-Congo haemorrhagic fever (CCHF) was also estimated by sero-survey with findings of mean apparent prevalence of 9.53% in goats and 13.86% in sheep. A total of six serotypes of bluetongue virus, viz. 1, 2, 5, 16, 23 and 24 were detected in Karnataka out of 150 isolates isolated during the year.

Anti-microbial resistance: AMR study from 256 isolates covering animal, foods of animal origin, aquaculture, environment and human hospital settings were sequenced using WGS approach. A total of 14 sequences were submitted to NCBI-GenBank with the accession numbers. The preliminary analysis revealed that *Staphylococcus aureus* ST 772 is epidemiologically important in animal and aquaculture as in human. The genetic characterization of AMR bacterial isolates from Karnataka and Assam revealed a high prevalence of methicillin resistance in dairy environment. Three genomes of *Pasteurella multocida* of sheep origin were also sequenced and submitted to GenBank. *Escherichia coli* ST131 was identified as epidemiologically important in Indian context in one-health environment.

Diagnostics

Diagnostics released: ICAR-NIVEDI, Bengaluru developed and launched two effective kits, namely



Diagnostic kits developed by ICAR–NIVEDI

Surravey-Kit for population survey of trypanosomiasis and indirect ELISA for detection of antibodies against classical swine fever in pigs using recombinant Erns protein.

Indirect ELISA based on four recombinant proteins (Ag1, Ag1V1, Ag2 and Ag2V1) for sero-surveillance of porcine cysticercosis and indirect ELISA using cathepsin B2 and B5 for fasciolasis in cattle and buffaloes were also standardized.

The patent applications for 'Competitive ELISA for the differential diagnosis of brucellosis infected from vaccinated animals' and 'Recombinant Leptospiral surface antigen-based immuno-diagnostic test for Leptospirosis' were filed.

Serum repository: A total of 6,100 pig and 25,599 small ruminant serum samples received through AICRP-ADMAS centers were added to the National Livestock Serum Bank maintained at the Institute.

CIRC-Cattle BLAD diagnostic assay kit: It is used for diagnosis of Bovine Leukocyte Adhesion Deficiency (BLAD) carrier bulls at their early stage of life based on identification of an SNP (D128G) in CD18 gene. The test will help avoid the transmission of BLAD from breeding bulls to its progeny. The test described in the kit is earmarked with its rapidity, user friendliness, economy and specificity.

Quick and early detection kit for coenurosis in goats: Coenurosis resulted due to parasitic cyst lodged in brain and spinal cord, which lead to culling of animals. The advantage of this serological technique is excellent specificity cum early detection of coenurosis due to the use of Oncosphere based peptide antigen unique to *Taenia multiceps*. A total of 341 sera samples were subjected to TM16p-iELISA, of which 6.16% were positive for Coenurosis.

New isolate for ET in goat for diagnostic kit: Novel isolates of *Clostridium perfringens*, which are unique with mutations at the ETX gene were identified based on molecular characterization and phylogenetic analysis. Both these ELISA diagnostic tools were validated on-site at CADRAD, ICAR-IVRI, Izatnagar, and will be subsequently commercialized.

Development of an IgM-ELISA kit for serodiagnosis of Japanese encephalitis in equines: An Indirect IgM ELISA kit was developed for serodiagnosis of JE in equines. The kit had 100% relative diagnostic sensitivity and 73.3% relative diagnostic specificity, when compared with a commercial JE IgM ELISA kit for horses (Biospes, China). A total of 228 equine serum samples collected from different endemic parts of India were screened by using JE IgM ELISA kit, which revealed a sero-positivity of 21.05% for IgM against JEV.

Development of multiplex RT-qPCR kit for avian influenza: A Multiplex Real Time Reverse Transcriptase PCR kit for avian influenza A virus typing and differentiation of H5 and H9 subtypes developed was released.

Sandwich ELISA kit for detection of Rotavirus: An early and rapid detection of Rotavirus (RVs) is a feasible alternative for initiating necessary measures to prevent the spread of infection to other animals as well as humans. The present indigenous ELISA kit provides an efficient way to know the early presence of the RVA in diarrheic calves.

Synthetic endometrium: Developed a structurally and functionally competent '3-dimensional endometrial cell culture (3D-ECC) system for ruminants, as an alternate to animal experimentation to study early embryonic development and uterine infection in ruminants. Devised 'Endometrium-Pathogen/ Embryo' interactions model using developed 3D-ECC system help study patho-physiology of embryonic development and uterine infection.

Therapeutics

Development of *in vitro* serology based statistical models for potency testing of commercial FMD vaccine: ICAR-IVRI, Bengaluru developed a serology based (serum neutralization test) statistical model for potency testing of FMD vaccine. The tests were standardized by estimating antibody titer on 28th day after vaccination before challenging them. The protection data of individual animals were correlated with antibody titer by statistical modelling technique such as probit and logistic regression. The cut-off or threshold antibody level for each of three virus types was established to replace challenge-based potency testing. Except administration of vaccine and collection of blood, no other intervention is required on the animals. This method has additional advantage of finding the protective level of antibody response for all the three types of virus present in the commercial FMD vaccine.

Selection of bovine viral diarrhoea (BVD) vaccine candidate strains: Based on the genetic, antigenic characterization of currently circulating bovine pestiviruses in India and virus growth kinetics studies, 3 BVD vaccine candidate strains, one each for BVDV-1, BVDV-2 and HoBiPeV species were selected to develop inactivated vaccine.

Live attenuated Classical swine fever cell culture vaccine: Live attenuated CSF cell culture vaccine was developed from an indigenous strain. The titre of the vaccine virus was very high (1×10^9 TCID50/ml) and around 60 lakh doses can be produced from a 75 cm^2

culture flask. This vaccine will be highly cost effective and can be easily scaled up. This technology was assigned to AgrInnovate India Ltd for commercialization.

Treatment of mastitis and metritis using mesenchymal stem cells (MSCs) in cattle: Mastitis and metritis in dairy cattle and buffaloes reduce milk yield and fertility leading to immense economic losses. This study aimed at treating these diseases in cattle by treatment with MSCs. MSCs isolated from the adipose tissue of a cow were characterized by confirming the expression of specific markers, viz. alkaline phosphatase, CD73, CD90 and CD105 and absence of CD34, CD45 and CD79a. MSCs were injected through local and intravenous routes. All the animals were cured completely demonstrating the potential of MSCs for treatment of mastitis and metritis in cattle.

(a) Before treatment of mastitis with MSCs; (b) 60 days after treatment with MSCs

Biomarker discovery for subclinical endometritis in dairy cattle through comparative proteomics approach: Few uterine fluid proteins that could act as potential candidate biomarker(s) for early diagnosis of SCE in dairy cattle were identified. Proteomic profiling using tandem mass tags (TMT) coupled with mass spectrometric analysis identified a total of 717 and 148 unique proteins in subclinical endometritis affected Deoni and HF crossbred cows, respectively, as compared to normal cows. The expression of protein SCE1 in uterine fluid of subclinical endometritis affected Deoni and crossbred cows was > 2 folds in both LC-MS/MS analysis and Western blotting.

Use of anti-CPV IgY can augment therapeutic response in managing parvovirus infection in dogs: Canine parvovirus (CPV) specific egg yolk immunoglobulins (anti-CPV IgY) were produced by inoculating CPV antigen to white leghorn birds and IgY was extracted. Sixty parvovirus infected dogs were enrolled randomly in this study. The results of the present study documented that anti-CPV IgY have significant therapeutic potential in management of CPV associated gastroenteritis of dogs.

Day "0"

Day "7"

Anti-tick herbal acaricide: To protect crossbred animals from multi-acaricide including Ivermectin resistant tick infestations, three safe, stable and characterized flowable and natural cream formulations were developed. The efficacy of anti-tick natural formulations was validated at field level and more than 80% efficacy was reported.

Surgical interventions

- Intra-lesional administration of allogenic BMSCs is effective in managing neural deficits associated with non-deviating spinal cord injury in canine patients.
- Hip denervation and intra-articular infiltration of stromal vascular fraction and platelet rich plasma improved gait, facilitated early return to weight bearing, reduced pain on hind limb extension and improved ability to jump in cases of hip dysplasia in dogs.
- Two designs of hybrid external skeletal fixation systems for use in tibia of large ruminants were developed, tested and submitted for design registration.

Diagnostic services

Human samples testing for COVID-19 and genetic characterization of SARS-CoV-2 virus: As national emergency response, NIHSAD has been regularly testing samples collected by the State Health Department from different districts of Madhya Pradesh and providing timely results for SARS CoV-2 by RT-qPCR. Whole genome sequencing of SARS-CoV-2 was done for 9 clinical samples, sequences were submitted to GISAID database. Based on the GISAID phylogeny, 7 sequences belonged to Clade G (Clade B.1) while 2 sequences belonged to Clade O (Clade B. 6).

Avian influenza: A total of 14,944 samples (13,152 morbid materials and 1,792 sera) from various States/ Union Territories of the country were tested as part of avian influenza virus surveillance. These included random samples (12,927), emergency samples (198) and POSP samples (1,819). Out of 198 emergency samples, 49 samples from seven states tested positive for H5N1 notifiable AIV. During screening of 12,927 routine samples (including live bird markets), 20 H9N2 viruses were isolated from Chhattisgarh (16) and Madhya Pradesh (4). Six serum samples were tested

positive for H9 AIV antibodies from Chhattisgarh, Kerala and Madhya Pradesh.

Bovine viral diarrhoea (BVD): Out of 120 morbid samples from cattle and sheep in Tamil Nadu, 24 samples from 8 cattle had tested positive for bovine pestivirus (HoBiPeV). A total of 300 imported bovine samples were tested negative BVD.

Border disease (BD): A total of 1,796 samples from 898 imported sheep from Australia tested negative for border disease (BD).

Porcine reproductive and respiratory syndrome (PRRS) and African swine fever (ASF): A total of 325 imported samples tested negative for PRRS. A total of 151 field samples from Madhya Pradesh (108) and Punjab (43) tested negative for PRRS. A total of 47 imported samples were negative for ASF.

Other porcine diseases: Seven, twelve and sixteen samples out of 102 samples from Madhya Pradesh showed antibodies against Porcine Epidemic Diarrhoea virus (PEDV), Transmissible Gastroenteritis virus (TGEV) and Porcine Respiratory Coronavirus (PRCV) respectively by ELISA. One serum out of 112 samples from West Bengal showed antibodies against PEDV. Samples collected from 258 pigs imported from the UK were screened for TGE, swine influenza and were found negative.

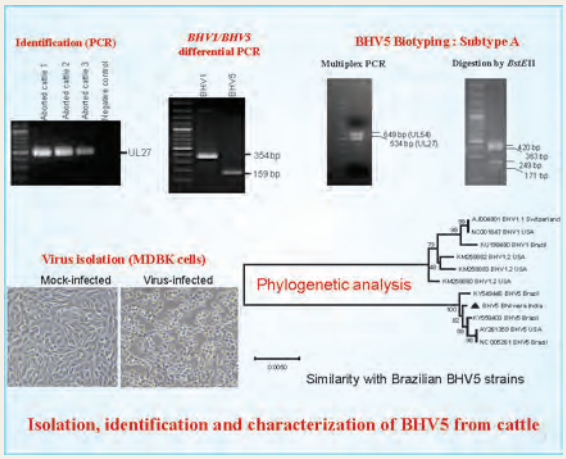
Crimean-Congo haemorrhagic fever (CCHF) virus: A total of 38 bovine sera collected near the CCHF human index case in Botad, Gujarat were tested by ELISA, and 33 were found positive for the anti-CCHFV antibodies.

Nairobi sheep disease & Rift valley fever: The imported samples of sheep were tested for the Nairobi sheep disease (n=66) and Rift valley fever (n=66) were found negative.

Nipah virus: After two successive outbreaks of 2018 and 2019 of Nipah virus infection in human in Kerala, it was necessary to screen Indian pig population for Nipah virus antibodies. All the 99 pig serum samples from different states (West Bengal-50, Bihar-16, Andmans-14 and Mizoram-19) were negative for the presence of Nipah virus antibodies.

Cattle

Isolation and characterization of Bovine Herpes virus 5 (BHV5) from cattle in India: Bovine herpesvirus 1 (BHV1) and 5 (BHV5) are genetically and antigenically related alpha herpes viruses. BHV1 infection is usually associated with rhino-tracheitis and abortion, whereas BHV5 causes encephalitis in cattle. BHV5 outbreaks are sporadic and mainly restricted in South American countries. The NCVTC reported BHV5 infection from aborted cattle in India. The isolate was confirmed as BHV-5, subtype A. Phylogenetic analysis revealed that the isolated virus clustered with BHV5 strains and showed highest similarity with Brazilian BHV5 strains. This is the first report of BHV-5 from India.



2), Porcine Parvovirus (PPV) and Classical Swine Fever Virus (CSFV), and another for rapid detection of Methicillin-Resistant *Staphylococcus aureus* (MRSA) from biological samples.

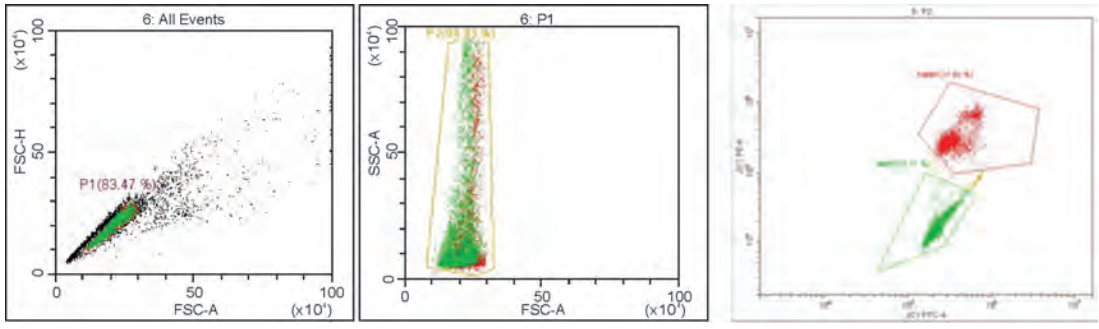
Molecular epidemiology of Japanese encephalitis virus in pigs and mosquitoes in Assam: Seasonal distribution of JE sero-positivity in pigs was evaluated from January 2019 to December 2019. Screening of 947 serum samples of pigs revealed 9.18% sero-positivity for JE. Out of 65 whole blood samples and 54 tissue samples, 11 blood samples and 5 tissue samples were positive for JEV by RT-PCR.

Pig

Developed rapid laboratory and field assays kits: NRC, Pig developed two multiplex PCR kits; one for simultaneous detection of Porcine Circovirus -2 (PCV-

Equine

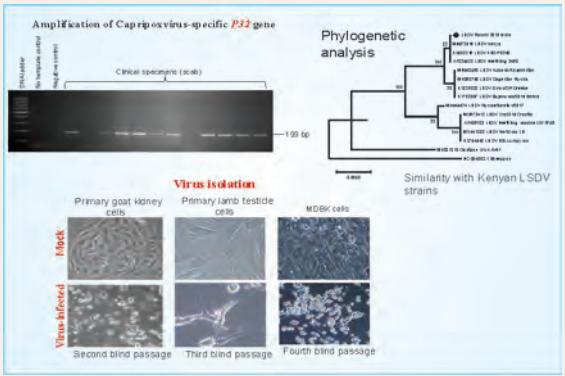
Evaluation of mitochondrial membrane potential in equine spermatozoa using JC-1: The JC-1 staining technique was standardized to assess the mitochondrial



Flowcytometric evaluation of MMP in stallion spermatozoa

Isolation and characterization of Lumpy skin disease virus (LSDV) from cattle in India

An outbreak was investigated in infected cattle of Ranchi. The most prominent clinical finding was skin nodules all over the body surface and could be seen immediately after febrile stage. The lesions were particularly extensive in the fetlock region, extending up to the underlying subcutis and muscle. Few pregnant animals aborted. Morbidity was ~8% in the organized dairy farm and up to ~50% in small dairy units in the villages. The etiological agent was identified by the NCVTC as Lumpy skin disease virus. The virus could be isolated in primary goat testicle cells and confirmed by the amplification of three LSDV specific fragments. Phylogenetic analysis suggested that the isolated virus is closely related with Kenyan LSDV strains.



membrane potential (MMP) in the equine spermatozoa. A positive correlation was observed between the progressive motility and MMP of the equine spermatozoa. Significant differences were observed between the MMP levels of donkey and horse stallion groups in their fresh semen. The technique was found to be most reliable and suitable technique for assessing the mitochondrial membrane potential of equine spermatozoa.

Flow cytometry has emerged as the technique of choice for analysis of the mitochondrial membrane potential (MMP) ($\Delta\Psi m$) in stallion spermatozoa. Healthy non-apoptotic cells will be detected and cells with altered mitochondrial function due to apoptosis or other cellular processes will remain bright in the FL1 channel, but will have reduced FL2 intensity (FL1 bright, FL2 dim).

Camel

Evaluation of udder health and milk quality in dromedary camel: A total of 20 animals suffered from clinical mastitis were treated with antibiotics and anti-inflammatory drugs. A field side-test Porta SCC available for use in cattle and buffalo was evaluated for its efficacy in diagnosis of mastitis in camel.

Yak

Identification of circulating microRNAs (miRNAs) as probable biomarker of Bovine herpesvirus-1 (BHV-1) infection in yak: A total of 14 putative miRNAs were identified as probable biomarker for BHV-1 infection in yak by profiling and cataloguing the miRNAs in the blood of healthy and BHV-I infected yaks using Next Generation Sequencing approach. Out of these 14 miRNAs, 3 miRNAs (chi-miR-25-5p; aca-miR-20a-5p and aca-miR-101-3p) were highly significant for differential expression between infected and healthy animals.

Poultry

Higher tolerance to fowl cholera was observed in Aseel than Ghagus and Nicobari. A single dose of immune complex vaccine against Infectious bursal disease (IBD) at day-old induced equivalent immune response as that of live vaccines, besides avoiding handling stress and reducing vaccination cost.

Foot and mouth disease

A total 52 FMD outbreaks were recorded. There has been reduction in disease incidences in the entire region of the country. The serotype O continued to be most predominant one and was responsible for 98% of the outbreaks recorded. The capsid coding region (P1/VP1) sequences of 31 FMD virus strains were deduced and analysis revealed the protracted dominance of lineage O/ME-SA/Ind2001 strains. The lineage O/ME-SA/Ind2001 has been dominating the outbreak scenario since 2008 with the emergence of sub-lineage O/ME-SA/Ind2001d in 2008 and sub-lineage O/ME-SA/Ind2001e in 2016. A total of 9 FMD virus serotype O isolates were antigenically characterized. The field situation suggested all of the isolates were antigenically homologous to currently used vaccine strain INDR2/1975.

Under NADCP sero-monitoring program to assess the effectiveness of vaccination, a total of 297,900 serum samples were tested. Till date, 1,532,320 serum samples have been tested for estimation protective antibody level against each of the three serotypes (O, A and Asia1). In this process, a sum of about 4,596,960 tests were conducted and results were communicated to DAHD. Under National FMD Sero-surveillance, 30,413 bovine serum samples randomly collected from various parts of the country were tested using r3AB3 NSP-ELISA (DIVA) for assessing the prevalence of NSP-antibody (NSP-Ab) positive animals, which is an indicator of FMD virus exposure regardless of vaccination status and virus circulation. The test revealed overall seropositivity in 20.8% samples/animals, which is slightly higher than the previous year's average of 19.98%.

Exotic and emerging diseases

Molecular epidemiology of H5N1 avian influenza viruses isolated in India during 2019 and 2020: Complete genome sequence of seven H5N1 highly pathogenic avian influenza viruses isolated from chickens, ducks, crows and wild bird in six states revealed that the Odisha, Kerala, Uttar Pradesh and

Post-disaster mitigation

Due to unprecedented heavy snowfall during the last winter since January to April 2019, an incidence of high yak mortality was reported from Muguthang valley and adjoining areas of North Sikkim. Around 500 yak mortalities were attributed to prolonged starvation due to sudden unprecedented continuous heavy snowfall, which made the area inaccessible for transportation of feed, fodder and other utility items. ICAR-NRC on Yak in collaboration with Animal Husbandry Department, Govt. of Sikkim conducted various programmes to benefit the affected farmers. The institute extended all possible support to the yak farmers of Sikkim by providing feed, fodder, and animal healthcare aids.

Post disaster mitigation measures taken up by ICAR-NRC on Yak and Department of Animal Husbandry, Govt. of Sikkim in North Sikkim

Jharkhand viruses grouped separately from H5N1 viruses of Bihar and Chhattisgarh (>5% divergence between the viruses) even though all viruses belonged to the HA clade 2.3.2.1a of H5N1 viruses.

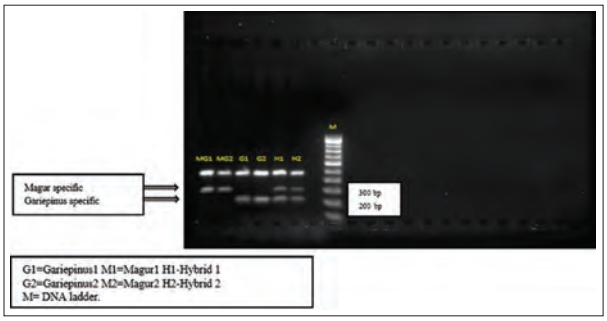
Emergence of Lumpy skin disease (LSD) in cattle in India: Several incidences of LSD suspected outbreaks in cattle were observed in five districts of Odisha during August 2019. The disease was confirmed as LSD by real-time PCR, virus isolation and nucleotide sequencing. Phylogenetic analyses based on partial P32, partial F gene and RPO30 gene sequences showed that all Indian LSDV strains were identical and clustered with other field strains of LSDV circulating globally.

African swine fever in pigs for the first time in India: During January 2020, disease outbreaks with unusually high mortality in domestic pigs were observed in 2 districts of Arunachal Pradesh and 5 districts of Assam. The disease was confirmed as African swine fever by laboratory tests, viz. qPCR, virus isolation and nucleotide sequencing. Genetic analyses showed that the Indian ASFV isolates belong to genotype-2. This was the first occurrence of ASF in India and notified by OIE.

Fisheries

PCR-based *magur* and *gariepinus* hybrid detection system: African catfish, *Clarias gariepinus* is an invasive species that proliferates rapidly and is a threat to native species. This has led to the prevalence of Indian magur × gariepinus hybrids in the market. Anecdote information suggested that the juveniles of *C. gariepinus* and its hybrids are sold as *Clarias magur,* the high-quality indigenous catfish species. In this context, a PCR-based identification kit was developed which can identify a hybrid in just two steps with genomic DNA as starting material. This is a specific kit designed for the identification of *Clarias magur* (magur), *Clarias gariepinus* (gariepinus) and their hybrid.

Molecular characterization of M×1 of *Labeo rohita*: In rohu (*Labeo rohita*), m×1 full-length cDNA sequence consists of 2440 nucleotides (nt) encoding



628 amino acids (aa) polypeptide of 71.289 kDa. Structurally, it belongs to the family of large GTPases with one DYNc domain (13-257aa) comprising dynamin family motifs (LPRGSGIVTR) and the tripartite GTP-binding motifs (GDQSSGKS, DLPG and TKPD) at the N-terminal and one GED domain (537–628aa) at C-terminus. Rohu M×1 is closely related to zebrafish M×1 and is widely expressed in gill, liver, kidney, spleen and blood. In response to rhabdovirus vaccinations, poly I : C stimulation and bacterial infections, m×1 gene expression in rohu were significantly induced in the majority of the tested organs/ tissues.

Antibacterial activities of recombinant proteins of rohu antioxidant genes: Full-length CDs of four major antioxidant genes, i.e. catalase, glutathione peroxidise, glutathione S-transferase and CuZn superoxide dismutase were amplified, cloned and sequenced. Recombinant proteins, i.e. GPX, GST and CuZnSOD of *L. rohita* were expressed in *E. coli* BL21 (DE3) cells. The antimicrobial activities of r*Lr*GPX, r*Lr*GST and r*Lr*CuZnSOD were checked by minimum inhibitory concentration in gram-negative (*Aeromonas hydrophila*) and gram-positive (*Staphylococcus aureus*) bacteria, and the activities were observed in 200 µg/

ml concentration for all the recombinant proteins.

Cloning and characterization of full-length *lgp2*-cDNA (complementary DNA) in rohu: The full-length *lgp2*-cDNA sequence obtained through rapid amplification of cDNA ends-PCR consisted of 2299 nucleotides with an open reading frame of 2034 bp encoding 677 amino acids. Rohu *lgp2* consisted of four conserved domains with several important functional motifs. In respect to both *in vitro* and *in vivo* treatments using double-stranded RNA (polyI:C), *lgp2* gene expression was significantly up-regulated in all tested tissues and also in the LRG (*L. rohita gill*) cells. *lgp2* gene expression significantly increased on stimulation of LRG cells using γ-D-glutamyl-meso diaminopimelic acid and muramyl dipeptide. *In-vivo* treatment using lipopolysaccharide and *Aeromonas hydrophila*-derived RNA resulted in both up and down regulation of *lgp2* gene expression.

Immune response of *Labeo rohita* to *Dactylogyrus scorpius*: A new species of *Dactylogyrus* was isolated from infected *Labeo rohita* from Puri district of Odisha. It was identified as *D. scorpius* using 28s rDNA sequencing. Sequence analysis revealed that the identified parasite was having 96.21% sequence homology with *D. scorpius* belonging to African *Dactylogyrus* lineage III. A cohabitational challenge study revealed that rohu was a susceptible species among Indian major carps. Gill tissue of rohu juveniles at different time points post-infection was subjected to expression analysis of different immune genes, viz. specific immune-related genes (IgM, IgZ, MHC I), recognition molecule (TLR 22), pro-inflammatory cytokines (IL 1β, IL 6, IL 8, IL 15, TNFα), anti-inflammatory cytokines (IL 10), antioxidant (MnSOD, GPx, catalase) and antimicrobial peptide genes (ApoA-I, Lysozyme G). A significant up-regulation of all immune genes except MHC I and IL-15 was observed indicating the role of both specific and non-specific immune responses during *D. scorpius* infection.

Indian Network of Fisheries and Animal Antimicrobial Resistance (INFAAR): Antimicrobial resistance (AMR) is recognized as one of the most important public health threats of the 21st century. To quantify the burden of AMR in food-producing animals and aquaculture through structured surveillance, ICAR in cooperation with FAO initiated a Network project known as Indian Network for Fisheries and Animal Antimicrobial Resistance (INFAAR). INFAAR is currently operational through 18 organizations (15 ICAR institutes and 3 State Agriculture Universities) in 20 centers (9 centers from fisheries and 11 from the livestock sector) spread across the country. Under the Fisheries component, the fish and shrimp samples were collected from 35 districts of India covering 11 states. A total of 1,037 farms were sampled and 1,037 fish/shrimp samples were analysed for isolation of *E. coli*, *Aeromonas/Vibrio* sp, *Staphylococcus aureus* and Coagulase-negative *Staphylococcus* (CONS). During the study, 1,753 bacterial isolates were recovered from freshwater fish, comprising 628 isolates of *E. coli*, 11 isolates of *Staphylococcus aureus*, 560 isolates of *Staphylococcus* sp and 554 isolates of *Aeromonas* sp. Similarly, a total of 896 bacterial isolates were recovered from shrimp and marine fish, comprising 245 isolates of *E. coli*, 73 isolates of *S. aureus*, 217 isolates of *Staphylococcus* sp, 247 isolates of *Vibrio* sp and 114 isolates of *V. parahemolyticus*. In *E. coli* strains, the highest AMR was observed against ampicillin (36%), enrofloxacin (30%) followed by amoxicillin/clavulanic acid (25%) and cefotaxime (25%). Resistance to cefoxitin (indicative of methicillin resistance) was observed only in 8.5% of the *S. aureus* isolates. Higher resistance (31%) to cefoxitin was observed in CONS as compared to *S. aureus* isolates (8.5%). *Vibrio parahemolyticus* isolated from shrimps and marine fish was mainly resistant to cefotaxime (54%), ampicillin (47%) and cefoxitin (43.9%). However, *Aeromonas* species isolated from freshwater aquaculture ponds showed a low level of AMR to most of the antibiotics. The data generated by INFAAR will lead to the identification of strategies to prevent and reduce the emergence and spread of AMR in aquaculture and food animals.

National Surveillance Programme for Aquatic Animal Diseases: The National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) operated in the country for the last seven years which is being implemented by ICAR-NBFGR through 31 collaborating centers and with the financial support of the National Fisheries Development Board (NFDB), Government of India, has been successful in the strengthening of passive disease surveillance in the country. The programme is

States and Union Territories being covered under NSPAAD and collaborating centres responsible for implementing surveillance in each state

PARA^{CIDE}—A emamectin benzoate based product to control parasitic infestation in fishes

Efficacy of emamectin benzoate (EB) was evaluated against parasitic infections *Caligus minimus* in pearl spot, *Etroplussu ratensis* and *Lernaea cyprinacea* in Asian seabass, *Lates calcarifer*. EB was administered through feed top dressing at a dose rate of 50 µg/kg of fish body weight (BW)/day. In 7–10 days treatment emamectin benzoate could control parasitic infestations. Based on the results, a EB based product called PARA^{CIDE} was developed.

helping in developing a network of aquatic animal health laboratories across the country; diagnostic capability for detection of OIE/NACA-listed and emerging aquatic animal pathogens; the mechanism for first-time confirmation of exotic and emerging diseases and sending alerts/advisories to stakeholders; and providing scientific advice to the farmers. NSPAAD received positive commendations during the OIE Global Conference on Aquatic Animal Health held in Chile in April 2019 and the 2nd International Conference on Aquatic Animal Epidemiology (AquaEpi II) held in Thailand in November 2019. The surveillance programme is assisting the Department of Fisheries, Government of India in improved understanding of disease situations in aquatic animals in the country and with credible international disease reporting as an obligation under the WTO-SPS agreements.

Field-based LAMP test for detection of white spot disease in shrimp: White spot syndrome virus (WSSV), the causative agent of white spot disease (WSD) in shrimp, causes severe economic losses in the shrimp industry. For the diagnosis of WSSV in the field, a rapid, sensitive, specific field-based loop-mediated isothermal amplification (LAMP) protocol was developed. LAMP primers were designed based on ORF 121 gene. The target sequence of WSSV was amplified at a constant temperature of 65°C for 45 min and amplified LAMP products were visually detected in a closed tube system. This simple, closed tube, visual LAMP assay has great potential for diagnosing WSSV at the farm level.

Lumiphage—A bacteriophage-based therapy as an alternative to antibiotics: Bacterial diseases such as vibriosis often cause significant mortalities of shrimp larvae and considerable economic loss to hatchery operators. The use of antibiotics poses concerns of residues and antimicrobial resistance. As an alternative to antibiotics, bacteriophages are developed for biocontrol of vibriosis in shrimp hatcheries. Bacteriophages also called 'phages', infect and kill specific disease-causing bacteria. They are specific to their host bacteria and harmless to other microflora and fauna. The product has been branded as Lumiphage, and comprises a cocktail of phages that can neutralize a wide range of specific pathogenic bacteria in the hatchery settings. The product was commercialized, and would be available to the shrimp hatchery operators for the prevention and control of bacterial diseases, as an alternative to the use of antibiotics.

CIFE-ARGUNIL—A medicated fish feed mix: Developed a medicated feed mix, named as CIFE-ARGUNIL, which is effective for the control and treatment of *Argulus* and other ectoparasites of fishes. CIFE-ARGUNIL is available in the form of feed mix, which can be mixed with commercial feeds as gel coating and also available as medicated feed for direct use. It was developed based on ivermectin and has been granted patent.

❑

"We will link farmers to global markets.
We will give the world the Taste of India"

— Narendra Modi

9. Mechanization and Energy Management

Farm mechanization

High speed planter for soybean: Timely sowing of field crops is one of the major challenges especially during *kharif* when number of clear sky days available for sowing/planting is very limited. A high speed planter will cover more area per unit time in comparison to conventional seed-cum-fertilizer drill/planter. Keeping these points into consideration, a tractor mounted six-row high speed (5–7 km/h) planter was developed with modified pneumatic metering mechanism at ICAR-CIAE, Bhopal. The approximate cost of machine is ₹ 90,000 and its cost of operation is ₹ 615/h. The breakeven point and payback period of the machine were 64.8 h/year and 1.96 year, respectively.

Deep placement fertilizer applicator as an attachment to ride-on type rice transplanter: A sensor based deep placement fertilizer applicator as an attachment to ride-on rice transplanter was developed to overcome the loss of nitrogenous fertilizers. The performance parameters of rice transplanter with deep placement fertilizer applicator such as fertilizer application efficiency, field capacity and field efficiency are 71%, 0.16 ha/h and 82%, respectively.

Small tractor mounted hydraulic platform: The development of suitable matching equipment for small tractor is of prime importance due to small fragmented land holdings, hill agriculture, shifting cultivation and lack of mechanization for leading horticultural sector. The operating height of the machine is 3 m (10 feet approx.). Overall dimension of the system is 3,000 × 1,500 × 1,450 mm, it weighs 700 kg and its load carrying capacity is 150 kg. Spraying system (500 l tank capacity) is attached with platform for application of fungicides/pesticides from top of the plant aiming at uniform distribution over the canopy. The field capacity and field efficiency of the machine is 0.3 ha/h and 85%, respectively for orchards having 6 × 6 m plant geometry. Cost of the equipment is ₹ 400,000. Operating cost of the equipment is ₹ 6,520/ha. The developed system can also be used for other operations in orchard crops like pruning, spraying and fruits plucking.

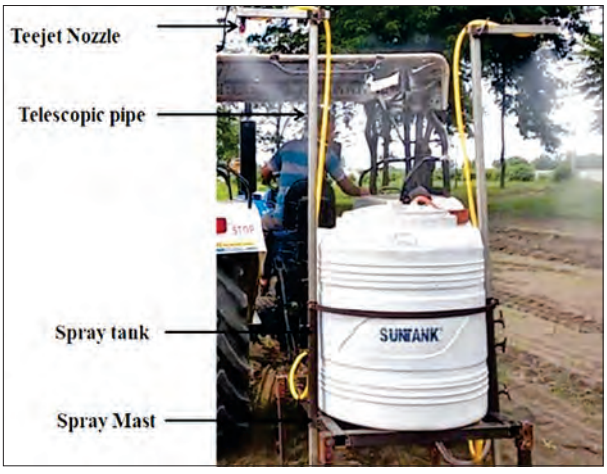
Liquid urea spraying system retrofitted on straw baler: One of the possible ways to increase the digestibility of poor quality roughages like rice and wheat straw is urea treatment. The urea treated straw is liked by cattle and helps to increase the milk production and body weight of animals. Conventionally, the straw is mixed manually with urea solution. The handling task can be minimized substantially by treating straw with retrofitted urea solution spraying system on straw baler.

An urea solution spraying system for straw baler (rectangular type) was developed to pre-treat paddy straw during baling operation. The urea solution having concentration of 8% was used with the system for on the go spraying of urea solution on loose straw during conveying to compression chamber of baler. The capacity of straw baler with urea spraying system is 109 bales/h for paddy at straw load of 8.3 t/ha. The cost of retrofitted urea solution spraying system is ₹ 30,000 and cost of urea treatment is ₹ 0.50/kg of straw. The weight and moisture content of bales increased in the range of 50–70% after application of urea solution. The urea treated bales were wrapped with polyethylene sheet and stored for three weeks at room temperature. The baled wheat and paddy straw samples were analyzed for crude protein (CP) of the feed. Urea solution treatment increased CP in all the treatments and ranged from 9.14 to 13.41% for wheat and 8.93 to 12.28% for paddy straw. On the basis of overall nutritional analysis, treating the straw with urea solution (8 kg/100 l) for paddy straw (50% moisture content) and wheat straw (70% moisture content) was recommended for straw baler with the system.

Animal drawn multi-crop planter cum herbicide applicator: A three row multi-crop planter cum herbicide applicator was developed by AICRP on UAE (IGKVV, Raipur centre) for planting of seeds and application of herbicide simultaneously. It consists of a frame, seed hoppers, seed metering devices, seed delivery tubes, inverted T type furrow openers, sprayer tanks, boom and nozzles. Sprayer nozzles, seed metering mechanism, hoppers and seed delivery tubes are mounted on inverted T type furrow openers, and can be adjusted for row spacing of 230–240 mm. The performance of implement was evaluated for sowing of soybean, greengram and fodder maize crops. The effective field capacity for soybean, greengram and fodder maize was 0.183, 0.121 and 0.124 ha/h, respectively. Cost of the implement is ₹ 15,000. The cost of sowing operation per ha was ₹ 440, ₹ 666 and ₹ 650 for soybean, greengram and fodder, respectively.

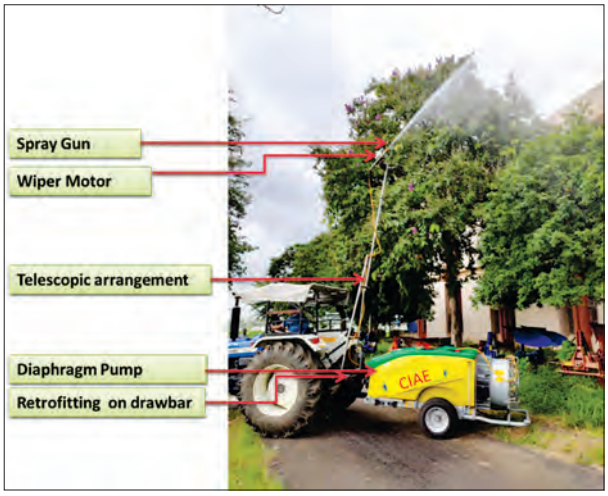
Animal cart mounted solar sprayer: A bullock drawn solar powered sprayer was developed to utilize the available solar energy. The solar energy is used as power source for the operation of sprayer unit and bullock power used for pulling the cart. It consists of solar photovoltaic (PV) modules, chemical tank, DC motor, spray boom with hollow cone nozzles and cart. All working components were fitted on a bullock cart for mobility in the cropped field for spraying. Due to high clearance it is useful for spraying tall field crops. This sprayer is being used for spraying of insecticides, pesticides and weedicides at fields of research stations of VNMKV, Parbhani.

Ultra-low volume (ULV) spraying system: A ULV spraying system was developed. It is a tractor-mounted sprayer that was specifically designed for the control of migrant pests such as locusts, grasshoppers, and



armyworm at the spray volumes of 0.5–3.0 l/ha. The sprayer can produce the droplets in the range of 50–100 µm. One nozzle was mounted on each side having a discharge rate of 0.2–0.6 l/min. The performance of the sprayer was evaluated using water-sensitive paper. Water sensitive papers (WSP) were used to collect the spray droplets at a height of 1.5 m (top surface), 1 m (middle surface) and 0.5 m (bottom surface) from the ground. Deposit scan open-source image analysis software (USDA affiliated) was used for them to measure the droplet characteristics from WSP. The results showed that the droplet range VMD varied from 195 to 450 µm at the pressure of 4 bar. The per cent coverage and deposits/cm^2 were 9.06, 16.3 and 9.62%, and 293.2, 235.6, 42.5 deposits for bottoms middle and top surface.

High pressure variable range sprayer: A high pressure variable range sprayer prototype was developed to control the hopper and adult locust. The developed system comprises the spray gun (15 m range), UV stabilised HDPE PVC tank having capacity of 1,000 l, diaphragm type pump, pressure regulator, automated spraying unit and braided flexible pipe. Automated spraying unit developed from DC motor (72 watt), speed controller driver (20A, 12 V DC), battery (42 Ah, 12 V) and regulator to control the direction of spray gun. The automated spraying unit was mounted



on a telescopic frame having height of 5 m, fabricated by using the square steel pipe. The developed unit can be retrofitted on any tractor operated sprayer unit. The developed high pressure variable range sprayer prototype was tested at ICAR-Central Institute of Agricultural Engineering, Bhopal, at tractor rated engine rpm 1,500 and operating pressure of 30–40 kg/cm^2. The sprayer discharge is adjustable in the vertical direction having range of 18–22 m and droplet size 200–500 µm.

Tractor operated intra row cum inter row weeder for orchards: A low hp tractor operated intra row cum inter row weeder was developed. It is easy to extend and retract the rotary unit by swiveling action of hydro-mechanically controlled sensor. Hence, there is no need of ultra light sensor based movement of the arm. In the weeder, wrap around frame ensures upfront visibility to the operator. Mechanical linkages with hydraulic mechanism were used to reduce cost of the machine. The effective field capacity of the machine is 0.17 ha/h with 89% field efficiency in pomegranate orchard and 0.15 ha/h with 81% field efficiency in grape vineyard. The weeding efficiency

of the machine is 95%. There is net saving of ₹ 1,775/ha in pomegranate orchard and ₹ 1,480/ha in grape vineyard over traditional method.

Sprayer equipped with electro-pneumatic system to control whitefly in cotton crop: The cotton crop is cultivated in an area of 0.67 million ha in Haryana with production of 1.63 million bales. The whitefly attack causes a lot of damage to cotton crop resulting into reduction of plant growth and crop yield in Haryana state. A prototype of sprayer equipped with electro-pneumatic system was developed. At 550 PTO rpm, the aspirator speed, forward speed, effective field capacity and field efficiency of machine were 1,825 rpm, 1.74 km/h, 0.091 ha/h and 78.45%, respectively which resulted in 38% reduction in number of whitefly. Similarly, at 760 PTO rpm, the aspirator speed, forward speed, effective field capacity and field efficiency of machine were 3,018 rpm, 3.45 km/h, 0.15 ha/h and 65.22%, respectively, which succeeded in 40% reduction in number of whitefly. And at 860 PTO rpm, the aspirator speed, forward speed, effective field capacity and field efficiency of unit were 4,068 rpm, 4.19 km/h,

0.168 ha/h and 60%, respectively, which reduced 42% whitefly.

Tractor operated planter for tissue culture banana: Conventional planting of tissue culture banana is done manually making the process labour intensive and tedious. Therefore, a tractor operated planter for tissue culture banana was developed by AICRP on FIM (TNAU, Coimbatore centre). The planter can plant tissue culture banana at a spacing of 1.82×1.52 m. The valve is designed to open automatically at fixed plant to plant spacing of 1.52 m through ground wheel measuring system with the help of cam and lever. Seedlings are earthed up by a suitable shovel and the soil around the plant is compacted by the set of press rollers. The effective field capacity of the machine is 0.19 ha/h. Cost of the planter is ₹ 50,000 and cost of operation is ₹ 3,500/ha. The operation can be done timely and accurate plant spacing may be maintained, thus leading to higher productivity. It helps in saving 50% in time, 81% in cost of operation, and 90% in labour requirement as compared to traditional practice of manual planting.

Dust separation system for wheat straw combine: Wheat straw harvested by commercial straw combines contains undesirable materials like soil and other foreign materials which may lower feed intake, disrupt digestion and may have adverse effect on animal health. Dust separation system was developed for wheat straw combine to reduce the soil entrainment into the bruising unit and eventually in the bruised straw. For wheat crop variety HD 2967, the average effective field capacity of the machine was 0.30 ha/h at forward speed of 2.02 km/h. The fuel consumption of the machine was 6.28 l/h. The average size of the bruised straw was 18 mm, which was 16% higher than the average straw size obtained from *Harambha* thresher (16 mm) and 19% lower compared to straw obtained from existing commercial straw combine (22.5 mm). The average dust concentration in developed machine, *Harambha* thresher and commercial straw combine, were 6.70, 5.40 and 11.25%, respectively.

Trimming mechanism type banana sucker pairing equipment: At present sucker paring is done manually and it requires more labour and tedious operation. To eliminate human drudgery the sucker pairing device with trimming mechanism was developed. The equipment consisting of the holder on which the banana sucker to be trimmed is placed. The spring loaded holder from the top, gives the grip on the sucker to be trimmed and it can be locked in the required position. The holder is rotated with the help of 1 HP motor at the required speed. The trimming knife is placed at the required position so that the banana sucker placed on the rotating holder is trimmed to the desired shape to get the paired banana sucker ready for planting.

An additional knife is mounted on the working platform, which can be used to cut the bottom roots before placing it on the holder for trimming. The equipment is best suited for large size suckers. The capacity of the equipment is about 120–150 suckers/h.

Banana pseudostem injector: It consists of chemical tank, peristaltic pump, control unit with non-return valve and injector. The peristaltic pump is attached to pump the liquid from chemical tank to injection system. The control unit is attached with electronic embedded system to control chemical quantity and depth of injection by 8 mm I/P and O/P Screw Variable valve. The non-return valve (¼ thread, one way valve) is attached with control unit to restrict the chemical back flow to the injector after injection. Quantity of liquid injected is 2–4 ml/tree ml, coverage 140–150 trees/h, spillage percentage and injector efficiency was recorded as 2% and 95%, respectively.

Tractor operated banana bunch harvester: At present, bunch harvesting as is done manually requires more labour, and is tedious operation. To eliminate the human drudgery, a tractor operated banana bunch harvester was developed. The hydraulic cylinder is provided for operating harvesting boom and bunch holding and cutting assembly. Power from tractor PTO is transmitted through 1:5 step up gearbox to the Gear pump (clockwise, 27 lpm) to operate the hydraulic cylinders through two double acting spring center directional control valves.

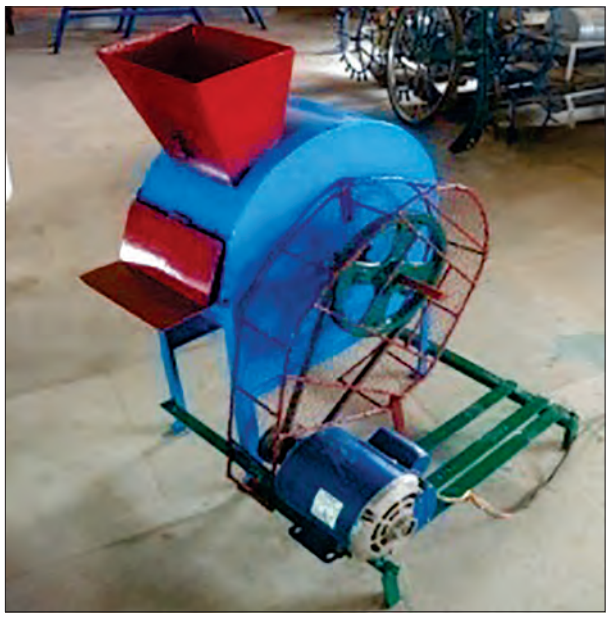
Cashew apple slicer: Two models of cashew apple slicer were developed.

Multiblade type cashew apple slicer: The multiblade type cashew apple slicer consists of nine blades of 165 mm diameter coupled to 1 HP motor. Motor was coupled to a variable speed drive wherein the speed of the cutting blade could be controlled. The gap between the two blades was kept at 2 mm so that the output of 2 mm is obtained. There is an ejector mechanism kept on the rear end side of multi blade, in the cashew apple slicer. The capacity of the equipment is about 70 kg/h.

Vertical feed and horizontal slicing blade model: Cashew apple to be sliced is fed vertically. The blade is rotated by 1 HP motor at about 2,000 rpm. There is a brushing arrangement placed so that the blades can be cleaned at the end of one cutting cycle. The output capacity of the equipment is 75–80/h. Since there is no separate ejector mechanism the sliced cashew apple is directly collected through the outlet rather than being ejected out with the help of ejector. The cleaning of the developed equipment is easy.

Lifting platform for operations in green house: Green house operations like pruning and harvesting being done at overhead height by use of existing system, result in greater muscle loading, increased level of discomfort, reduced performance due to restrictions on posture, difficulty in moving the system forward and backward, no height adjustment and unsafe. The

Cleaner for multiplier onion: Cleaning of the stored onions prior to marketing is an essential unit operation in the processing of multiplier onion. At present cleaning is carried out in the fields involving human labour, hence is labour intensive and time consuming. An attempt was made to develop engine operated cleaning equipment for multiplier onions. The developed cleaning equipment consists of main frame, material flow bed, air distributor, engine operated blower, feeding inlet, outlet for blowing out dead skin and dirt, collecting tray for cleaned onion. The unit is a portable one. Maximum cleaning efficiency was 98% at 10.41 m^3/s air flow. The capacity of the cleaner was 850 kg/h.



modified platform was developed and used in green house for prunning and harvesting operations. The sytem is powered with rechargable battery power pack for operation for forward movement and adjustment of the platform height using hydraulic system. The force required to move platform is 6 kg, gear ratio 1 : 9, time required is 10s, energy required to move 1.5 m was 600 Nm, forward speed is 0.15 m/s, lifting per stroke is 1.5 cm, total lift was 1.20 m, energy required to lift platform for change of stage (400 mm) is 400 Nm.

Power operated mini rhizome planter: In NER, simple traditional tools like a spade, dao, khurpi, hoe etc. are used for ginger cultivation. A power-operated mini rhizome planter with cup and chain metering mechanism was developed. Provision was provided in furrow opener to operate at different depth as desired. Average seed spacing was 25 cm, depth of operation 2.5 cm and 4.5 cm and actual field capacity 0.074 ha/h.

Power operated groundnut stripper-cum-decorticator: Groundnut is the sixth most important oilseed crop in the world. An effort was made to combine the stripping and decortication operation and a small 0.5 hp motor operated groundnut stripper cum decorticator was developed. The equipment can be used only for stripping or stripping-cum-decortications purpose. The height of the hopper was kept as 93 cm considering the anthropometric body dimensions of female agricultural workers. In a manual stripper four women can strip 11 kg of pods in one hour. The developed power operated groundnut stripper has average output capacity of 12.1 kg/h and it needs only one operator, saving time as well as labour. The threshing efficiency is around 95% and the total pod losses lies within 5%. The cleaning efficiency is 70%, which can be enhanced by adding a blower mechanism.

Dust protection mask: Dust mask is personal protective equipment recommended to reduce the dust exposure to workers. Five different dust masks were designed and developed with the combination of different filtering material. The filtration efficiency and breathing resistance of developed dust mask was assessed at 75, 90 and 105 l/min air flow rate and it decreased with increase in air flow rate. The filtration efficiency for all the dust masks is between 91.7 to 94.8% at an air flow rate of 75 l/min. The results show that the breathing resistance of all mask except Mask 5 was d≤4 mbar (40 mm water column), whereas Mask 5 (non-woven synthetic + double woven cotton mechanically napped + flannel) has higher breathing resistance. There is no significant difference in filtration efficiency of Mask 1, Mask 5 and Mask 3 at low air flow rate. Whereas the breathing resistance was minimum for Mask 3 (raw cotton sheet + double woven cotton + flannel napped cloth). Effect of washing these masks was also studied and observed that filtration efficiency of all of the masks decreased with dry wash than that with easy wash condition. Based on the filtration efficiency, Mask 1 and Mask 5 and Mask 3 were found at par with no significant difference.

Whereas, Mask 3 was superior among the others based on breathing resistance.

Solar fan assisted headgear for environmental heat stress: A solar hat with air circulation system has developed which can further reduce the risk of heat stress and improve the comfort of agricultural workers. The developed solar hat consists of solar panel, fan and shell. The potentiometer (470 k) is connected in series with solar panel and motor to regulate the speed of fan. An on/off switch is also provided to switch off the fan when cooling is not required. Presently three headgears namely bamboo hat, white pagdi and felt hat with 90 mm brim width are used by agricultural workers. Therefore, these headgears were also tested with the developed headgear in similar climatic condition, i.e. WBGT 28, 30 and 32ºC.

Farm safety app: Farm safety app was developed by AICRP on ESA Center at CIAE Bhopal. App provides information about agricultural accidents and their cause, precautions and safety gadgets for its preventions. The app will be used to create awareness among farmers, users and operators' about different safety measures and first aid in emergency. It also provides guidelines for different farm machine uses and safety. It will give information about accident compensation in different states. Farm safety app is available in Google play store.

Non-thermal plasma pyrolysis reactor: A sophisticated research facility to generate and use the non-thermal plasma (fourth stage of matter comprising the free and charged radicals) was established at biofuel laboratory of ICAR-CIAE, Bhopal. This contains a reactor to study the pyrolysis/thermal degradation of crop residues. The system consists of stainless steel (SS) main reactor equipped with viewing glass, needle valve for allowing carrier gas in the reactor, passage for high vacuum system and plasma gun. System can generate the vacuum as high as 10^{-8} bars. The thermal

Initiatives to tackle the COVID-19 Pandemic

The portable touch-free hand wash system, hand sanitizer unit and pedal operated sanitizer dispensing unit were developed by CIAE which can be adopted by hospitals, offices, malls, crowded market, railway station, industries etc. to follow the guidelines of regular hand washing to prevent spread of COVID-19.

Touch-free hand wash system

The portable touch-free hand wash system consists of water tank, infrared sensor, 12V DC water pump, DC speed regulator, 12V DC battery, relay board, touch-free sanitizer dispensing unit and water disposing plastic hose. When the hand reaches near the sensor, it produces output pulse relay which triggers (act as a switch) the pump to turn it on. Pump in turn ensures the flow of liquid soap/water from tank to liquid soap/water outlet. A single relay triggers up to 5 ml of liquid soap from touch-free dispenser unit and 100 ml of water from water tank. The discharge rate of liquid soap and water can be regulated based on necessity by using DC regulator switch. The capacity of the automatic refillable system is 120 handwash/h. The system can either be powered by AC current or by DC battery for portable use. The provision is also made for charging the battery and operation by a solar panel.

Touch-free hand sanitizer unit

The touch-free hand sanitizer is a stand-alone wall mounted or placed on the table to dispense the sanitizer without touching the unit. The device is easy to fabricate and light in weight (1 kg without sanitizer). In this unit, infrared sensor is located near the outlet to detect the user hands. As soon as the hand is detected, relay (act as switch) triggers the AC/DC pump to operate and up to 5 ml of sanitizer is dispensed at delivery end. The capacity of the unit is 180 hands sanitization/hour. The provision is given to use 12 V DC water pump with 12 V DC battery. The touch free hand wash system and touch free sanitizer dispenser unit were licensed for commercial production of the units.

Touch-free pedal operated sanitizer dispensing unit

The touch-free pedal operated sanitizer dispensing unit was developed for hand sanitization without touching any surface with hand. The unit is very simple in construction and operation, and is designed in such a way that required quantity of sanitizer or liquid soap can be dispensed by pressing the foot pedal. Total height of the unit is 1,100 mm. It is portable and can be placed at entrance of lobbies, corridors, farms, meeting rooms, outside the shops etc. The cost of this unit is about ₹ 1,000.

Solar assisted micro-algae harvesting system

Electro-flocculation is one of the efficient and easy methods for harvesting of micro-algae. An electro-flocculation harvesting system was developed considering the optimized harvesting time and voltage for better efficiency. It consists of two solar panels connected in series that produce 60 V and 6.9 A current at an average solar insolation of 5.35 kW/m^2/day on tilted surface. Total time required for harvesting is 4 h to bring down optical density of microalgae from 0.98 to 0.16. The harvesting efficiency of the system was achieved in the range of 81% to 86%. Average power output from solar panel was 0.32 kW and energy consumption for electro-flocculation was 2.96 kWh/kg of dry micro-algae biomass.

degradation behaviours of crop residues can be studied under different levels of vacuum and plasma intensity in different environment. The generation of free and charged radicals in plasma under different levels of vacuum with different type of gases is the one of important functionalities of system. This R&D facility is very important to study the influence of free and charged plasma on biomaterial molecules.

Development of low cost farm level milk cooling system: The experimental setup of Farm Milk Cooler (FMC) for 40–80 litres capacity was designed and fabricated. Data logger based sensors were placed at different locations in the developed unit to record temperature as a function of time. Refrigeration system of 1 TR capacity was used to cool the milk in FMC. Forced water-air cooled condenser designed and evaluated and the system was compared with the air cooled condenser. Controlled environment chamber (CEC) designed and fabricated for testing of refrigeration system of farm milk cooler. It was noted that the suction pressure did not remain constant at different temperatures in all experimental studies. The pressure of condensation ranged from 13 bars to 15 bars, 13.90 bars to 16.00 bars and 14.5 bars to 16.50 bars at different temperatures. The study revealed that the air temperature used for the condenser significantly influenced the condensing pressure of the FMC vapor compression cooling system.

Development of mechanized whey dewatering system for *Chhana*: Chakka is the semi-solid intermediate dairy product obtained by draining off the whey from the curd mass. Traditional method of whey removal from curd mass is very tedious, time consuming and unhygienic. It helps in predicting draining characteristics such as moisture ratio which gives better understanding the process of moisture removal from *chakka*. The developed equipment would be suitable for small-entrepreneurs for the production of chakka and fulfils the requirement of time saving and hygienic production.

Anti-fouling plate heat exchanger for milk processing: A study was undertaken at ICAR-NDRI to alter the surface properties of the plates of PHE by applying non-sticky coating of nanomaterials to mitigate the fouling deposition during heat treatment of milk. The heat transfer coefficients for uncoated surface decreased continuously with the processing time, after an initial induction period, whereas those of the coated surface were almost constant. ❑

“By adopting modern scientific farming practices, we can boost national economy in a big way.”

— Narendra Modi

10. Post-harvest Management and Value-addition

Machines/equipment

Green pea depoder machine: The *Pisum sativum* (commonly known as pea) contributes approximately 2.88% (5,422.14 thousand MT) share of the total vegetable production and 4.6% of the total vegetable producing area in India (NHB 2018). Green pea is used as fresh pod, frozen seed and for preparation of various recipes. The shelling/de-poding of pea seeds from the matured pod is requisite unit operation for its consumption in various forms such as fresh peas, frozen pea, canned pea and in dried pea seed form. The machinery available for de-poding are of large capacity (minimum 1 ton/h) and costly for the marginal farmers and also leads to the damage or splitting of kernel during operation. A small to medium scale green pea de-poding machine was developed at ICAR-CIPHET with capacity of 45–55 kg/h, shelling efficiency of 90–95%, and damage of 2–3%. The better capacity and efficiency of the machine in comparison to manual shelling (3–3.5 kg/h) will help to reduce the human drudgery. The machine is developed to cater the needs of small and medium scale farmers who generally sell their produces in local mandies. These farmers can also establish a small pea processing plant to generate more income and employment. The complete de-poding system costs around ₹ 1.75–2.0 lakh.

Primary makhana roasting machine: Primary roasting machine is a beneficial unit used for first roasting of raw makhana seeds before tempering and popping. Primary roasting is the crucial step, which plays a supreme role for obtaining good quality popped makhana as even a slight change in processing conditions may affect the product quality. The developed Primary roasting machine is an indirect batch type conduction heating system. Sun-dried and graded raw makhana seeds can be roasted in the machine conveniently. It consists of a rotating iron pan, which is heated by using LPG. The agitators placed at specific locations mix the seeds continuously during roasting (at 260–300°C). After completion of roasting (4–8 min), roasted seeds are discharged through a hollow pipe and collected directly in jute bags. This machine is operated by a 1 hp geared motor at 40–60 rpm and can roast 8–10 kg seeds in one batch. One skilled labour can operate this machine as well as the roasting machine can be operated manually. Roasting by this machine reduces about 25% fuel and labour expenses.

Loading/unloading device: The ICAR-PHET-PDKV loading unloading device having sorting table with small inclined belt conveyor and tractor trolley attachment was developed for unloading onion from tractor trolley and loading/unloading into/from storage

structure and loading into tractor trolley or grading machine with capacity 15–20 tonnes/day (8 h). Food grade PU belt is used for loading unloading device. Wheels are provided to make the unit mobile. This assembly of loading unloading device was found economically viable. The cost of machine is approximately ₹ 2.85 lakh.

Solar assisted dryer for drying of groundnut pods: The on-farm solar assisted dryer for drying ground nut pods was developed. After drying, the ground nut pods can be stored for a longer time. The capacity of the machine is 120 kg/h. The cost of the machine is about ₹ 360,000 and is easy to operate.

Poultry processing-cum-by-product collection unit: For sale of poultry meat under hygienic conditions, a small smart eco-friendly mobile poultry shop with slaughtering unit was developed. An e-rickshaw (battery operated) was modified to form the mobile processing unit having facilities for carrying out all slaughtering operations like bleeding, defeathering, dressing and storage of carcass under chilling conditions. Besides, it has a carrying capacity of 50 live birds. Further, the machine also has a by-product collection system under chilling condition thereby promoting effective utilization of by-product and reduced environmental nuisance. All the units in the machine are operated on 12 V DC current supplied using 4 lithium ion re-chargeable battery fitted with the rickshaw. The unit will be a suitable alternative for small poultry vendors/ butchers in cities and towns and will also add in providing hygienic and wholesome meat to the consumers at the doorstep besides keeping the city clean. The cost of the machine is ₹ 160,000.

Automated amylose detection sensor system for assessment of ageing of rice grain: The developed sensor consists of different light sources (red, green and blue LEDs) along with the red LED of wavelength 652 nm, which are connected to the ESP8266 (Node MCU) microcontroller with the help of suitable resistors. LDR photodiode is used as a light detector for recording the light intensity before and after placing the test solution in the cuvette. A 9 V battery is used as a power source to run the device. All the components

are embedded in the outer body, which is made of Acrylonitrile Butadiene Styrene (ABS) with the help of 3D printing. Further, an android mobile application was developed to record and analyze the real time data for assessing the ageing of rice as a graphical user interface (GUI). The developed instrument is used for assessing the ageing of rice. The capacity of the machine is 10–12 samples per hour. The cost of developed sensor is ₹ 3,000 for mass production.

Portable solar dryer for hill: The capacity of dryer is 25–30 kg with lower operational cost because it is operated with solar powered exhaust fan to remove moistened air. Drying was accomplished in 2–3 days to final moisture of 5–8% (WB). It was installed at two farmers' field and 10 nos. were supplied to farmers through TSP. In the dryer 15–20ºC higher temperature can be achieved than ambient conditions (25–30ºC). The cost of dryer is ₹ 15,000.

Portable ozone based fruits and vegetable washer-cum-purifier (Ozo-C): During the COVID-19 pandemic as people bring home fruits, vegetable, mutton and fish, the fear of contracting corona virus from the same also looms large. To ensure food safety, after buying such commodities from the vendors and bringing home a suitable gadget with standard protocol is urgently required to ensure complete safety of commodities at home.

ICAR-CIPHET, Ludhiana, has developed a portable fruits and vegetable washer-cum-purifier named Ozo-C based on Ozone technology. The portable system is an excellent ozonator which removes pesticides, bacteria, viruses and harmful chemical from the surface of fruits and vegetable, sea food and meat, making them hygienic. The system works on principle of silent corona discharge method. It uses electric discharge to produce ozone by splitting the normal oxygen molecules in the air into single atoms. These atoms recombine with air (i.e. O_2) to form ozone (O_3). The unit cost of the device is approximately ₹ 3,500. This compact device may find a place in every kitchen, hotels, small scale fruit vegetable processors and vendors where it can play a vital role in reducing the risk of infection especially during this pandemic period. The technology has been transferred to two firms, M/s Siri Labs, Ongole and M/s CRD Invotech, Maharashtra.

Portable smart ultraviolet-C disinfection system (UV*i*C): A portable surface disinfection system for disinfecting personal items and office stationery was developed to help fight against COVID-19 pandemic. Unlike chemical sanitizers, UV-C does not leave a residue and does not require extensive safety equipment. It works as a mode of surface sterilization by destroying nucleic acid and disrupting the DNA of microorganisms. The developed system exceeds UV-C exposure of 1.22 J/cm^2 (total dose) which is well above the amount of exposure needed to inactivate SARS-CoV-2. The working capacity of the unit in terms of the total surface area of the objects to be treated/exposed is 25 × 25 cm^2. The estimated cost of the unit is approximately ₹ 1,500. However, the system can be scaled up as per the need. The system has been tested for inactivation of *Escherichia coli* as classic examples of gram-negative bacteria. The influence of the treatment parameter, i.e. the exposure duration was investigated on *E. coli*. Findings indicated that no visible *E. coli* colonies were observed after six minutes of continuous UV-C exposure. The developed system is unique, portable and cost-effective which can be installed in offices, homes, shops, hospitals, malls, etc. The technology was transferred to two firms, M/s CRD Invotech, Maharashtra and M/s Sakhi Soaps, Hindustan Soaps and Salts Company, Andhra Pradesh.

Process/products

Novel process for production of protein isolates/ concentrates from de-oiled cakes/meals: At present, chemical process comprising alkaline extraction and acid precipitation is followed for production of protein isolates. The strong alkaline and acidic conditions alters the functional properties of the protein, which adversely affects its quality. A novel process to produce protein isolates/concentrates from oilseed cakes/meals (example soy meal, groundnut cake) without addition of strong or diluted acid was developed. The developed process is unique as it is added acid free and also provides about 5% higher yield of protein as compared to the existing chemical process. The protein produced using ICAR-CIPHET method is superior in terms of solubility, wettability, water absorption capacity and degree of hydrolysis. The yield so obtained is about 35–36% of the total weight of soy meal and 25% of total weight of groundnut cake used, whereas, in the existing process, maximum 30% protein yield from soymeal can be obtained. The developed method comprises novel bacterial strains isolated from a food sample for producing protein from de-oiled meal/flour. The obtained supernatant after precipitation of protein from a particular batch may be used for precipitation of another batch and so on. National and International (PCT) patent applications were filed. The protein produced through developed process may find demand at national as well as international level to boost

immunity. The plant protein is used in protein supplements, texturized vegetable proteins, imitation dairy products, sea food products, beverage industry, infant food formulations, weaning food formulations, bakery products, and meat analogues for various purposes.

Fat-free flavoured makhana: Demand of flavoured makhana is increasing in the export and domestic market continuously. In the conventional processing method to produce flavoured popped makhana, the fat/oil use is as high as 30%. Such high oil content is not desirable for better shelf life and consumption by obese and

health conscious people. ICAR-CIPHET developed a process for preparation of fat/oil free flavoured makhana, particularly for the health conscious consumers. The developed process comprises a formulation of edible spices and permitted flavouring materials, process of applying formulation to the popped makhana and method of mixing. Shelf-life is as high as popped makhana itself.

Activated carbon from walnut hull: The process of making activated carbon from walnut shell/hull was developed. The activated carbon is obtained from walnut shell and the surface area of this walnut based activated carbon is more than the coconut based activated carbon. The ash content of walnut based activated carbon is 1.20–1.26%, which is lower than the activated carbon developed from coconut based activated carbon which is 2–3%.

Wallnut shell

Activated carbon

Natural dye (Juglone) extracted from walnut hull: Juglone, a natural dye was extracted from Walnut hulls. Test trials were conducted on Pashmina wool in combination with different mordants. The results are excellent.

Wallnut hull

Juglone extract from wallnut

Testing kit for detection of adulterants in selected spices: Among many commercial crops sown in India, spices occupy an important place. They are known for their fine quality and flavour and Indian cooking is incomplete without the use of spices. The demand for these items has gone up considerably in the international market also. Turmeric, red chillies, black pepper, coriander, etc., are a few important spices grown and immensely consumed in India. The spices which are known for their health promoting qualities

Rose petal jam

Rose, termed as 'Queen of flowers', finds its application in food products, medicinal and cosmetic industry. It is a highly nutritive flower with vitamin-C, carotenoids, phenolic components, anthocyanidin, and some minerals. Value-added products of rose are rich in antioxidants, used as astringent, tonic, mild laxative, anti-bacterial agent, treatment of sore throat, enlarged tonsils, cardiac troubles, eye disease, gall stones, anti-HIV, anti-bacterial, and hypnotic activities. Rose petal jam and gulkand is usually used synonymously. However, the manufacturing process of gulkand is entirely different from the conventional jam preparation process. In true sense, the rose petal jam is not yet available in the Indian market. ICAR-CIPHET developed a process for preparation of rose petal jam without using any fruits or vegetables or their powder or essence but with the desired quality of the end product, i.e. jam. The developed process comprised formulation of rose petals, sweeteners and permitted food additives, paste preparation without affecting the colour quality and antioxidant activity, and the process for preparation of jam with good sensory quality.

fell prey to adulteration. Turmeric is known to be adulterated with metanil yellow and/ or lead chromate; red chilli with Sudan and/or Rhodamine dye, in coriander starch is added in bulk and black pepper is adulterated with papaya since both papaya and black pepper seeds have similar appearances. Dyes are generally added to give bright and attractive colour to the spice. However, these dyes are non-permitted and carcinogenic. Need is always there to develop simple, quick and easy methods so that the pure and adulterated powder samples can be differentiated. Keeping this in view ICAR-CIPHET, Ludhiana has developed biochemical tests based testing kit for detection of above mentioned adulterants in turmeric, red chillies, black pepper, and coriander. The method of detection is quick and simple to perform and also validated by NABL accredited Punjab Biotechnology Incubator Laboratory, Mohali. Approximate cost for the kit involving six tests with 100 tests (each) is around ₹ 5,000. The kit contains chemicals, glassware and procedure for detection of adulterants, viz. metanil yellow, lead chromate, sudan dye, rhodamine, starch and papaya seed powder from spices.

Soy based composite edible film: Soybean aqueous extract was used as the main ingredient for the development of an edible film with different additives which increased the water barrier, mechanical and anti-bacterial properties. The water barrier property of the film ranged from 5.3 to 9.2×10^{-10} g/ms Pa. The tensile strength of the film varied from 5.1 to 8.2 MPa, which is higher than similar composite edible films. The elongation of the film ranged from 70 to 88%. The edible film was used as a packaging material for the instant *masalas* of ready-to-cook noodles. Sensory evaluation of the film showed very good consumer acceptability of the product with an overall acceptability score of 7.80 out of 10. The film was also tested as a cheese slice separator in cheese packaging. The

application of edible film to the cheese slice reflects its suitability for separating ingredients in sandwiches and burgers or to wrap the food product.

Omega 3 rich flax seed and chia seed fortified eggless chocolate cake: Essential polyunsaturated fatty acids cannot be produced by the human body and must be obtained from the diet. Flax seed (*Linum usitatissimum*) is an important oilseed crop which is high in fibre and is a significant source of α-linolenic acid (omega 3 fatty acid) in the diet of vegetarian people. Flax seed consumption in the diet prevents serious diseases like coronary diseases, cancer, diabetes, obesity, gastrointestinal, renal and bone disorders. Chia (*Salvia hispanica*) seeds are rich in protein, dietary fibre, minerals, vitamins and antioxidants. Chia gum is also an important food ingredient due to its emulsifier and stabilizer potentials. To utilize nutrients in flax seed and chia especially α-linolenic acid, chocolate cake was fortified with flax seed meal and chia gel. Eggless cakes were developed using chia gel as egg replacer; whole wheat flour cake and wheat flour along with 5% flax seed meal. The batters and cake were tested for physical, colour, rheological, textural, nutritional and organoleptic properties to study the effect of chia gel as egg replacer with wheat flour; combination of wheat flour, flax seed meal and egg replacer and comparison with whole wheat flour cakes with eggs. Texture analysis of the batter showed that the firmness, consistency, cohesiveness and index of viscosity of wheat flour cake along with 5% flax seed meal were similar to the control cake. Wheat flour cake along with 5% flax seed meal contained the highest ω-3 fatty acids (7.84% of total fatty acids present). Test cakes showed higher phenolics, flavonoids and anti-oxidants compared to the control cake. Sensory analysis showed that the acceptability of test cakes especially of wheat flour cake along with 5% flax seed meal was high (8.2 on the 9 point hedonic scale). Therefore, whole wheat eggless cakes with chia and flax seeds are a tasty and good way to boost the omega-3 fatty acid, and antioxidants in the diet.

Cotton gin trash treatment system: Cotton ginning industries serve as a source for reintroduction of pink bollworm (PBW); as during ginning operations, alive PBW may escape through gin trash and get disseminated in neighbourhood cotton fields. Pink bollworm, a dreaded pest, adversely affects cotton yield, fibre quality and thus income of farmers and ginners. Ginning performance of PBW infected cotton on DR gin showed 17%, 14% and 11% reduction in ginning percentage, fibre length and tenacity, respectively, along with significant deterioration in colour grade of cotton. SEM analysis indicated poor fibre development and growth of microbes on PBW infested cotton in comparison to healthy cotton. Hence, it is must to breakdown life cycle of PBW and prevent damage to cotton crop in subsequent season.

A gin trash treatment system comprising centrifugal trash fan, cyclone and compactor was developed with a capacity of 2.5 tonnes of trash per hour to crush and treat gin trash in such a way that all PBWs are destroyed. The trash fan wheel which crushes gin trash should have minimum of six straight blades with

(*a*) Gin trash treatment system, (*b*) Pink bollworm infestation

minimum fan diameter of 490 mm. The trash fan should generate an air volume of 4,800 m^3/h and run at a pressure of 363 mm wgp. The minimum fan tip speed of 4,192 m/min, i.e. about 3,000 rpm should be maintained. The minimum air velocity through 254 mm ducting should be more than 17 m/s. The 1D-3D cyclone with diameter of 815 mm and height of 2,445 mm needs to be employed to separate out air and trash passing through the trash fan with a pressure drop of 360 mm wgp. The compactor enables the volume reduction and cost effective disposal of gin trash after treatment. The screw conveyor of compactor should have pitch and diameter of 320 mm and should run at a speed of 72 rpm. With this protocol the developed system successfully attained the intended function of destroying PBW and the mortality rate of larva and pupae was 100%.

Cotton interlined sleeping bags for better comfort: Defence personnel, Central and State Reserve Police force, Anti-Naxalite Task Force, and Trekkers need sleeping bags for protection from external environmental elements, insect/ reptile bites, etc. during outdoor stays. At present sleeping bags are manufactured using synthetic materials especially Nylon, Polyester and Polypropylene and are mostly imported. M/s Shree Agro Invent-Tech Pvt Ltd, Mumbai which is a start-up incubated at ICAR-CIRCOT has developed an innovative sleeping bag with the functional finishing technology licensed from CIRCOT with more comfort. These sleeping bags can be modified to protect user in low temperature conditions. The salient features of the sleeping bags are:

- inner layer of 100% cotton for better comfort and to avoid static charge generation;
- high abrasive resistant, light weight outer layer of Polyester fabric;
- anti-bacterial inner cotton layer to avoid odour generation due to sweating; and
- sleeping bag has pocket to place mosquito repellent pouch as well.

This technology was released during 92nd Foundation Day and Award Ceremony of the Indian Council of Agricultural Research (ICAR) held on 16 July 2020.

Agro-residue reinforced natural rubber garden pots: ICAR-CIRCOT developed technologies for efficient utilization of agro-residues to develop innovative sustainable and biodegradable composites. The present product was developed as an alternative to conventional clay and plastic pots. Manufacturing technique involves use of different agro residues for reinforcing natural rubber to develop an innovative rubberized composite. The composite is prepared by mixing of pulverized agro-residues with natural rubber. Different colours are mixed into the composite mixture. The rubberized composite sheet was molded into different shapes and sizes of garden pots at specific temperature and pressure. These pots are 10–15 times more durable than conventional pots, dimensionally stable, unbreakable, and due to flexibility reduce damage to growing roots, and is biodegradable.

Innovative lysimeter for on-farm water management: An incubate of ICAR-CIRCOT, M/s Green Prosperity Innovations, Satara, Maharashtra developed this innovative lysimeter for effective management of water at farm level. The system comprises intelligently designed components with high measurement accuracy and is easy to install, operate and manage with customized soft tool.

Features

- Used for both surface or pressurized irrigation systems.
- Cost effective solution that is easy to install, operate and maintain.
- User-friendly soft tool gives user customized solutions and guidance.

- Improves water use efficiency by 25%.

Applications

- Fertilizer or soil-based input management.
- Sub-surface drainage design and management.
- Irrigation water quantity and time management.
- Reclamation of contaminated soils.

Engineered jute based agro-textiles for enhancing crop yields: Crop yields are generally limited by several factors like water, soil nutrients availability, proper managements, etc. Mulching manipulates the crop-growing environment to increase crop yield and improve product quality by controlling soil temperature, retaining soil moisture and reducing soil evaporation. A major limitation of polyethylene mulch involves disposal of mulch, if not properly disposed off, can fragment, and cause damage to environment, i.e. land and water resources. Jute based mulch can be a sustainable alternative of synthetic mulch.

Jute based agro-textiles were engineered using 50% pure jute with 50% caddies (waste jute) on weight basis. For research purpose six different categories of jute non-woven 100% jute of 250, 450, 650 GSM and 50% jute plus 50% caddies of 250, 450, 650 GSM with synthetic and rice straw as mulch were used. Engineered Jute based Agro-textiles, i.e. 50% jute plus 50% caddies of 450 GSM outperformed among

Jute based agro-textiles

High value fine textiles from banana/jute/regenerated cellulosic fibres

Banana is one of the world's oldest cultivated crops and it is also one of the major fruit crops growing in each and every state of India. Banana stem is commonly discarded after harvesting the fruit. Banana pseudostem is mainly composed of four different parts: fibre, scutcher, sap and central core. From the stem, the fibre is extracted after scutching and washing in water or dilute chemical. The extraction of fibre from the banana stem is now-a-days gaining academic interest and decentralized product development, especially in the village level. This fibre can be used for making fabric, high quality handmade paper and different attractive handicrafts. The fibre is coarser and stiffer as compared to jute fibre, but possesses good ultraviolet (UV) resistance and fire resistance properties and very much suitable for making coarse yarns with good tensile strength. Therefore, a pre-treatment or surface modification of fibre is needed to make them soft and fine so that it can be blended with jute in different proportions to make a comparatively finer yarn. Blending of the fibres helps to utilise the unique properties of individual fibres and to produce yarn with superior characteristics.

Jute and banana were treated with eco-friendly biocatalysts followed by bleaching with hydrogen peroxide. The control as well as chemical treated banana fibres were blended with jute and regenerated cellulosic (viscose) fibres in 35 : 35 : 30 ratio to produce ternary blended fine yarn of 4, 6 and 8 lb/spy jute count in jute spinning system. This ternary blended yarn was subjected to dyeing using reactive dyes in solid shade to produce coloured yarn with attractive look and high wash fastness properties. The bleached as well as dyed yarns were used to produce woven fabrics in handloom to develop stripe design, which can be judiciously utilised for making fine table cover, bed cover, jackets, etc. as shown above. Only bleached ternary blended yarn can also be converted into plain weave fabric in handloom and later on can be effectively dyed with bright and wash fast colours using reactive dyes without deteriorating fabric's strength. Ternary blended white fabric was also taken for printing with different design to improve the look of the products.

Value apparel and home textile products developed from banana/jute/viscose fibres

all the mulches used for experiments. There was one demonstration in Malda in collaboration with ICAR-CISH regional station and KVK, Malda on summer tomato crop. Various soil parameters were improved, evaporation losses were restricted, weed growth was controlled and water use efficiency (WUE) improved significantly. Yield of summer tomato crop increased significantly by 40%. Therefore, it may contribute to narrowing the yield gap between actual yield and attainable yield. Site specific knowledge is very much needed for the mulch management of crops.

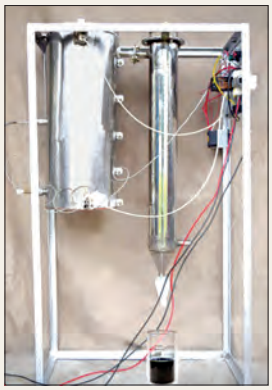
Jute and yak fibres blended high value textiles: Yak is one of the important domesticated bovid animals, conducive to grow in extreme cold region, and is found throughout the Himalayan region of the Indian subcontinent, the Tibetan Plateau, Mongolia and Russia. Total population of yak in India is approximately 56,000. It is mainly domesticated for its milk and meat. However, the use of yak hairs (both coarse and fine) has not been explored much for making value added products, including textile. Presently, the availability of yak fibre in India is estimated as 220 tonnes—200 tonnes of coarser and 20 tonnes of fine hair fibre. At ICAR-NINFET, Kolkata, in an effort to develop high value textile products by encompassing the positive attributes of both the yak and jute fibres, fabrics were developed from coarser yak hair (diameter 80–120 μ) and jute fibres with an areal density of 400 g/m^2. These fabrics were used to prepare long coat, half jacket and full jacket with a good thermal insulation value. Likewise, the fine yak fibre (diameter 20–30 μ) was used to develop high value shawl, suiting fabric and jackets. The shawl consists of 30% jute, 40% fine yak fibre and 30% silk fibres by weight with a price approximately ₹ 2,500. To improve the feel and softness of the jute/yak fibres blended fabric, it was finished with suitable chemical. The chemical finish leads to improvement in total-hand-value (THV) of the fabric from 2.38 to 3.28 (1 means poor and 5 means excellent). Scientific intervention in this area will be beneficial to jute farmers and yak herders (farmers).

Chemical free process technology for the production of raisins: The existing practices of raisin making involve intense use of chemicals especially for pre-treatment, during drying and post drying as well. In this practice, the drying time of grapes is about 13–20 days depending on the environmental conditions; the process involves more number of unit operations and is tedious and laborious. Disposal of solution of chemical and water after use creates environmental issues. On the other hand, there is a consumer demand for chemical free products.

A package of technology with chemical free process was developed at ICAR-CIAE, Bhopal for the production of raisins. It includes a grape de-bunching machine (capacity: 150 kg/h) to separate intact grape berries, abrasive pre-treatment equipment (capacity: 135–150 kg/h) to remove waxy layer from the grape surface, drying protocol for grapes, packaging and storage of raisins. This package of technology is suitable to produce good quality raisins with no use of chemicals in entire

Tubular condenser integrated bio-oil apparatus

A bio-oil production unit capable of converting biomass to bio-oil in slow pyrolysis mode was developed having loading capacity of one kg powdered biomass. The main unit is vertical stainless steel reactor. The reactor was coupled with specially designed tubular condenser for condensing the bio-vapour generated during heating treatment of biomass. The condenser is equipped with five SS tubes. The pyrolysis vapour is immediately passed through the heat exchanger to condense the bio-oil from gas. The process temperature for destructive distillation of biomass is precisely controllable in this system from ambient until 700°C. The unit has been tested with recovery until 48% with pine needle biomass. System also has provision for injecting nitrogen for maintaining inert atmosphere to conduct the studies on pyrolytic behaviour of biomass.



Grape de-bunching machine

Abrasive pre-treatment equipment

Drying of grapes

Mechanized whey dewatering system

process and there is reduction in drying time of grapes (by 30–40%). Solar dryer or convective type hot air dryer can be used to dry the grapes.

Salient features of the developed technology—

- No use of any chemicals in entire process of raisin making;
- reduced drying time;
- reduced processing cost; and
- suitable to produce organic raisins, if production is organic.

Sorghum yoghurt: Non-dairy plant based lactose free yoghurt was developed from sorghum and soya milk. Sorghum milk was prepared from sorghum grain. The milk was cooked to carry out complete gelatinization of starch. Further, sorghum milk was blended with soya milk in different concentrations. Yoghurt culture was added at 15% concentration. It was found that sorghum-soya blend containing 60% sorghum milk and 40% soya milk gave the best quality yoghurt. The developed product was superior in nutritional value with total solids, 5.305, titratable acidity as 0.07425% as lactic acid, and 6.31 g/100 g of protein and was microbiologically stable. Shelf life of the product was up to 7 days under refrigeration.

Development and quality evaluation of omega-3 fatty acid fortified butter: The process for omega-3 fatty acid fortified butter was optimized by studying the effect of flax seed oil @ 2.9 to 5.1% and its emulsion @ 4.8 to 8.6% into cream at two different stages, i.e. before ageing and after ageing on textural, sensory and colour characteristics. No yeast and mould, coliform was detected during 90 days storage. Developed butter provides nearly 25% recommended dietary allowance of ALA in one serving.

Technology of probiotic curd rice: A technology was developed for production of probiotic curd rice containing probiotics in the form of encapsulated bead. Inulin at a concentration of 3% was used as prebiotic for encapsulation of *Lactobacillus rhamnosus* CRD-11 in alginate beads. Microencapsulation significantly increased the survivability of probiotic against low pH, high bile and moderately high thermal conditions. For probiotic curd rice, free and encapsulated probiotic were added in curd separately. Standardized levels of curd, rice and salt for probiotic curd rice were 55%, 50% and 0.75%, respectively. The probiotic count was 9.78 log cfu/g.

Technology for omega-3 rich table spread: A table spread was developed at ICAR-NDRI using flax seed oil (as a source of vegan omega-3 fatty acid) and butter as a source of fat. The salient feature of the product was its alpha-linolenic acid content which was around 13.8 g α-linolenic/100 g of fat and is good enough to meet around 50% of its RDA at a serving size of 10 g. The shelf life of the developed product was 120 days under refrigerated storage.

CIRC-COWCAM assay kit: It is useful for detecting cow milk adulteration in camel milk and vice versa at a minimum level of 1%. The kit is less expensive, user friendly, rapid and specific in detection of adulteration of camel milk with cow milk or vice-versa. The test described can be completed in less than 4 h.

Coarse wool core braided rope for foot mat: The study was conducted to know the effect of coarse wool core and different natural fibre sheath on braided rope water absorption capacity. The water absorption capacity was higher (289%) for wool sheath braided rope as compared to cotton sheath braided rope (142%). Jute braided rope absorbed 57% less water in comparison with wool braided rope. Thickness of coarse wool braided rope was between 4.9–8.1 mm.

Camel milk and products: In order to promote use of camel milk, different consumer friendly value added products are being prepared. The protocol for production of good quality paneer from blends of camel and buffalo milk, camel and skimmed milk powder and camel and cow milk was standardized. Good quality fresh cheese from camel milk could be prepared and popularized as high value camel milk products.

Braided rope mats

Camel milk and its products were developed, popularized and tested for their commercial viability by sale of pasteurized milk, kulfi, flavoured milk, ice cream, tea, coffee, etc., at the Centre's camel milk parlour.

Meat

The process standardized and cost evaluation was performed for the following products—

- Standardization of natural preservatives in development of chicken kebabs utilizing spent hen.
- Shelf-life evaluation of chicken seekh kebab during storage at 4 ± 1ºC under aerobic packaging conditions.
- Determination of cost of production for processing of chicken seekh kebabs and consumer evaluation study.
- Development of different value added poultry products for income generation: Processing

technology and formulation for development of functional turkey meat seekh kebabs (FTMSK) was standardized for effective utilization of tough meat from adult turkey.

- Standardization of processing technology for development of bone-in chicken pickle using spent hen: Processing technology for preparation of bone-in chicken pickle brine dipping method was employed.

Fish

Plankton^{Plus}-Fish waste to wealth: Fish trimming waste were fermented and developed in a product called Plankton^{Plus} for boosting plankton density in aquaculture ponds. An increase in plankton density reduces the demand for feed and increases productivity. Application of Plankton^{Plus} in shrimp ponds at 30 ppm increased productivity to 1.60 tonnes/ha with a 20% reduction in feed use. Hence, Plankton^{Plus} could save 20% feed as well as could enhance productivity to the tune of 1.6 tonnes/ha.

Plankton^{Plus} application in shrimp culture pond

ASTA CIFT-Astaxanthin capsules: ASTA CIFT, astaxanthin capsules, were prepared using astaxanthin extracted from shrimp heads. Extracted astaxanthin was dispersed in virgin coconut oil with chitosan as a stabilizing agent that was produced from a deproteinized shell. The resulted sample exhibited better colour and high viscosity compared to control samples. Astaxanthin is characterized by its antioxidant and UV protective properties.

Seaweed-based products: Cadalmin^{TM} IBe is a natural product to improve the innate immune system and is purified from selected seaweeds namely, *Sargassum wightii* and *Turbina riaconoides*. Long-term pre-clinical trials of the active ingredients used to develop Cadalmin^{TM} IBe showed no toxicity related significant changes in renal or hepatic function, haematological indices and serum biochemical parameters in the experimental subjects. This nutraceutical is purely natural, which does not have any side effects.

Antiosteoporotic extract (Cadalmin^{TM}AOe) is a nutraceutical product developed from seaweeds, as a natural remedy for osteoporosis. It increases the activity of alkaline phosphatase and bone morphogenic protein, along with higher serum osteocalcin levels and prominent mineralization, which were corroborated with increase in bone mineral density, and were found

Cadalmin^{TM} IBe to boost immunity

Cadalmin^{TM} AOe to combat osteoporosis

Seaweed-based hand sanitizer

Solar fish cooler

ICAR-CIFT developed a solar-powered cooling system that can be used by retail fish vendors. This solar fish cooler is powered by two solar panels and can hold 50 kg fish at 0 to 5°C. The solar-powered cooler is expected to reduce the dependency on ice, prolong the shelf-life and ensure the quality and hygiene of fresh fish sold in the retail markets.

to be effective for bone health development. Cadalmin^{TM}AOe suppresses the osteoclast activity and increases the alkaline phosphatase activities, which are related to osteoblastic cell formation in bone tissue to combat osteoporosis related disorders and improve bone health.

Seaweed-based hand sanitizer, containing spirulina, isopropyl alcohol, glycerol and aloe vera gel was developed. The seaweed component was used as an emulsifying agent while aloe vera gel was used as a moisturizing agent. The technology was commercialized.

3D printed product from fish surimi: Standardized the process parameters for development of 3D printed products from fish surimi. Shrimp shaped product was developed using lizardfish surimi incorporating shrimp flavour using 3D printing technology.

Hot air assisted IR dryer: Developed a prototype of hot air-assisted IR dryer and evaluated its performance under the various mode of operation like IR alone, hot air alone and IR with hot air assistance using shrimp. IR with hot air assistance was found as an efficient drying method with a total drying time of 2 h, which is one-third reduction in normal drying time.

Time-temperature indicator (TTI) for frozen stored products: Chitosan and gold nanoparticle-based 'Time-Temperature Indicator (TTI)' for frozen stored products was developed to indicate frozen temperature abuse. Upon exposure to higher temperatures, developed TTI changes to irreversible colour change, which can be easily identified by the common man.

Marine ambulance: The first marine ambulance was designed and constructed under the supervision of ICAR-CIFT for rescue operations in rough weather for the Department of Fisheries, Government of Kerala. The ambulance has three beds for rescued fishermen, first aid facilities, facilities for crew and a mortuary. ❑


Marine ambulance

"भारत के हमारे किसान साथी - हमारे अन्नदाता, हमारे कृषि वैज्ञानिक,
हमारे आंगनबाड़ी-आशा कार्यकर्ता, कुपोषण के खिलाफ आंदोलन का आधार हैं।
इन्होंने अपने परिश्रम से जहां भारत का अन्न भंडार भर रखा है,
वहीं दूर-सुदूर, गरीब से गरीब तक पहुंचने में ये सरकार की मदद भी कर रहे हैं।"

— नरेन्द्र मोदी

11. Agricultural Human Resource Development

Agriculture is a major sector in Indian economy and technological progress in agriculture is crucial for overall economic development of the country. India's food grain production is increasing every year, and presently the country is among the top producers of several crops such as wheat, rice, pulses, sugarcane and cotton. It is the highest producer of milk and second highest producer of fruits and vegetables. Developing quality human resources in the field of agriculture and allied sciences is a pre-requisite for agricultural development. ICAR has been playing a leadership role towards building and nurturing future ready agri graduates and skilled human resources, equipped with research as well as entrepreneurial acumen. Support is provided for strengthening teaching, PG research, overall capacity building, skill development and quality assurance of higher agricultural education in agricultural universities across the country.

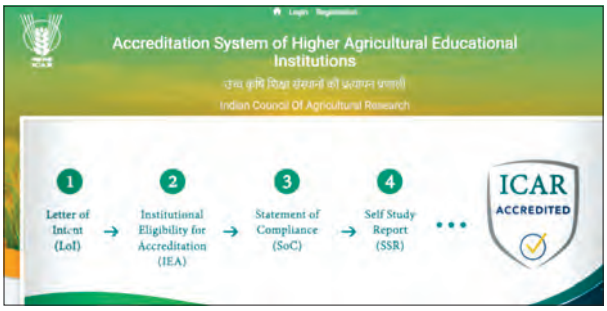
The National Agricultural Education and Research System (NARES) is one of the largest in the world. The effective functioning of this system in close association with education and extension has contributed towards the rapid growth of agriculture in the country. The present system comprises essentially of two main streams, viz. ICAR at the National level and agricultural universities at the state level, besides other organizations involved in agriculture and allied activities.

The Agricultural Education Division, ICAR through its Plan Scheme supports and enables 74 Agricultural Universities (AUs), viz. State Agricultural Universities (63 SAUs), Deemed-to-be-Universities (4 DUs) and Central Universities (4 CUs) with Agricultural faculties under the National Agricultural Research and Education System (NARS), to maintain quality higher agricultural education through accreditation, periodic course updation/revision, attracting talented students, capacity building of faculty in challenging areas, as well as through promotion of holistic higher education.

Governance and quality assurance

Accreditation of agricultural universities: To address the concerns of quality higher agricultural education, the National Agricultural Education Accreditation Board (NAEAB) was established to advise the Council in evolving norms and standards for accreditation of institutions and programmes of agricultural education.

The NAEAB in its XXV meeting decided to implement online mode process for invitation of LoI/ IEA/Statement of Compliance and its preliminary examination. Accordingly, online portal was developed. Further, the Standard Operating Procedure for this portal available at https://accreditation.icar.gov.in along with user manuals for NAEAB Secretariat, NAEAB Regional Centre and Registrar of degree awarding University. The Online portal was launched on 11 August 2020.



Ranking of agricultural universities: The ranking of Agricultural Universities was initiated by ICAR to drive the universities towards improving quality standards and enhance their visibility. The ranking status allows the students to make informed choices for university placement. Further, the ranking process is expected to help the universities, to self-assess themselves on the quality and enhance their abilities.

The emphasis on parameters such as teaching resources and outcome, faculty profile, students' performance, research productivity, research impact, research excellence, extension activities, outreach programmes, revenue generation and peer recognition of the faculty, students and staff of the university, etc., are considered while evaluating the agricultural universities.

So far, the ranking has been done for the last three years based on the information received from the

universities in the prescribed proforma through hard copies. In view of the Covid-19 pandemic situation, the required information is being obtained online from the universities. Accordingly, an Agricultural University Ranking System (AURS) was developed to enable the submission of the required data by the universities and the evaluation/verification by the Committee online.

Development of syllabus for BSc (Hons) Agri-business Management: Considering the importance of Agri Business Management as a subject, it was recommended to include this as one of the subjects of Agricultural Sciences for inclusion in the Fifth Deans' Committee Report. Accordingly, an expert committee under the chairmanship of Dr PG Chengappa, former VC, UAS, Bengaluru was constituted to develop the syllabus as per the framework of Fifth Deans' Committee encompassing Student READY programme. Subsequently, the syllabus developed by the committee was duly approved by DG, ICAR, and was shared with all the universities for its implementation.

Student READY: For building skills in project development and execution, the component of Student READY (Rural Entrepreneurship Awareness Development Yojana) programme is supported across AUs. The aim of the programme, offered to undergraduate students during the final year of the course, as an essential prerequisite for the award of degree, is to ensure hands on experience and practical training depending on the requirements of respective discipline and local demands. The programme helps to reorient graduates of Agriculture and allied subjects to develop entrepreneurs in emerging areas.

The final year UG students undergoing Rural Awareness Works Experience (RAWE) across AUs are exposed to farm planning, watershed programme, agro-clinics, KVKs, NGOs during their village stays and this serves as an excellent opportunity to rediscover and connect with the farmers. It also enables the students to gain rural experience, gives them confidence for problem solving in real life situations encountered in fields as they work closely with the farmers. The students are also exposed to various agri industries. 13,438 students were trained under RAWE through Council's support.

Activities under RAWE

Experiential learning: Experiential learning is the process of gaining 'Hands-on-experience' where the students have access to real-time coaching and feedback.

Twenty new modules were sanctioned under Experiential Learning during the year in various profitable areas. The total number of modules supported by Council for skill development of UG students is now 485. The modules were supported in the disciplines of Sericulture, Community Science, Crop Sciences, Agricultural Engineering, Agriculture Biotechnology, Fisheries and Horticulture. The various modules sanctioned were Mushroom production, biofertilizer production, nursery raising, chawki rearing, protected cultivation, processing, ornamental fish raising, etc. in 13 agricultural universities.

Activities under some Experiential Learning Modules

Human Resource Development

Teaching, research and capacity building

Niche Area of Excellence: The NAE programmes are being supported in the important focussed areas, viz. assessment of heavy metals in crop plants, enhancement of shelf life of pearlmillet flour, development of standards for veterinary vaccines and diagnostics, nanomaterial for tissue regeneration in animals, veterinary immuno-biologicals, disease management in plants, etc.

Significant achievements

- MOOC on Teaching Excellence was conducted during 1–30 November 2019 with 1,329 participant enrolments and course completion rate of 51.92% with revenue generation of ₹ 5.98 lakh by the centre at ICAR-NAARM.

Online interaction with MOOC participants

- Four digital courses in interactive mode, viz. agronomy, horticulture, entrepreneurship and communication skills and veterinary histology were developed.
- Digital content development in consultancy mode was done for developing content for NIPHM, Hyderabad on Rodent and Household Pest Management" and ICAR-NDRI, Karnal, on Milk Processing and Value Addition, and Commercial Dairy Farming with total revenue generation of ₹ 30.67 lakh.
- To develop a seedless and easily peelable mandarin hybrid, 1,742 hybrids were identified through molecular markers in the cross of Kinnow × Mukaku Kishu, of which 455 are under field evaluation at PAU centre.

Digital course development in consultancy mode for NIPHM and ICAR-NDRI

Field evaluation of Kinnow × Mukaku Kishu hybrids

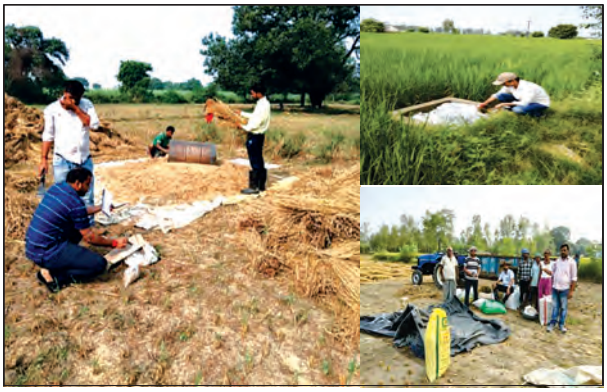
- Physico-chemical, functional characteristics and nutrient composition of proso millet, kodo and brown top millets were analyzed. Effect of level of polishing on the physico-chemical properties, functional characteristics and nutrient composition of barnyard millet was studied. Nutrient compositions of byproducts developed using barnyard millet at various levels of polishing were also analyzed.

Unpolished Semi-polished Fully polished

Kodo millet pasta

- The putative lipase gene from pearl millet cv. Pusa 1201 was identified, and LOX enzyme was observed to the major contributor for rancidity development in pearlmillet flour, by the NAE centre at IARI.
- 1,876 paired grid based (1.47×1.47 km^2) soil (0–15 cm) and plant samples with GPS coordinates (were collected covering 22 basmati rice growing districts of Uttar Pradesh, viz. GB Nagar, Ghaziabad, Eta, Etawah, Hathras,

Mainpuri, Firozabad, Mathura, Agra, Bulandshahr, Kannauj, Farukhabad, Auraiya, Sahajanpur, Muzaffarnagar, Bagpat, Saharanpur, Meerut, Bijnor, Badaun, Bareilly, Pilibhit. In addition, 1,000 irrigation water samples were also collected across these districts for analysis of metals and metalloids by centre at IARI, New Delhi.



Collection of soil, plant and water samples from basmati growing areas of UP

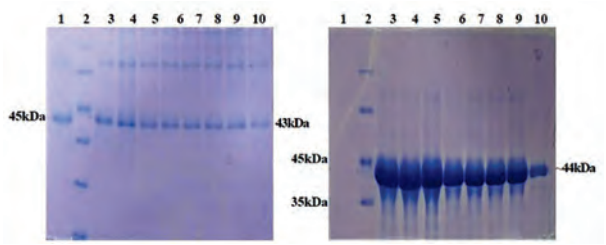
- Lime application at 1% under alternating wetting and drying moisture regime was found most effective for immobilization of DTPA-extractable Pb, Cd, Cr, Ni and Olsen-extractable As in metal-contaminated soil. Sunflower and marigold can be used effectively for phytoextraction of pollutant elements in soil.
- Thirty-five traditional cultivars were screened for blast tolerance in field as well as *in vitro* conditions, and Sadanunia and T4M-35 were identified as aromatic cultivars with high resistance to blast for further inclusion in breeding programs by the centre at UBKVV, Coochbehar.

Resistant genotype against blast

- The centre at IARI evaluated 10 essential oils against juveniles of *M. incognita* and *Brassica juncea*, essential oil with LC_{50} and LC_{90}, 0.20 and 1.92 µg/mL, respectively, had strongest action. Molecular docking and simulation studies of the major constituent (allylisothiocyanate) of *Brassica* essential oil showed π-cation of electrostatic interaction, π-donor H bonding and π-sulphur bonding between AITC and TRP391. SEM imaging confirmed that the oil readily entered the nematode body through lipid layer of the cell wall and asserted its effect.
- In a study conducted by centre at GADVASU, Ludhiana, *Staphylococcus aureus* was observed to be the most predominant organism isolated from mastitis animals (clinical and subclinical) followed by *Klebsiella pneumoniae*, *E. coli* and *Streptococcus* spp. Antibiotic sensitivity test revealed that *Staphylococcus* spp. was sensitive to sparfloxacin, tetracycline, gentamicin, vancomycin and doxycycline and resistant to amoxicillin, and *Vibrio* isolates from fishes were highly sensitive to gentamicin, tetracycline, chloramphenicol and sulfisoxazole.

Interaction with fish farmers regarding antibiotics usage

- The centre at LUVAS, Hisar developed *Pasteurella multocida* B:2 p 52 whole cell lysate (WCL) as antigens which was characterised.
- Two novel synbiotic nutraceutical products were developed by the centre at IVRI: (*i*) A probiotic-polyphenol based nutraceutical containing a canine-origin probiotic and two different polyphenols (probiotic-PPE-JAE) intended for gut health promotion of dogs. (*ii*) A probiotic-prebiotic (probiotic-JA inulin) based nutraceutical intended for gut health promotion of dogs.
- Inactivated IBD vaccine standard for quantification of IBD antigen in the inactivated vaccine was developed by the Centre at IVRI. This quantification will replace the use of birds for potency testing of IBD virus vaccine and save time of 21 days.

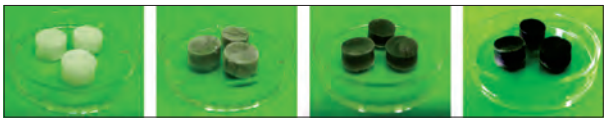


Purified truncated VP2 proteins of IBDV

- The cente at SKAUST-Kashmir, evaluated the whole cell vaccine against virulent foot rot. The vaccine elicited an optimal immune response and

the protection lasted for 5 months. The animals are protected from day 30 and continued to be as such till day 150.

- Fifteen types of scaffolds (6 types of hydrogel, 8 types of electrospun scaffolds and 1 bead type) were developed at ICAR-IVRI centre.



Visual aspects of lyophilized SF Hydrogels with various MW-CNT-COOH concentrations

- Pratapdhan gained maximum body weight under organic poultry production as compared to other breeds, viz. Mewari, Kadaknath, Rhode Island Red and supplementation of the organic feed with either aswagandha (*Withania somnifera*) or satawari (*Asparagus racemosus*) at 1% in the daily diet of chicks grown under organic management gave an increase of 80% in body weight as compared to farmers' practice.

Performance of RIR and Kadaknath breed poultry under backyard organic production at MPUAT, Udaipur

The NAE centres organized 26 training programmes/ awareness workshops/ camps/ workshops leading to capacity building of 79 faculty and 322 farmers and 101 other stakeholders. 27 PG students completed degree programme and 28 students are continuing research work and pursuing degree, utilizing the facilities developed under NAE programmes being supported by Council in AUs.

Centre for Advanced Faculty Training/ Summer/ Winter schools and Short courses: During the year, 111 summer winter schools/short courses comprising 61 summer/winter schools of 21 days, and 50 short courses for 10 days were organized at various ICAR institutes and SAUs. The skills, knowledge and capacity building of 2,513 (1,756 M/757F) faculty were enhanced.

The 39 Centres of Advanced Faculty Training imparted training to about 1,500 (1,038 M/ 462 F) scientists/ faculty members from the National Agricultural Research System through 63 training programs in cutting edge areas of agriculture and allied sciences to 3,952 faculty members/scientists. All the training programs sponsored by Agricultural Education Division were monitored through workflow based online management system.

Attracting talent

All-India entrance examination for admission to UG: The 25th Undergraduate Examination for admission to 15% seats (100% seats at ICAR-NDRI, Karnal, RLBCAU, Jhansi and Dr RPCAU, Pusa) of degree programmes in agriculture and allied subjects, other than veterinary sciences, including the award of National Talent Scholarship (NTS) was held on 16, 17 and 22 September 2020. The examination attracted 197,902 applications, out of which 139,360 candidates (70.42%) appeared. Of these, the highest number of candidates (100,370) appeared in PCB (Physics, Chemistry, Biology) group, followed by ABC (Agriculture, Biology, Chemistry) group (21,560), PCM (Physics, Chemistry, Mathematics) group (16,297) and PCA (Physics, Chemistry, Agriculture) group (1,133).

All-India entrance examination for admission to PG: The examination was conducted on 23 September 2020 for admission to 25% seats (100% seats of ICAR-DUs, RLBCAU, Jhansi and Dr RPCAU, Pusa) in PG programmes including award of ICAR-PG scholarship. A total of 19,945 candidates appeared in the examination (69.18%), out of 28,832 applicants. The highest number of candidates (2,975) appeared in the major subject group of Plant Sciences, followed by those in Agronomy (2,913) and Horticulture (2,809).

All-India competitive examination for PhD admission and award of Junior/Senior Research Fellowship: The examination was held on 23 September 2020 for admission to 25% seats (100% seats of Dr RPCAU Pusa and ICAR-DUs) in PhD programmes including award of ICAR-JRF/SRF(PhD). A total of 9,516 candidates appeared (67.56%) in the examination, out of 14,086 applicants. The highest number of candidates (760) appeared in Subject Genetics and Plant Breeding, followed by Agronomy (725) and Agricultural Biotechnology/Biotechnology/Molecular Biology and Biotechnology (649).

Merit-cum-means scholarship: Scholarships to meritorious under-graduate students belonging to below poverty line families to study agriculture, and allied subjects are awarded annually on the basis of merit-cum-means. During the year, 829 students were awarded scholarship.

Post-matric scholarship: It was granted to 8 students.

Internship allowance: It was provided to 3,153 veterinary graduates trained by agricultural/veterinary universities was provided.

National Talent Scholarship (NTS): Merit based support through National Talent Scholarship to the under-graduates (UG) and Master degree students admitted in AUs through ICAR All India Entrance Examination (AIEE), was provided. During the year 3,917 UG and 1,857 PG students were provided NTS.

ICAR Fellowships for post-graduate students: For recognition of talent and promotion of merit in general, and for encouraging talented students to undertake higher agricultural education in particular, the ICAR awards ICAR-PG scholarships and JRF/ SRF Fellowships (PGS) to post-graduate (PG) and doctoral students, in different disciplines of agriculture and allied sciences. The 600 and 297 students were awarded ICAR-PG Scholarships and ICAR-JRF/ SRF(PGS) for Master's and Doctoral studies, respectively.

ICAR-Post Doctoral Fellowship: The ICAR Post-Doctoral Fellowship (ICAR-PDF) is a new programme initiated to identify and support motivated young researchers for conducting research in frontier areas of agriculture and allied sciences to build the national capacity. It provides them a platform to develop as an independent researcher capable of initiating a new programme in nationally important priority areas under the supervision of a mentor. Against the approved slots of 25 PDFs (10 per year for ICAR-IARI Pusa, New Delhi, and 5 each per year for ICAR-IVRI Izatnagar, ICAR-NDRI Karnal and ICAR-CIFE, Mumbai respectively), two fellows joined the programme at ICAR-IARI, Pusa New Delhi.

Globalization of agricultural education: ICAR awards Netaji Subhas-ICAR International Fellowships and coordinates Special Agricultural Scholarships under India-Africa Forum Summit (IAFS), Indo-Afghan Fellowship Scheme to support the human resource development in newer and challenging areas through formal education of scientists/faculty/students in India. The ICAR facilitated admission of 143 foreign students from 21 countries in Indian Agricultural Universities by considering the applications received through the DARE, Education Consultants India Ltd (EdCIL) and Indian Council of Cultural Relations (ICCR). Total 219 applications were received from the students from 38 countries.

Netaji Subhas-ICAR International Fellowships: With the objectives to develop competent human resource and showcasing the strengths of National Agricultural Research and Education System (NARES) and to create a pool of scientist-envoys for enhanced future co-operation, Netaji Subhas ICAR International Fellowships are offered for pursuing Ph D programme at Indian agricultural universities (AUs) and overseas universities for Overseas and Indian candidates, respectively. The amount of fellowships for Indian and overseas candidates is @ US$ 2000 and ₹ 40,000 per month respectively. During the year, based on the priority areas of study related to plant sciences, animal sciences, social sciences, fisheries, agricultural engineering, food processing and natural resource management, 29 candidates were selected for their Ph D study including 22 Indian candidates at overseas universities and 7 foreign candidates at Indian SAUs/ ICAR DUs. So far, 209 candidates have been selected and out of which 147 joined in overseas laboratories for pursuing PhD and 28 foreign candidates have joined in Indian laboratories. Because of COVID-19 pandemic situation, 34 candidates are waiting for the commencement of their academic programme.

India-Africa Fellowship Programme: India-Africa Forum Summit III (IAFS-III) has been implemented since session 2017–18 with allotment of 500 seats (375 PG and 125 Ph D) for African nationals under Special Agricultural Scholarship. Twenty African candidates (16 PG; 04 Ph D) from 16 countries have joined the programme during session 2019–20. A total of 114 African nationals (88 PG; 26 PhD) from 17 countries were enrolled successfully in 33 Indian Agricultural Universities/ CAU/Deemed Universities.

India-Afghanistan Fellowship Programme: India-Afghanistan Fellowship Programme has been implemented since 2010–11 for providing fellowships to Afghan nationals for attaining higher education in agriculture and allied sciences in identified Indian agricultural Universities (AUs). To attain maximum enrolments in India-Afghanistan Fellowship Programme, the tenure of programme is extended up to 2020–2021 with the available slots of 614 fellowships for Bachelor's 50%, Master's 30% and Ph D 20%. During academic year 2019–20, a total of 74 Afghan nationals (2 UG, 60 PG and 12 PhD) are currently enrolled in Indian AUs.

Introduction of new Fellowships

BIMSTEC Fellowships: On the basis of the decision taken in the First BIMSTEC (Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation) Ministerial meeting on Agriculture which was held on 12 July 2019 and as well as preceding the First Senior Official Meeting on Agriculture (1st SOM-A) on 11 July 2019, it was decided to introduce BIMSTEC Fellowships to pursue Master's and Ph D programmes in agriculture and related business in agricultural universities in India. The BIMSTEC Secretariat will be the nodal agency for collecting applications from all member states and forwarding these to DARE/ICAR.

ASEAN Fellowships: During 16th ASEAN-India Summit held at Bangkok during November 2019, the Prime Minister announced 50 Scholarships to agricultural scientists and technicians. These scholarships are available to the member states of

Association of Southeast Asian Nations (ASEAN) to pursue PG and PhD programmes in Agricultural Universities and ICAR Institutes and will be implemented from 2021 to 22.

Promoting excellence

ICAR National Professor: ICAR operates National Professor Scheme with the twin objectives to promote excellence by recognizing outstanding scientist with proven output and outcome for creating a culture of basic research through their project work in the National Agricultural Research System (NARS) and establishing and nurturing a novel school of thought around the recognized person. During the period under report, 6 National Professors were in position and among these 4 are in Crop Sciences, one each in Natural Resource Management and Economics, Statistics and Management.

Salient achievements

Crop sciences

- Long term selection under aided epiphytotic conditions allowed identification of introgression lines with resistance to *Sclerotinia* stem rot and mustard aphid. Predicted 11 candidates linked to mustard aphid in three introgression lines (IL64, IL, 101, IL104), on the basis of whole genome sequencing.
- Two sets of chromosome segment substitution lines (CSSLs) were developed. In the genetic background of two widely grown, popular rice varieties MTU1010 and Swarna using one *O. rufipogon* accession from Odisha which showed high photosynthesis. Two sets of CSSLs were also identified from previous backcross inbred lines (BILs) derived from two crosses of Swarna with *O. nivara* accession IRGC81848 from Uttar Pradesh and IRGC81832 from Bihar.
- Novel quantitative trait loci were mapped for traits related to yield, photosynthesis, nutrient and water use efficiency using SSR markers in BC_2F_2 and BC_4F_2 of MTU1010 × *O. rufipogon*, BC_2F_2 of Swarna × *O. rufipogon*, BC_2F_8 of two Swarna × *O. nivara* populations and one F2:3 population using selected BILs. Elite high yielding introgression lines (IL) were identified from other interspecific crosses of Swarna and KMR3 with introgressions from *O. nivara* (3 accessions) and *O. rufipogon* WR120 respectively.
- 23 elite ILs showed moderate resistance to BLB, Blast, BPH, and tolerance to low phosphorus and high temperature at IIRR. ILs from 6 interspecific crosses were shared with scientists in IIRR-Hyderabad, NRRI-Cuttack, NRCPB-Delhi, RARS-ANGRAU-Maruteru, IIAB-Ranchi to evaluate for yield and tolerance to abiotic (including tolerance to submergence, water limited and aerobic conditions) and biotic stresses (including resistance to false smut, nematodes, leaf folder) and map QTLs.
- A major QTL for anaerobic germination contributed by wild rice accession NKSWR70 was mapped on chromosome 7 using 95 segregating families. Another F2:3 mapping population from cross IR64/NKSWR397 comprising 300 families was developed and a major QTL for anaerobic germination and coleoptile elongation under water was mapped on rice chromosome 6 using random 92 of these families.
- Chloroplast genome based *Oryza* species specific SSR, InDels and SNP markers were identified. Total 15 InDel markers were validated in PAGE and 399 SNP markers differentiating 22 *Oryza* species was identified and a SNP chip was designed.
- Collection and screening of 25 accessions from five wild chickpea (*C. judaicum, C. reticulatum, C. microphyllum, C. bijugum, C. cuncatam*) and three cultivars of chickpea (*C. arietinum*) (reported to be mild tolerant) for defence against *H. armigera* was done.
- Trypsin protease inhibitor gene (Ti) from ILWC-46 (accession from *C. reticulatum* that had highest Trypsin Inhibitor protein) was cloned.
- Construction of a cisgenic cassette for the expression of Trypsin protease inhibitor gene (Ti) from cultivated and wild accessions of chickpea driven by a RUBISCO SSU promoter from chickpea has been completed.
- Promoter sequences (1000 base pair) of FHG (Floral Homeotic gene) and MADS (Minichromosome Maintenance1, Agamous, Deficient and Serum response protein) genes that expressed at high level in flower and pod wall of chickpea were isolated and validated through GUS expression.

Natural resource management

- The modelling studies suggested that the effect of global warming on soil organic carbon in majority of soils in India will be minimal as the warming effect will be foremost at mean annual temperatures below 25ºC.
- Quantification of C footprint of agriculture in Punjab showed that the current carbon equivalent (CE) emissions (4705 Gg) are 3-times higher than in 1980–81. Groundwater irrigation and fertilizer use have dominant influence on C footprint of food grain production. Carbon cost per unit grain production (kg CE M/g) was highest for rice (693) followed by wheat (207) and least for maize (152). While carbon use efficiency of rice has decreased over time (15.5 to 7.8) that for maize remained stable between 11.9 and 14.8. The environment footprint of food grain production can be reduced by diversifying to less water requiring crops, improving irrigation water productivity and pumping efficiency, and increasing fertilizer use efficiency.

Economics, Statistics and Management

The impact of heat-stress on wheat and effects of adaptation measures, viz. irrigation was assessed. Also quantified the effects of climatic hazards on agricultural growth, and the role of important adaptation measures towards mitigating the adverse effects on growth.

ICAR National Fellow

ICAR operates National Fellow scheme with the twin objectives to promote excellence at national level in agricultural research and education and to recognize the meritorious contribution of individual agricultural scientists/teachers and facilitate their research and related activities in agriculture. There are 25 positions of National Fellows across National Agricultural Research and Education System. During the period under report, 18 National Fellows were in position. The areas of specialization in which they carried out research work were as diverse as horticulture, animal science, fishery science, natural resource management, agricultural engineering and economics, statistics and management.

Salient achievements

Fishery sciences

- Technology of production of seaweed sanitizers was transferred to M/s Kerala Nutraceuticals Pvt. Ltd., Kerala.
- Methodology was developed for the preparation of chitosan nanoparticles loaded fish gelatin membrane.
- Biocompatible poly (vinyl alcohol)/starch based composite hybridized films developed.
- A loop-mediated isothermal amplification (LAMP) assay as well as a polymerase chain reaction (PCR) targeting major capsid protein (MCP) gene of CyHV-2 were developed and evaluated for detection of CyHV-2. New LAMP and PCR capable of detecting 10 copies of the plasmid construct containing 942 bp fragment of MCP gene of CyHV-2.
- Full length CDs of four major antioxidant genes namely glutathione peroxidase-1(GPX-1), glutathione stransferase (GST-mu), CuZn superoxide dismutase (CuZnSOD) and catalase (CAT) were amplified and the sequences were submitted to the NCBI database. The complete bioinformatic analysis including domain architecture of the genes were carried out. The ontogeny, tissue specificity and the expression levels in three infection models were studied.
- Constitutive expression of C9 in rohu during the different stages of ontogeny and in response to pathogen exposures along with high degree of sequence homology with other fish species proved it as an important primitive immune molecule of the complement system lytic pathway.

Animal sciences

- Using state-of-art molecular techniques picorna viruses were detected for the first time in porcine population of the country. Molecular epidemiological survey established the presence of porcine enterovirus in Indian pig population. Molecular epidemiological survey also established the presence of porcine sapelovirus and porcine teschovirus infection in Indian pig population.
- RNAseq based transcriptome data were generated and analyzed in skin fibroblast cells of Sahiwal cows and Murrah buffaloes exposed to heat stress. Several genes and pathways impacted due to heat stress in both the major dairy breeds of India were identified.
- Genotype by sequencing data was successfully generated in 105 cattle samples representing 12 native Indian cattle breeds from different agro-climatic regions to identify SNPs and variation in heat responsive genes. By employing Illumina Hiseq 2,000 sequencing platform, 21.32 million raw reads (100 ntq seq files) were generated. A total of 82,878 SNPs tags, were identified in all cattle breeds, with an average SNP to SNP distance of 30 kb across the reference genome. The mean nucleotide diversity among all breeds was 0.178463846. Ongole and Malnadgidda cattle showed the lowest and highest genetic diversity, respectively. The SNPs identified and characterized in the current study serve as useful markers for the conservation, genetic studies and population evaluation of the native Indian cattle breed *Bos indicus.*
- Using proton nuclear magnetic resonance (1H-NMR) spectroscopy, metabolome profiling of high altitude adapted livestock species was completed. The aim of the study was to unravel the types of circulating metabolites in high altitude adapted species. This is the first report on serum metabolome signature of 51 individuals of Ladakhi cattle (LAC), Jersey cattle (JYC; maintained in Ladakh for several generations), Ladakhi donkey (LAD), Zanskar ponies (ZAP), Changathangi goat (CHG), and Ladakhi yak (LAY).
- Molecular characterization of immunogenic diagnostic serine protease (hypodermin B and C) of goat warble fly was done.
- For identification of genes associated with thermos tolerance, a comparative transcriptome of native animals (pigs and goats) reared in two different agro-climatic zones (Assam/Rajasthan) was examined to identify heat tolerant transcriptomic signatures. The functional annotation of the whole transcriptome was completed, and genes and their functions differentially expressed in animals reared in high temperature region were identified.

- Based on the genomic data and previous studies, a draft array was designed for screening animals incorporating production as well as adaptation traits. For identification and development of heat tolerant animals, pigs from different breeds (Large White Yorkshire and Ghungroo) reared at ICAR-NRC on Pigs were identified and screened for presence/expression levels of thermo-tolerance related genes.
- Designed and synthesized shRNA molecules to analyse their effect under *in vitro* cell culture system initially and later, under *in vivo* system. Developed knock down chicken for two important genes namely, acetyl Co-A carboxylase alpha (*ACACA*) and sterol regulatory element binding protein 1 (*SREBP-1*) involved in *de novo* lipid biosynthesis. Overall, the knock down birds showed reduction of 20.2 and 24.8% serum cholesterol and triglycerides content as compared to the control birds. It is concluded that knock down of *ACACA* and *SREBP-1* genes showed significantly lower serum cholesterol content over the control birds, which may reduce the cholesterol content in meat and egg in the knock down birds.
- In total, 5,371 genes (>2 FPKM) are identified to be involved in the fertility related functions including early embryonic development. The paternally delivered transcripts for 413 genes were identified in buffalo sperm.

Crop sciences

- E-Herbarium launched to public access (pgrinformatics.nbpgr.ernet.in/nhcp).
- The water atmosphere GHGs fluxes were higher from stagnant water as compared to during tide and 'after tide'. Soil labile C pools namely RMC, MBC, $KMnO_4$-C and WSC were significantly higher during summer followed by winter in mangrove ecology.
- These soil labile C pools were higher in mangrove than that of adjacent rice and aquaculture considering all the locations and seasons.
- The microbial diversity under mangrove ecology was significantly different than that of adjacent rice soil due to difference in salinity, tidal intrusion and continuous wet drying nature of the mangrove sediments. Total methanogens population was less in mangrove sediments due to higher salinity and regular tide flow (wetting-drying condition) in mangrove system.

Natural resource management

- Over 1,300 and 282 field observations on surface soil moisture (SSM) and sub surface soil moisture (SSSM) were collected using soil moisture meter and soil moisture probe, and partly by gravimetric methods. These will serve as ground truth for satellite data estimates of SSM. Twenty access tubes were permanently installed to act as SSM and SSSM monitoring network at IARI farm (by using soil moisture probe).
- The ^{137}Cs data revealed that there were different redistribution patterns in different phases of erosion. In the study areas, the 137Cs concentration ranged from 198.71±15.54 Bq m-2 in very severely eroded phase to maximum 1081.87±89.97 Bq m-2 in reference site.
- Based on the findings at plot scale it was observed that at the national level in India, erosion transported about 4.87 Pg of soil and 115.36 Tg of C every year, which consequently emits about 34.61 Tg of C to the atmosphere.
- The results also revealed that the contribution of C-losses due to erosion was 15% in very severely eroded unfertilized pots and was 4% in slightly eroded unfertilized plots.

Horticulture

- Regeneration and hardening of transgenic onion plants expressing GFP-tail swap was done.
- Targeted mutagenesis silencing of *AcCenH3*, gene in onion is done.
- *Klebsiella oxytoca* was shown to be responsible for sexual behaviour and reproductive organ maturation in insects, is transmitted to the next generation by females, and is responsible for sexual attraction cues in *Bactrocera dorsalis*.
- GC-EAD studies using volatiles from different stages of *B. dorsalis* infested mangoes helped identify specific cues that attracted the endoparasitoid, *Diachasmimorpha longicaudata*. This study is extremely beneficial for developing biological control strategy.
- It was observed earlier that *B. cucurbitae* females and males were highly attractive to the volatiles of cut cucumber and ridge gourd volatiles, with this information, blends were constituted and tested in fields. The highest numbers of insect catch (males and females) were observed in the blends like CB (cucumber blend) followed by CB + C (cucumber blend + cu-lure), RB + C (ridge gourd blend + cu-lure) in the field of bitter gourd, bottle gourd and cucumber fields suggesting that the above blends could be used as part of IPM.

Agricultural engineering

- Fortification of chocolate cake with flax seed meal and chia gel was performed to enhance the consumption of health beneficial polyunsaturated fatty acids like eicosapentaenoic acid, docosahexaenoic acid. The total omega 3 content (ALA) was found highest for chocolate cake with flaxseed meal and chia gel and found to be best among all the cakes with high potential to be used as an alternative to refined flour and eggs in cakes.
- Encapsulation of flax seed oil through freeze-

drying and spray drying was studied with the aim of protecting it against environmental conditions. The results showed that nanoparticles encapsulated with gum arabic had the highest encapsulation efficiency (EE) and the lowest surface oil.

- Sensitization workshops were conducted specifically to sensitize farmers regarding the opportunities in production and processing through incubation at CIAE. The technology developed under NF project was showcased such that the interested farmers can turn entrepreneurs bringing in profit in their chosen enterprise.
- High pressure processed pineapple had superior textural and nutritional properties compared to minimally processed pineapple.
- High pressure processed ripe jackfruit samples showed the best textural and nutritional quality with increased shelf-life. Hence high pressure processed ripe jackfruit bulbs could be stored for long period without affecting organoleptic quality.
- Blanching time and temperature of pineapple was optimized based on enzyme inactivation. The best combination for blanching of pineapple was 100°C with 3 min.
- Retort processing parameter for pineapple was standardized. Pineapple processed at 80°C temperature for 12 min exhibited good quality parameters.
- Retort processing parameter for tender jackfruit was standardized. Heat penetration curve of thermally processed tender jackfruit showed that the time taken by sterilization at 121°C temperature for attaining F0 value of one was 15 min.
- Retort processing parameter for matured jackfruit was standardized. Matured jackfruit processed at 110°C temperature for 10 min exhibited good quality parameters and sensory properties.
- Retort processing parameter for ripe jackfruit was standardized. Ripe jackfruit processed at 108°C temperature for 6 min exhibited good quality parameters and sensory properties.

Economics, statistics and management

Small area estimation of food insecurity incidence for the state of Uttar Pradesh by combining survey and census data: The method is applied to estimate the extent (or incidence) of food insecurity in rural households in different districts of Uttar Pradesh in India by linking data from the 2011–12 HCES collected by the NSSO of India and the 2011 Population Census. A map showing district level inequality in distribution of food insecurity in Uttar Pradesh is also produced. This map provides important information for analysis of spatial distribution of food insecurity among different districts of the state. The disaggregate estimates are useful and relevant to sustainable development goal indicator 2.1.2—severity of food insecurity. The estimates and map of food insecurity incidence are expected to deliver invaluable information to policy-analysts and decision-makers.

Competency enhancement

Fifty three Emeritus Scientists and 45 Emeritus Professor were supported. The aim of this programme is to complete the work in hand for its fruitful conclusion, utilize their talent in teaching specialized courses, student research guidance, developing instructional material/ textbooks including e-learning resources for use in national agricultural education programme and distance education and use their experience in addressing nationally important issues in different ICAR-institutes and SAUs.

Emeritus scientist

Salient achievements

Crop Sciences

- Out of 494 fungal isolates studied from the salt tolerant Pokkali rice variety, two endophytes–V4J (*Fusarium* sp) from Pokkali rice and *F. oxysporum* (MH511104) from *I. pes-caprae* imparted salinity tolerance in the salt sensitive IR-64 rice variety as there was significant enhancement in the root and shoot ratio in the plants enriched with the above endophytes.
- To understand the molecular mechanism transcriptome analysis of the 10-day old IR-64 seedlings with V4J (*Fusarium* sp) under salinity stress (E-S+ and E+S+; E: Endophyte; S: salt stress) was carried out. A total of 46.31 million reads (9.26 GB; E+S+) and 52.17 million reads (10.43 GB; E-S+) were generated. Further, 81.50% (E+S+) and 73.25% (E-S+) HQ reads were successfully aligned to the reference genome. Alternative splicing (AS) of transcripts is a well-recognized phenomenon in plants. Using the above transcriptome data, AS events were mined and the results showed an unequivocal decrease in the number of AS events under salinity stress as influenced by the endophyte. This is the first documented evidence of an endophyte-induced alteration in the frequency of alternative splicing event in plants subjected to salinity stress.
- Soil application with neem cake at seed treatment of groundnut with *T. harzianum* Th3 at 8 g/kg seeds + drenching with *T. harzianum* Th3 at 8 ml/l water at 40 days after sowing exhibited the root rot complex reduction up to 64.4% with increased yield of 3.65 t/ha at Jaipur 73.9% with biological yield of 3.56 t/ha at Banswara agro-climatic conditions. Maximum pod yield per plant of ~40–42 was observed in the combined treatment with *T. harzianum* Th3, *M. anisopliae* Ma1 and also with chemical.
- The maximum disease reduction of 68.02% was

observed at combined application of *T. harzianum* Th3 + *M. anisopliae* Ma1+ Flonicamid and also increased yield of cumin up to 541.50 kg/ha at Banswara agro-climatic conditions.

- Purified Salkathi (CR AC. 35181; IC IC0256801; INGR 17069) and Dhobanumberi (CR AC. 35184; IC0256804; INGR19005) for Brown Plant Hopper (BPH) resistance, were registered as rice donors.
- High BPH-resistant and multiple resistant genotype CR2711-76 (Tapaswini × Dhobanumberi) submitted to the SVRC, Odisha as CR Dhan-317 after its promising performance in farmers' field of BPH endemic areas of Odisha with average yield of 5.42 t/ha. High BPH-resistant breeding line CR3006-8-2 (Pusa 44 × Salkathi), also performed well in farmers' field during 2018 and 2019, and the variety release proposal is in progress.
- Ten stabilized promising rice genotypes were identified with seed protein content of more than 12% and zinc grain content of 20%. Two promising lines with high zinc and iron content, and five genotypes with high methionine, lysine, and amylose content were listed. Including higher grain yield, six genotypes were separated for further multiplication and bigger trials (Plant Nos.23-5-237, 23-5-297, 23-5-224, 23-5-92, 23-5-94, and 23-5-279) and based on performance one genotype 23-5-297 was taken for field farm trial in identified farmer field for large scale testing.

Animal Sciences

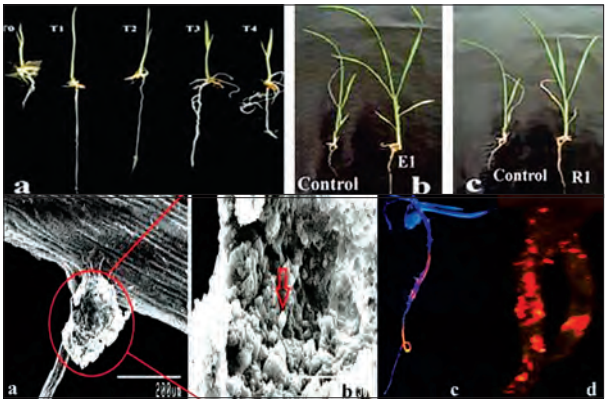
- The mycoplasmological examination of 74 tissue samples collected from the commercial poultry affected with respiratory infections from different parts of Haryana revealed the isolation of 10 *Mollicutes* organisms (13.5%) including 4 *M. gallisepticum* (MG), 1 *M. synoviae* (MS) and 5 mixed infections of MG and MS confirmed by different biochemical and molecular tests. Higher prevalence of MG 9/74 (12.16%) was reported as compared to MS 6/74 (8.1%) among poultry flocks.
- Anthelmintic efficacy of ethanolic fruit extract of *E. ribes* was assessed in *in vivo* trial in sheep. The results suggested promising efficacy of ethanolic fruit extract of *E. ribes* against most pathogenic GI nematode *H. contortus* and an effective formulation can be developed from fruit extract of *E. ribes*.
- Polymerase spiral reaction (PSR) test and Loop-mediated isothermal amplification (LAMP) test were developed and standardized using in-house synthesized primers specific for MDV-1 oncogene (*Meq*) to visualize the amplified product under naked eye or UV light after addition of SYBR Green-I dye.
- Latex agglutination test (LAT) was developed and standardized using rpp38 antigen to detect MDV-1 antibody in field chicken serum samples.
- Recombinant antigen (rpp38) based immunocomb dot-ELISA was developed and evaluated for detection of MDV-1 antibody in chicken serum samples.

Horticultural Sciences

- Ready-to-eat and convenience foods such as Instant Halwa mix, Idli mix, Dhokla mix, Khichdi mix and Daliya mix were standardized and developed using different composite flours of coarse cereals, germinated chickpea and tulsi leaves. The products prepared using composite flour of blanched pearl millet: sorghum: dehusked oat: germinated chickpea in ratios of 60:10:10:20 and blanched pearl millet: sorghum: dehusked oat: germinated chickpea: tulsi leaves powder in ratios of 60:10:10:15:5 were found to be most acceptable organoleptically and nutritionally superior as compared to wheat based products (control). It could be stored in polythene bags at room temperature (25–30°C) for 3 months and were acceptable up to 3 months. Supplementation of tulsi leaves powder caused significant reduction in fat acidity and peroxide value in all stored instant mixes.
- Supplementation of tulsi at 5% level further increased the nutritional value of products in respect of available minerals (calcium, iron and zinc), *in vitro* protein and starch digestibility. The antioxidants activity (total phenolic content and DPPH free radical scavenging activity) of all the products blended with tulsi was better.

Natural Resource Management

- Compatibility among the plant growth promoting bacteria (PGPB) was assessed to identify the prospective PGPB for consortium formulation. The W1 (*Bacillus* sp.), S36 (*Salinicola* sp.), SV4 (*Bacillus* sp.), RP8 (*Enterobacter* sp.), NR4 (*Pseudomonas* sp.) and Avi2 (*Azotobacter* sp.) were most potent PGPB. However, they differentially retained PGP functions under 6% NaCl, CO_2 and 40°C stresses. Maintenance of all PGP functions by S36 under different stress (but 40°C) adjudged it as the most effective stress tolerant PGPB.
- The Swarna, Naveen and salt tolerant Luna Sankhi seeds treated with 10^8 bacteria/ml resulted in 100% germination and improved radical/plumule length, root/shoot fr./dr. wt., tiller/leaf no., 100 grain/panicle wt. etc. Single treatment with 1.2×10^8 cells/ml or second treatment after 5 d growth with 1.2×10^5 cells/ml had better effect on Swarna seedlings.
- FRET tagged diazotroph (Avi2) confirmed colonization and upward migration of the endophytic PGPB through the natural or injury openings of the roots.



(*top*) Rice seedling growth effected by endophytic PGPB. **a**. Swarna seedling growth in control (T0) and 2% salt stress along with 1.2×10^8 cells/ml (T1), 1.2×10^5 cells/ml (T2) and 1.2×10^8 cells/ml (T3) single treatment, and 1.2×10^5 cells/ml (T4) for 2nd treatment after 5d. Rice cv. Naveen treated with phosphate solubilizing PGPB, **b**. E1, **c**. R1.
(*bottom*) Colonization of endophytic *Azotobacter* sp. Avi2 in rice cv. Swarna. **a**. At primary and secondary root junction of under SEM. **b**. Enlarged colony under SEM. **c**. FRET detected fluorescent bacteria in root under fluorescent microscope. **d**. Enlarged FRET detected endocolonizer Avi2.

Fishery Sciences

- Standardized the methodology of brooder rearing of striped snakehead (*Channa striatus*), in cement tank and raised 100 brooders of both sexes to complete maturity with 100% survival. Successfully spawned 20 females with accuracy of 100% breeding success in indoor conditions. The problem of assessment of full maturity in male was solved. This practice will now facilitate hatchery seed production of striped snakehead to serve as a high valued diversified species in aquaculture.
- Produced 2 lakh early fry. Protocol of weaning larvae on commercial pellet diet for raising fingerling was standardized. Produced 11,000 fingerling (size 40–50 mm) weaned on commercial floating pellet diet for experimental grow-out production. Supplied 10,000 feed weaned fingerling to 3 farmers of Lucknow and Barabanki districts for experimental grow-out production. The practice will promote farming of this high valued diversified species. Efforts are being made to transfer the technology of breeding and seed production to a private farmer in Barabanki district.
- To review the Marine and Brackishwater cage farming along west coast of India, with special emphasis on Goa, Karnataka and Kerala, a survey was carried in the South and North Goa districts in Goa, Dakshin Kannada, Udupi and Uttar Kannada districts of Karnataka, Calicut, Kollam, Malappuam (Ponnani), Alappuzha (Thuravur Block) districts along Kerala coast. The production from brackishwater cage farming in different indigenous cages at Kerala and Karnataka carried out. The production in Kerala optimized as 25 kg/m^3 from 2 m × 2 m × 1.5 m cages and Karnataka as 50 kg kg/m^3 from 4 m × 2 m × 2 m rectangular cages. In Goa, the production rate was approximately 50 kg/m^3 from 6 m × 6 m cages.
- The suitable species identified for cage farming in brackishwater cages along Karnataka coast is Sea Bass, followed by Red Snapper and Grouper. In Kerala, cage farming is limited to Pearl spot, Sea Bass and Indian Pompano.
- The stocking size optimized for brackishwater cage farming along Karnataka is 50 g for sea bass and red snapper.

Cage cultured red snapper harvested in Uppunda, Karnataka

In addition to research work, some Emeritus Scientists were engaged in teaching advanced courses at PG and Doctoral levels, guiding postgraduate students in their research pursuits, and publication of books and development of practical and teaching manuals.

Emeritus professor

Salient achievements

ICAR-Emeritus Professors taught 76 PhD, 81 MSc and 40 Undergraduate specialized courses to the students and thereby assisted in mitigating the shortage of experienced faculty at the AUs to impart quality higher agricultural education. As a part of their mandate, they also developed 36 teaching/practical manuals on the topics of current importance. In addition, to this they also guided 25 MSc and 31 PhD students.

Library strengthening

Under the library strengthening, component funds were provided to 56 agricultural universities. The main objective was to connect all the libraries through KOHA, installation of RFID in all libraries of universities . Support was provided for print books, print journals, e-books and e-journals not covered/available in CERA, digitisation of thesis (MSc and PhD) and other important documents, etc. The library strengthening grants have an impact upon the quality of education imparted in the agricultural universities as evident by the number of students qualifying for various national and international examinations. Latest books, e-journals, etc. helped students to improve research, formulate projects, and led to improvement in publication quality and helped them compete at national and regional level competitions. Many students have succeeded in securing admission for Masters/Doctoral studies in institutes of repute, within the country and abroad.

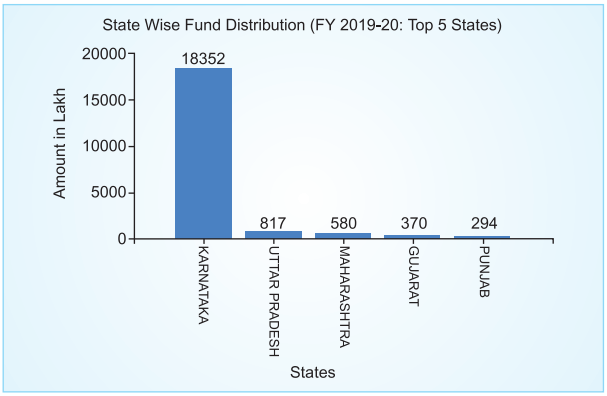
Strengthened facilities at the Libraries

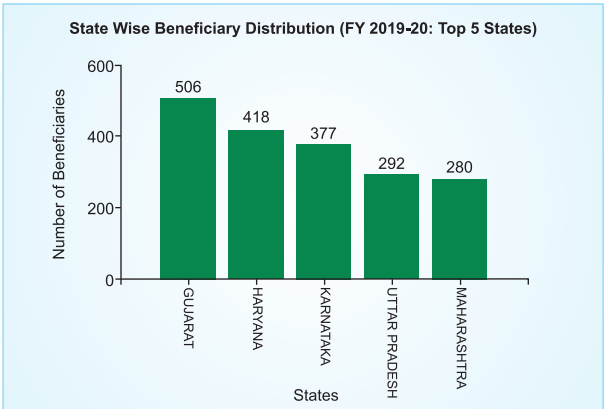
E-granth

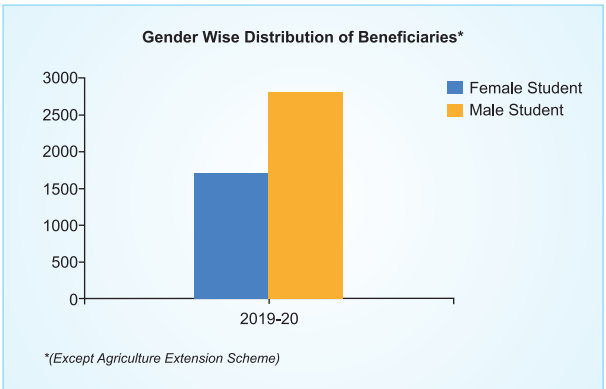
Under this project, Krishikosh is supported which is a digital repository which captures, preserves, archives and provides policy based access to the intellectual output of Indian National Agricultural Research and Education System (NARES). It is a unique repository of knowledge in agriculture and allied sciences. having collection of thesis, old and valuable books, institutional publications, technical bulletins, project reports, lectures, preprints, reprints, records and various documents spread all over the country. It is a customized digital repository platform for users of NARES Institutions, where they can upload and manage their own contents for compliance to open access policy of ICAR. Currently this digital repository (https://krishikosh.egranth.ac.in/) has more than 201,000 items.

Direct benefit transfer (DBT)

The direct benefit transfer (DBT) for 20 DARE/ ICAR components under various schemes is being done. During the year, data of 15,797 beneficiaries who were given ₹ 21,214.76 lakh under the different components was uploaded on the portal. The end to end digitization of DBT onboarded schemes of the DARE-ICAR was initiated. The figure depicts, fund



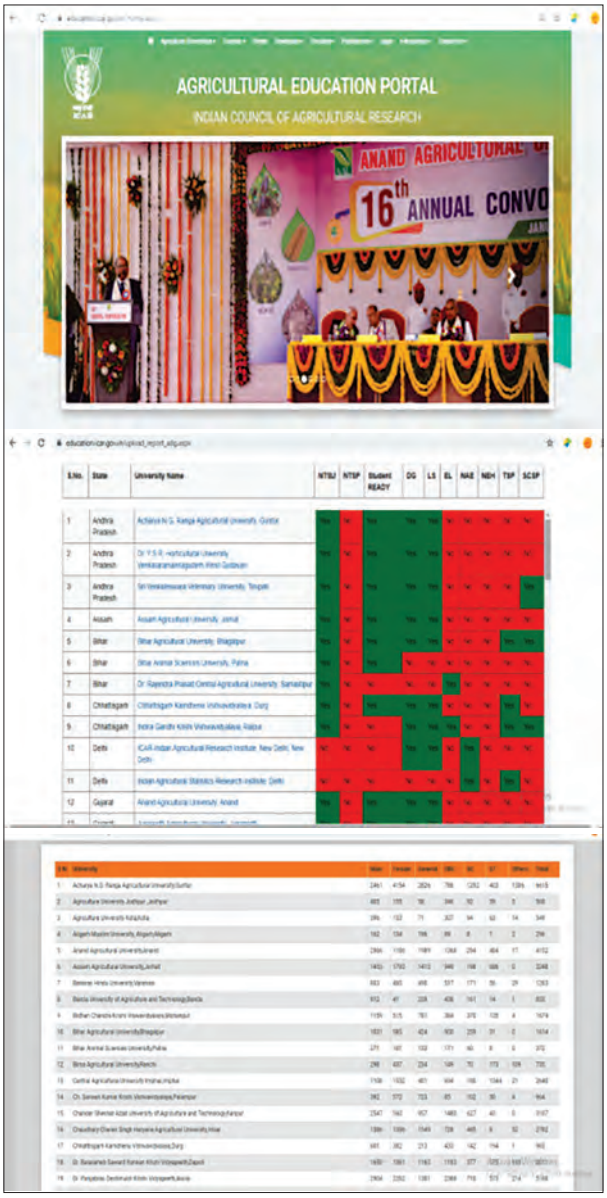




distribution in top states, number of beneficiaries from top 5 states and male and female beneficiaries.

Education portal/ NISAGENET

Education portal-ICAR (https://education.icar.gov.in) was developed as a single window platform for providing vital education information/announcements/ event schedules/e-learning resources from agricultural universities across the country in an easy and fast way. This portal is being upgraded/ customized with incorporation of new functions, viz. unspent balance amount is reflected, generation of sanction letter for releasing fund instalment wise, sanction letters of various components are generated through this portal. GFR 12A and GFR 12C forms were developed and are being reflected on portal. Support is provided for creating USID and also in mapping of USID under current university/college for students whose USID already existing in other university/college. At present,



Infrastructural support for teaching and learning facilities

Smart Classroom, UAS Bengaluru

Automatic microbial identification system (CIL), OUAT, Bhubaneswar

UID was generated for 146,326 students covering 74 AUs and interface of this portal was developed with DARE DBT portal. The portal is a major source of information for providing details of various sub schemes being operated in the area of agricultural education, their guidelines, information about various courses being offered by different agricultural universities.

The support under the component development and strengthening, continued during the year. The support was provided for ongoing new civil works, including the balance remaining funds for 16 student hostels as well as for renovation and refurbishing of old existing structures, with greater emphasis on providing amenities for students. Teaching facilities were enhanced with support for virtual/smart classrooms with emphasis on support for these in off campus colleges. These classrooms with most up to date audio visual aids, enabled effective delivery of course curriculum, ensuring enriched learning experience. Funding support was also provided for upgradation of laboratories through purchase of latest equipments and modernization of existing infrastructure. ICAR also continued the support for AUs for conducting UG and PG practicals and upgradation of these laboratories with need based equipment. The AUs were also

supported for various activities leading to holistic development of students.

Across the country, AUs were continued to be supported to design and implement comprehensive quality improvement programs, to bring about overall changes in capacity building of faculty, revision of course curriculum, learning materials, learning processes, learning outcomes, assessment and monitoring systems, to ensure that the quality of higher agricultural education and learning is improved. Smart classrooms, latest equipments in Central Instrumentation facilities were supported.

The upgradation of UG and PG laboratories improved both PG student research and practicals. Communication labs helped improve the language skills of the students as per requirement. For increasing awareness in latest techniques and research in cutting edge areas support was provided for student and faculty amenities/tours/capacity building and participation in seminars, symposia, workshops, trainings, etc. Practical manuals were developed in various subjects. Overall personality development and leadership programmes with the support from the Council helped the students become better persons and to grow as individuals.

Girls hostel, Solan

The hostel facilities for the students were improved with support from the Council. The improved amenities and infrastructure helped attract talented students. The support also helped improve amenities in the hostels and other services in the campus, including facilities for disabled. Placement cells helped students obtain placement or advice on career. Support from the Council was also provided to AUs to take necessary initiatives so as to encourage holistic development of students through sports, self-defence, yoga, personality development talks by eminent people, through workshops, coaching and counselling for clearing competitive exams on all India basis, etc.

Girls' Hostel, CSKVV, Palampur

Agrisports

XX Agrisports (All India Inter Agricultural Universities Sports and Games) at SVVU, Tirupati, from 1–5 March 2020. Students from 68 agricultural universities participated in the various sports. UAS Bengaluru won overall trophy in women section and MPKV, Rahuri won overall trophy in men section.

XX Agri unisports SVVU, Tirupati

AgriUnifest

The 20th All India Agricultural University Youth Festival was organized from 8 to 12 February, 2020 by Indira Gandhi Krishi Vishawavidyalaya, Raipur under the aegis of ICAR New Delhi. There were 1,400 participants from 60 participating agricultural universities. There were 18 different events, and students got a chance to exhibit their expertise in fine art and literacy as well. The overall champion trophy was won by Orissa University of Agriculture and Technology, Bhubaneswar, Odisha and Vasantrao Nayak Krishi Vishwavidyalaya, Parbahani, Maharashtra, was runner-up.

Tribal welfare programmes

The tribal welfare programmes were supported through projects related to agricultural and allied activities in 17 Agricultural Universities as per Ministry of Tribal Affairs (MoTA) approved districts in their respective states. The major activities supported were aimed to enhance livelihoods security and capacity building of scheduled tribe farmers. Skill Development Centres were established for empowering tribal youth, entrepreneurship opportunities of tribal youths. The interventions in the varied areas of agriculture, horticulture and animal husbandry led to improving food, income security of tribal farmers in these districts.

Various programmes were executed through 4,176 training programmes, 2,932 frontline demonstrations leading to the capacity building and creating awareness among more than 15,000 tribal farmers. In addition, the farmers were provided with inputs in the form of livestock, poultry, seeds, nursery planting materials, etc. to help them start their enterprise.

Various activities under Schedule Tribe Component

Support under Scheduled Caste Sub Plan (SCSP)

This is an umbrella strategy started in the Fifth and Sixth plan by the planning commission to ensure flow of targeted financial and physical benefits from all the general sectors of development for the benefit of Scheduled Castes. Under this component total ₹ 4,393.21 lakh was released to 37 number of universities in 15 states during 2019–20.

New infrastructure such as establishment/ construction of Skill Development Centre, Training centres, Committee Hall for promotion of vocational courses were supported. In addition, Fish Farming Unit and Bee Keeping Units, etc. were also established for imparting training. Inputs inputs such as training reading material, technical advisories, quality seed and biofertilizers, earthworms, polythene sheet and green net for *Azolla* production, High yielding variety of cereals, pulses, vegetables and fertilizer (urea, DAP) etc, were distributed to SC farmers. In identified clusters, 144 beneficiaries acquired bamboo handicraft skills, 400 SC beneficiaries received the training on modern scientific rearing of poultry birds and integrated farming with livestock, horticulture and nutrition gardening. Further, 1,134 participants trained under this programme, started their own entrepreneurship as a result of capacity building.

Book banks were created for the SC students enrolled in the AUs. More than 13,000 books were added in 12 Agricultural universities, which were distributed to the SC students. About 339 capacity building and need based interventions/ awareness programmes were organised for upliftment of the farmers in the SC clusters. Tutorial classes 514 in number were conducted for Personality Development Programme, Basic English Proficiency, Training programme on Entrepreneurial skill (startupreneur), Soft skills training programme and for preparing students to national/ international competitive examinations benefitting 4,544 students.

Active coordination with AUs on various aspects

To actively review, refine and strengthen various programmes implemented by the Education Division of ICAR, the virtual annual meeting of Vice Chancellors' was successfully held on 10 April 2020 and preparedness for lockdown situation and strategies for COVID-19 pandemic was reviewed. This also provides an opportunity to the Vice-Chancellors of AUs to interact with each other and develop strategy for effective functioning to maintain quality standards in higher agricultural education in the country. The virtual Nodal Officers meetings were conducted on 8 May 2020 and 11 June 2020. All the nodal officers were apprised of the steps taken by ICAR and necessary steps to be taken by universities during the pandemic situation were identified. The Council issued advisories to all the AUs to take necessary steps to connect each student through various online tools for their classes, assignments and other related activities, so that there is no time lag in the schedule of academic session. Further, the Education Division has identified the IT solutions and shared with the universities to avail the available online options by all the concerned. The ICAR Model Act based on the recommendations of the Committee and comments received from various stakeholders was revised.

Various webinars were also conducted, viz. webinar on 20 May 2020 titled Science, Society and Exponential Change: Reimagining the Future on 21 May 2020 titled ICT tools for the resilient agricultural education in India for the benefit of Directors, Vice Chancellors, Scientists, academic administrators, faculty and students of agricultural universities. A talk on Initiatives in Research, Teaching, Extension and Administration by Padma Sri Prof B.S. Dhillon was also organized on 10 June 2020.

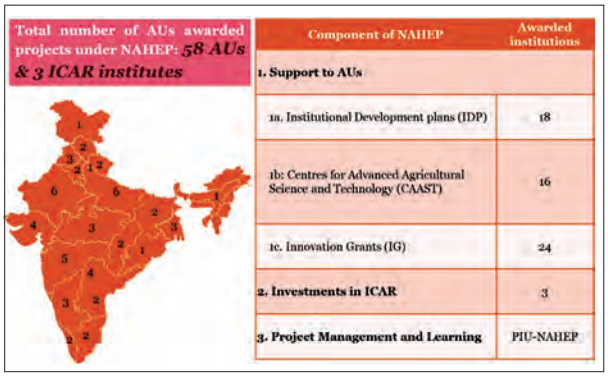
The Agricultural Education Division took initiatives to maximize the online work in view of the prevailing pandemic. Online Accreditation portal was launched on 11 August 2020 and also to obtain the required information from the AUs for national ranking,online system has been developed.

Activities under Schedule Cast Sub Plan

ICAR-National Agricultural Higher Education Project (NAHEP)

Indian Council of Agricultural Research (ICAR) commenced National Agricultural Higher Education Project (NAHEP) with the assistance of World Bank (WB) in November 2017 with an overall objective to support participating Agricultural Universities (AUs) and ICAR in providing more relevant and higher quality education to the students. NAHEP endeavours increased agricultural productivity and support quality improvements of higher education to create a more skilled workforce that continuously improves the productivity of key sectors, including agriculture. Overall, the project aims to develop resources and mechanism for supporting infrastructure, faculty and student advancement, and providing means for better governance and management of agricultural universities, so that a holistic model can be developed to raise the standard of current agricultural education system that provides more jobs and is entrepreneurship oriented and at par with the global agricultural education standards.

NAHEP is a multi-global practice collaboration (agriculture and education) project and supports activities and results directly related to cross-cutting strategic areas of climate change, jobs and gender. NAHEP is promoting efficiency and competitiveness through changes in working mechanism of AUs, raising the teaching and research standards through improved infrastructure, competency and commitments. The four key components under NAHEP are—Institutional Development Plan (IDP), Centres for Advanced Agricultural Sciences and Technology (CAAST), ICAR to support excellence in agricultural universities (AUs), and ICAR Innovation Grants to AUs. It is envisaged that improved AU performance through quality enhancement, better employment and entrepreneurship opportunities created for agriculture graduates, non-accredited AUs attaining ICAR accreditation, and institutional reforms implemented in Education Division of ICAR and AUs under these components together shall contribute to the achievement of the overall program objective.



Fifty-eight Agricultural Universities (AUs) were awarded under NAHEP, wherein 18AUs come under IDP, 16 AUs under CAAST and 24 AUs under IG in Component 1. Besides 3 ICAR institutes, i.e. ICAR-Indian Agricultural Statistics Research Institute (IASRI), ICAR-National Institute of Agricultural Economics and Policy Research (NIAP) and ICAR-National Academy of Agricultural Research Management (NAARM) have been implementing Component 2.

Institutional Development Plan (IDP): During last one year of implementation, call 1 and 2 awarded IDPs comprising 14 AUs have made significant

developments. IDP financed activities majorly focused on teaching and research infrastructure development, faculty development and training, networking and industry collaboration, vocational training, students' job placement, own revenue generation.

255 students and 55 faculties underwent international level trainings in reputed foreign universities, and more than 1,000 national level workshops/ seminars was conducted for UG level students under IDP. Among these trainings and workshops, high impetus was laid on enhancing employability and building entrepreneurship capabilities of agri students, so that the ripple effect of program in society could be created. Moreover, industry visits and Skill development programs also were organized majorly to cater the current market needs and enable the students to emerge as Job Creators rather than Job Seekers.

Centres for Advanced Agricultural Science and Technology (CAAST): Under CAAST component, 16 sub-projects were awarded to AUs, spread across 11 states of the country. The major activities undertaken by AUs under CAAST component included strengthening of teaching and research infrastructure; distinguished lecture series/ special lectures to bring about much needed vibrancy in the academic atmosphere and inspire students and faculty to perform better; national and international trainings for students, faculty and research scholars; collaboration with private sector related to the specialized areas to develop market-oriented programs, etc. 83 students have undergone international trainings, whereas more than 1,500 national level trainings/ seminars were conducted to develop

scientific entrepreneurship of students and enhance research effectiveness.

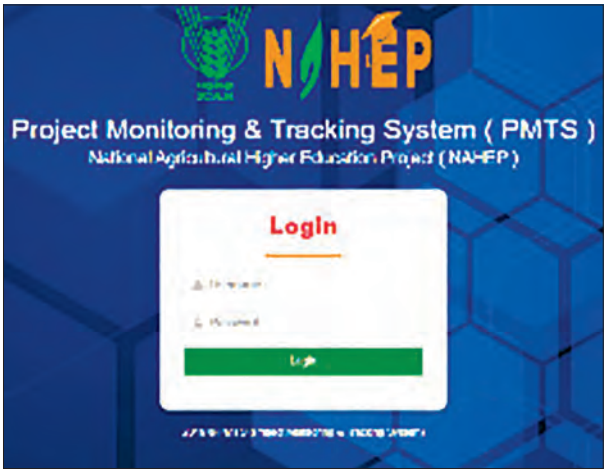
Innovation Grants: IG projects were awarded to select participating AUs to attain accreditation; 24 sub-projects were awarded under this component. Key IG activities included national level trainings for faculty upgradation; master and PhD sandwich programs; alumni linkages; industry seminars and professional workshops; e- enabled learning activities, etc. 7 AUs under the IG attained ICAR accreditation due to NAHEP support and interventions, additional 4 AUs submitted the Self Study Reports (SSR) to ICAR-Education Division to attain the accreditation at the earliest in FY 20–21.

Investments in ICAR for leadership in agricultural higher education: Component 2 aims to support ICAR to carry out institutional reforms within ICAR and enhance effectiveness in coordinating,

Evidence of attribution of NAHEP grants leading to project outcomes

Indicator	Unit of measure	Baseline (2016–17)	Achievement
% increase in AU on time graduation rate	%	77	93
% increase in student placement rates	%	41	59
Reduced student inbreeding	%	19.2	23
Reduced faculty inbreeding	%	45	53
Improved AU revenue generation	%	8.5	11
Accredited agricultural universities with revised norms and standards	Number	55	61
Direct project beneficiaries	Number	–	53,769
Female beneficiaries	%	–	30

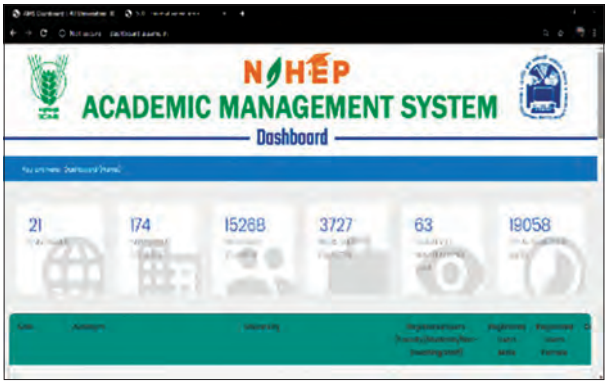
guiding and managing agricultural higher education in the country. During FY 19–20, activities undertaken are—strengthening of key digital infrastructures of ICAR AU system such as ICAR-DC; e-enabled learning activities in AUs through demonstrations of virtual classrooms; implementation of Academic Management System in 22 AUs; development of AU-PIMS (a workflow-based system developed with an objective to create unified information base for research projects); progress on constitution of External Advisory Panel; technical committee meetings to catalyze the participation of state government representatives in raising the quality and relevance of agricultural higher education, etc.



The major activities and achievements under Monitoring and Learning component included finalization of M&E framework; development and implementation of Project Monitoring and Tracking System (PMTS) in awarded AUs; capacity building activities; documentation of learning and monitoring related activities.

In order to establish a fair and transparent system, while effectively addressing the grievances of project stakeholders, a 3 tier grievance redressal mechanism was also established at PIU NAHEP, and made fully operational.

Environmental safeguard measures: The project is categorized as Category B as per the environmental safeguard policy of the World Bank, as the interventions like Institutional Development Plans that would update



infrastructure for research and teaching (under sub-component 1a, may have negative impact on the surrounding environment. The interventions proposed under sub-components 1b and 1c CAASTs and Innovation Grants offers scope for enhancing the positive impacts on environment through integration of pro environmental measures.

Over the year, 17 AUs have initiated implementation of green courses, lectures and workshops. Out of 5 compliances under ESM, E-waste management rules 2016 were made mandatory to all AUs to follow as per regulation of GoI. AUs have taken up the green initiatives in their campuses such as tree plantations, development of farm ponds, water harvesting structures, compost pits, etc. Some of the campuses have also been declared as plastic free campus.

Social safeguard measures: The project does not have any significant involuntary resettlement impact and the project overall was categorized as "C" as per the Social Safeguard Policies. The project institutions, especially those in low-income states, are located in states inhabited by tribal communities. Therefore, the World Bank Operational Policy on Indigenous Peoples (OP/BP 4.10) was triggered, and an Equity Action Plan (EAP) developed to incorporate social considerations in project planning, implementation, and monitoring and to ensure that potential adverse impacts are adequately mitigated and benefits of project are further enhanced to improve the effectiveness as well as the sustainability of the project. New construction activities are not allowed but the project was financing limited construction activities within the existing premises. These activities not causing any significant environmental or social impacts, Hence, the World Bank Operational Policy on Involuntary Resettlement (OP 4.12) was not triggered, but as limited construction activities are financed, keeping in mind the safety and security of labour, student, teaching and non-teaching staffs, a labour-management plan was developed and implemented for civil construction work.

Over the year, awarded AUs have improved the performance of the weaker students by organizing remedial classes, language learning trainings, student mentoring programs. Out of total beneficiaries ~10% female and ~11% male students from SC and ST were benefitted through various programs organised under NAHEP.

Whereas, other key initiatives like establishing user friendly campus for differently abled students were taken up by most of the awarded partner AUs during the year. In this initiative more than 500 facilities such as ramps, washrooms, Napkin vending machines, etc. have been established so far.

ICAR-National Academy of Agricultural Research Management (NAARM)

The National Academy of Agricultural Research Management (NAARM) focuses on creation,

dissemination and application of knowledge through its academic, training, research, consultancy and policy support programmes. The Academy expanded its activities to reach all stakeholders of NARES. The Academy has also widened the scope of its activities and initiated number of activities to develop a new generation of young leaders and managers who can contribute to sustainable agricultural development at the national level.

NAARM Registered Copyrights on Project Management Software: ICAR-NAARM developed three management tools, viz. AHP Analyser, Research Concept Writer and Project Log Frame Writer, which are web based open access applications and were copyright registered. These softwares are being used by more than 2,000 users in more than 80 countries. The software also works as wonderful classroom teaching tool, and are available on following links; AHP Analyser: https://naarm.org.in/ahp, Research Concept Writer: https://naarm.org.in/dwrp/, Project Log frame Writer: https://naarm.org.in/logframe/

Capacity building programmes: 2,654 participants successfully completed 75 need-based and mandated capacity building programmes of ICAR-NAARM consisting of Foundation Course for Agricultural Research Services, Induction training Programme to newly recruited Assistant Professors of SAUs, Management Development Programme, Entrepreneurship Development programme and Off Campus Programme, etc. Several programmes for administrative and technical staff for enhancing competency and efficiency were also organized for discharging their functions.

1,322 participants registered for online certificate course, viz. 'Massive Open Online Course (MOOC) on Competency Enhancement for Effective Teaching' aimed at improving the quality of teaching.

Academic programmes: The Academy is imparting Postgraduate Education in Agribusiness Management (PGDMA), Educational Technology and Management (PGDETM) and Technology Management in Agriculture (PGDTMA) to develop a new generation of young leaders and managers who can contribute to sustainable agricultural development at the national level. NAARM achieved 100% placement of final year PGDMA students.

Collaborative programmes: Ten collaborative in-campus and off-campus programmes were organized in collaboration with IINRG, Ranchi, Sri Venkateswara Veterinary University, National Bank Staff College, Lucknow; Coromandel International Limited, Institute of Hospitality Management, Catering Technology and Applied Nutrition (IHMCT & AN), Global Centre for Land-Based Innovation and Assam Agricultural University, benefitting 625 participants.

ICAR-NAARM as a Think Tank of ICAR: Academy also actively helps to maintain a futuristic vision as a Think Tank to address the diverse challenges in the field of agriculture. Therefore, to delineate the roadmap for transitioning the academy to be credible Think Tank of ICAR, scoping workshop was held at ICAR-National Academy of Agricultural Research Management (NAARM), Hyderabad, which recommended that NAARM should strive to provide sustained, general operating support for transnational and interdisciplinary research-based support on a range of policy issues, to the respective agencies through ICAR. The Think Tank Expert Committee constituted under the Chairmanship of Dr J C Katyal, presented the report during March 2020.

Memorandum of Understanding (MoU)

The Academy also signed Memorandum of Understanding (MoU) with various public and private sector organizations like National Centre for Sustainable Coastal Management (NCSCM), National Horticulture Board, Administrative Staff College of India (ASCI), Hyderabad in order to strengthen its activities in various areas.

Start Up through *AGRI UDAAN*: The Academy in partnership with CIIE, IIM-A, supported by DST launched Food and Agribusiness Accelerator Programme, 3.0 called AgriUdaan 3.0 in association with NABARD, Caspian, AgrInnovate, Omnivore, and other prominent partners to encourage startups to scale up. AgriUdaan 3.0 was launched in Hyderabad on 31 August 2019 and organized its roadshows in Bengaluru, Pune, Patna, Lucknow, Gurugram, Bhopal and Guwahati. Providing a truly Pan-India presence, AgriUdaan seeks to bring out innovations from across the country while also aiming to provide support to

Workshop on Development of Soft skills for Entrepreneurship among Veterinary and Dairy Science -Graduates under NAHEP component – 2A

the startups across the country.

National Agricultural Higher Education Project (NAHEP) Component 2 A: Under component 2 A of NAHEP, 9 Workshops and training programmes, viz. National Workshop on Academic Excellence through Building Partnerships and Resources Generation, Consultative Workshop on Academia-Industry-Government linkages for Quality Agricultural Education, Training of Trainers Workshop for organizing workshops on Development of soft skills for Entrepreneurship among Agri Graduates, Training Workshop on Education Management and Academic Leadership, and technical committee meetings were organized. A total of 528 participants gave their input for quality and relevance of agricultural higher education in the country.

Special programmes

Training programme for IFS Probationers (2018–20 Batch): In accordance with MoU with Indira Gandhi National Forest Academy (IGNFA), Dehradun, a total of 60 IFS Probationers and two Officers belonging to the Royal Bhutan Forest Service participated in the Training Programme on Participatory Rural Appraisal (PRA) and Communication Strategies including Integrated Watershed Management (IWM) organized for the IFS Probationers (2018–20 Batch) at ICAR-NAARM from 26–29 September 2019.

❑

"ये हमारे किसान ही हैं, जिन्होंने लॉकडाउन के दौरान देश को खाने-पीने के ज़रूरी सामान की समस्या नहीं होने दी। देश जब लॉकडाउन में था, तब हमारा किसान खेतों में फसल की कटाई कर रहा था और बुआई के नए रिकॉर्ड बना रहा था।"

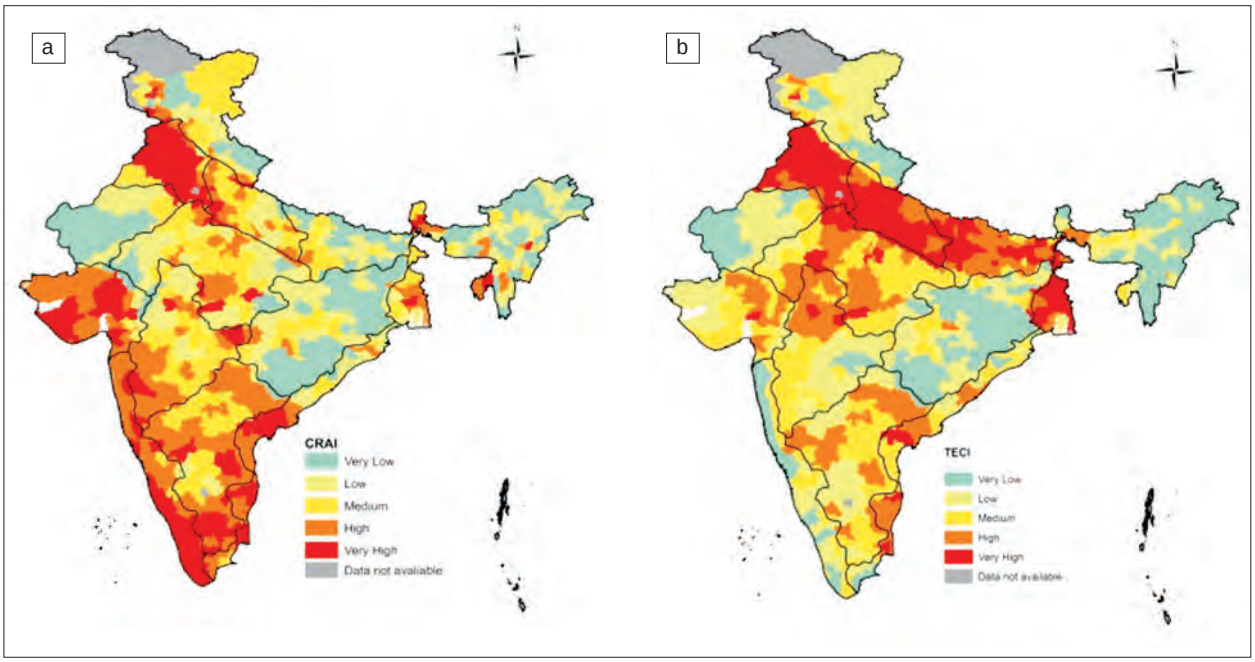
— नरेन्द्र मोदी

12. Social Science

Agriculture economics and policy

Climate resilience across agro-climatic zones of India: Total of 26 indicators, relating to environment (5), technology (7), socio-economic (7) and infrastructure and institution (7) dimensions were employed to purport *inter* and *intra* ACZ differentials in the level of resilience using district level information. Based on their index scores, 14 ACZs and 616 districts were categorized into different homogenous groups. The values of the estimated indices, did not reflect the absolute resilience, rather it only indicated the relative strength of ACZ/district to withstand climate risks. Overall high climate resilience was found in WCG, TGP, GPH and ECH. On the other hand, MGP (Bihar and parts of Uttar Pradesh) and EPH (primarily comprising Chhattisgarh, Jharkhand and Odisha) had the lowest resilience. In addition, other zones namely, WDR, EHR and UGP were also categorized under lower degree of resilience to climate change.

Most of the districts falling within the Gangetic Plains region and WDR had very low level of environmental resilience. Out of 89 districts lying in the EHR, about 67% had very high environmental resilience. Among the districts with very low to low level of technological resilience about 54% were concentrated in the EHR and EPH. Districts lying in the SPH had medium level of socio-economic resilience. Districts in southern India



Maps showing intra-ACZ (district level) distribution of resilience (ACZ demarcation is shown with *black boundary* line). (*a*) Technological Index, (*b*) CRA Index

Categorization of ACZs

Indices of resilience	High resilience	Medium resilience	Low resilience
Environmental index	CPH, EHR, EPH, WCG	ECH, GPH, UGP, WHR, WPH	LGP, MGP, SPH, TGP, WDR
Technology index	LGP, MGP, TGP, UGP	CPH, ECH, SPH, GPH, WPH	EHR, EPH, ECG, WDR, CPH
Socio-economic index	ECH, TGP, WCG, WDR	EHR, GPH, SPH, WHR, WPH	CPH, EPH, LGP, MGP, UGP,
Institutional and infrastructural index	GPH, SPH, TGP, WCG	ECH, EPH, LGP, WHR, WPH	CPH, EHR, MGP, UGP, WDR
CRA index	ECH, GPH, TGP, WCG	CPH, LGP, SPH, WHR, WPH	EHR, EPH, MGP, UGP, WDR

Note: Western Himalayan Region (WHR), Eastern Himalayan Region (EHR), Lower Gangetic Plains (LGP), Middle Gangetic Plains (MGP), Upper Gangetic Plains (UGP), Tans-Gangetic Plains (TGP), Eastern Plateau and Hills (EPH), Central Plateau and Hills (CPH), Western Plateau and Hills (WPH), Southern Plateau and Hills (SPH), East Coast Plains and Hills (ECH), West Coast Plains and Ghats (WCG), Gujarat Plains and Hills (GPH), Western Dry Region (WDR)

particularly districts of Kerala state and those falling within GPH and TGP showed better intuitional and infrastructural foundation. Overall, in CRA index among 124 districts with very low level of resilience, 66 districts were under north-eastern states forming part of EHR, 40 districts from EPH with maximum concentration from the states of Jharkhand and Chhattisgarh and 25 districts from MGP particularly from the state of Bihar. On the other hand, most of the districts in TGP and WCG showed very high resilience to manage climate risks.

To bring robustness in climate change adaptation planning, there is need to develop suitable location-need-context specific interventions and policy that builds resilience of agricultural system. In zones with injudicious extraction of groundwater, a comprehensive water resources management policy must be developed. For reducing agriculture emissions, mitigation alternatives should be researched with appropriate management of agri-activities and operations. Under climate change, enhancing equitable accessibility to irrigation along with suitable location-based cropping pattern is crucial for optimization of returns, water use efficiency and value creation. Moreover, to sustainably improve productivity, penetration and adoption of micro-irrigation systems such as drip, sprinklers must be evolved with appropriate building of farm capacity. In particular, diversifying to agro-forestry in ecologically fragile regions, increasing thrust on crop diversification and strengthening animal-based/crop-livestock system promotes farm resilience. Further, strengthening credit support to the zones with limited access to finance especially the eastern region could expand both the *ex-ante* and *ex-post* climate response space. Moreover, devising action plans with emphasis on awareness, preservation of natural resources, diversification, building physical infrastructure, strengthening of grass-root institutions and mainstreaming climate adaptation in the developmental policy is crucial for climate resilient pathways.

Impact of climatic hazards on agricultural growth: The frequency of climatic hazards such as droughts, floods, heat-waves and cold waves has increased in the recent past and an increase is predicted in the future, that will affect the performance of agriculture and the livelihood of millions of people dependent on it directly or indirectly. In India the climatic hazards are estimated to reduce agricultural growth by about one-fourth. But different climatic hazards impact it differently. Droughts and heat-waves have a larger negative impact, than other climatic hazards, and more so in the poor and predominantly agrarian states. Nonetheless, the negative growth effects of climatic hazards taper-off in the long-run due to the increasing use of mitigation and adaptation measures such as irrigation, crop diversification, changes in input-use and integration of animal husbandry into the farming systems, among others. Irrigation and crop diversification provide significant adaptation benefits against droughts and heat-waves, but these become smaller in case their frequency rises. The adaptation benefits of animal husbandry and fertilizer-use although are comparatively small but more sustainable against the frequent climatic hazards. The adaptation strategies are mostly traditional ones, but their effectiveness can be improved through the provision of support services and finances required to scale these up. One of the main implications is to strengthen the weather advisory services to enable farmers to take appropriate decisions regarding the adaptation measures. Another implication relates to the animal husbandry, an important source of livelihood for 70% of the farm households who often cultivate tiny pieces of land and maintain a few low-producing animals. Improving their scale of production requires policy support in terms of investment, financing and information on production practices related to breeds, feeds and health. Further, given the growing water scarcity there is a need to adopt water-efficient cropping patterns and technologies to conserve water resources.

Multi-objective optimization for sustainable agriculture in Bundelkhand: Considering current resource constraints, particularly the water in Bundelkhand region, sustainable cropping pattern and crop-livestock mix was envisaged. The input output coefficients were estimated using unit level data of cost of cultivation scheme for the TE 2014 while the level of resource availability was estimated using secondary data. Goal programming model was developed to maximize net returns and minimize water use with set of physical, economic and environmental constraints. Five different scenarios were built by simulating various resource saving technologies and policy interventions.

The findings suggested that currently the resources in the Bundelkhand region are used sub-optimally. Four out of five scenarios suggested to declining the area under paddy and wheat and even the plan with improved irrigation efficiency also indicated for capping the area under these crops up to existing level. Study brought out that increase area under sorghum, pulses and oilseeds (sesame) will help in utilising huge *kharif* fallow and also improve the crop-livestock integration in the region in turn augment the income of farmers. Plans with local cattle and small ruminants were found to be more profitable than the crop based plans. Inadequate infrastructural support for agriculture and farm credit were the most sensitive factor in the region, and provision of additional credit enhanced income as well as employment in the region. Study further found that though mentha is profitable crop but not sustainable from natural resource perspective.

Development of agricultural sustainability barometer with special reference to rice–wheat production system: Sustainable Development Goals (SDGs) are the key milestones for economic and agricultural development across the globe. A composite agricultural sustainability indicator (CASI) was designed especially suitable for rice–wheat production system. The index covers four broad dimensions, viz. soil, water, ecological and economic encompassing 79 indicators. The barometer so developed was applied to gauge the sustainability of Trans-Gangetic plains of India. The

composite index showed a moderate level of agricultural sustainability in the region (CASI 0.52). The sustainability indices for socio-economic and soil related indicators were comparatively better and environmental and water dimensions of the sustainability were the most eroded dimensions, needing special attention. The results have two major implications. Firstly, there is an urgent need to adopt district-specific cropping pattern based on natural resource availability and improve the efficiency of the production, by adoption of better technology and conservation practices. Secondly, the response variables like high investment in R&D, irrigation efficiency, drainage, etc., need special attention. Increasing efficiency of input and resources like increasing area under conservation agriculture, promotion of agro-biodiversity, and diversity of production systems, should be given high priority. In some cases, policy correction like targeting subsidy can lead to better sustainability outcomes. The framework has a potential for its application in other parts of the country. It would require concerted efforts to capture data on a large number of indicators periodically, particularly on agro-diversity indicators. Emphasis should be given on assessing the sustainability trends with relevant indicators feasible in terms of implementation and responsiveness.

Technology foresight in agriculture: The trends in scientific publication of emerging technologies such as synthetic biology and artificial intelligence in agriculture were studied. The study used lens.org, an open access platform, to search for articles, patents and citation of emerging technologies such as synthetic biology and artificial intelligence in agriculture. Both the technologies have application across different sectors. These are the key emerging disruptive technologies of the fourth industrial revolution. Application of these technologies such as deep learning and algorithms to predict disease and pest outbreaks, genome editing for new improved varieties are already in market.

The new technologies and business systems are evolving in agricultural sector and it needs newer set of laws and research. For example, the regulations on data sharing, new breeding techniques (CRISPR-Cas 9), requires the existing laws to evolve suiting the such rapidly advancing scientific improvements. In case of artificial intelligence, India needs to design and develop policy framework supporting democratization and distribution of data which can be utilized by these ventures to develop innovative solutions and business models. The policy should also take care of the issues with ownership, privacy, protection, security and transparency of these data.

The causes and consequences of various litigations on the intellectual property and competition, effect of regulatory policies of the government on anti-competitiveness in the *bt* cotton industry were also investigated. The timeline analysis was performed to understand the events in detail and concise the counterfactuals and consequences of the events. The timeline is divided into three phases, initial regulation phase 1 (1990–2002), lesser regulatory phase 2 (2002–07), strong re-regulations phase 3 (2008–2019).

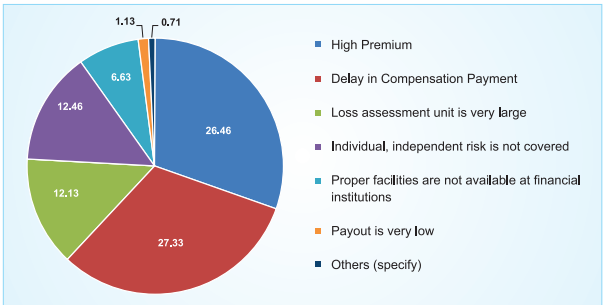
Based on the timeline analysis, it was revealed that the new business model (sub-licensing) resulted in barriers to entry for a non-patented product. Government intervention through enforcing price cap also discouraged the firms from investing in R&D based on new patents. The study showed that an interaction of business model and regulatory policies resulted in anti-competitiveness in the industry.

Structural transformation, regional disparity and institutional reforms in agriculture: Promoting agricultural exports could help to increase farmers' income. Using Social Accounting Matrix (SAM) framework, impact of export promotion policies on national output and employment were estimated. Three different scenarios were developed. The first scenario considered the case of increasing export of processed foods by 10%, the second considered the same extent of rise in food grains and oilseeds, and the third considered the case of fruits and vegetables. Two different SAM matrices corresponding to the years 2007–08 and 2012–13 were considered for simulation. Results indicated export promotion in processed foods will contribute higher to the GDP than other food groups in the contemporary economy. While it was estimated to contribute 0.04% additional GDP with 2007–08 base, contribution tripled in 2012–13 base to 0.11%. Export promotion of food grains and oilseeds was estimated to contribute half of the contribution of processed foods, while fruits and vegetables had the least impact. Similar was the impact on employment generation. While processed foods created an additional employment by 0.07%, contribution from food grains was 0.03%, and from fruits and vegetables it was just 0.01%. Promoting the export of processed foods rather than unprocessed foods would contribute more to economic growth. From consumption perspective, it was also found that share of the farm sector in total demand has declined from 12% in 2007–08 to 9.5% in 2012–13, and share of capital with respect to labor has increased from 50-66%. Demand for rural labor as well had declined from 58-53% during the study period.

Improving irrigation is an effective way of rising productivity. At this front, the impact of governance in irrigation sector on agricultural productivity was analysed. The Irrigation Governance Index (IGI) was constructed using 14 indicators, ranging from receipts from public irrigation, electricity charges in agriculture, revenue and capital expenditure on public irrigation, irrigation potential created under the Accelerated Irrigation Benefit Programme (AIBP), net area irrigated by public canals and tanks, stages of groundwater development as per the usage/extraction of water etc. The performance in public irrigation system was captured through the gap between irrigation potential created and potential utilized, and the role of irrigation governance (IGI), rainfall and proportion of area under non-food crops were studied using panel regression. The results

revealed that an improvement in irrigation governance leads to a reduction in the gap between the irrigation potential created and utilized. On farmers' perception on risk-taking, insurance uptake and governing factors, field survey was conducted in different districts of Uttar Pradesh. About 400 farmers were surveyed for this purpose. Risk preference attitude was perceived to be influenced by raising more income and profits. Around 40% of farmers reported profit-making as the key driver of risk taking. Equally, the other 40% farmers reported risk-taking as a way of experimenting with new methods. On existing insurance schemes, they opined that premium rates are relatively higher, and delay in compensation payments are much frequent. Both these factors contributed 54% of farmers' response as major dissatisfaction factors.

Analysis of agricultural extension and advisory services in India: **A system level perspective**: To study the functional nature of Extension and Advisory Services (EAS), a system level analysis was carried out with 36

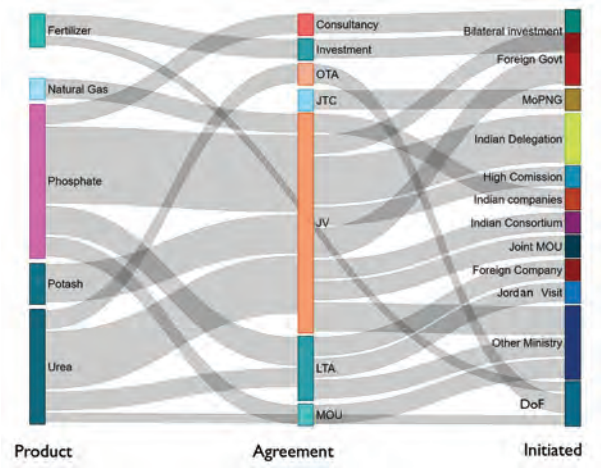


Farmers' perception and awareness
Impact of governance in irrigation sector on agricultural productivity

service providers from Maharashtra and Odisha; including Public, Private, Farmers' Producers Organisations (FPOs), and Non-Governmental Organisations (NGOs). All public EAS providers reported linkages and cooperation with other public EAS providers as well as non-public EAS providers. Though from government organisations' point of view all EAS providers were linked, the same is not always reciprocated by the other organisations, indicating that not all organisations are linked, and some are left outside as the linkages of public extension organisations. Moreover, linkages among non-public EAS providers were not as strong as expected; particularly, FPOs and some private EAS providers worked in isolation. Therefore, more synergy and inclusive convergence is needed at district level. Here, role of public organisations is important which can cement all them together. Among all the EAS providers, 65% time of field staff was devoted to extension and advisory service. Time devoted to extension activities was less in public extension organization (27% for District Agriculture Office, overall 43 for public organisations); the remaining time was devoted to research, administration and management, etc. All public EAS providers were providing advisories related to cereals, pulses, oilseeds, cash crops, fruits, vegetables, livestock and fishery, in varying degrees. Other EAS providers had varied orientation based on business interest.

As compared to crops, livestock extension was not a major target for all categories of EAS providers. At macro level, decomposition of extension expenditure showed that around 92% of total was allocated for crop husbandry and only 0.9% was allocated to animal husbandry and dairy segment. There was not much discrimination in targeting farmers by public service providers covering all categories of farmers; others targeted farmers based on their objectives and business activities. In terms of individual, group, and mass contact, SAUs and KVKs were using all the methods in a balanced way; Departments of Agriculture reported greater use of individual contact method. Considering more number of smallholdings, higher use of individual contact methods by public EAS providers can be understood. However, they were spending less time on advisory and considering the number of vacancies in the department; it is not possible for them to reach all farmers. Therefore, more use of group contact method (like exhibitions, agriculture fair, farmers' day, etc.), or mass media or ICT is recommended so that they can reach large number of farmers with the same resources and time.

Framing policy for overseas acquisition of raw material by the Indian fertilizer companies: Study for Department of Fertilizers, Ministry of Chemicals and Fertilizers, on Framing policy for overseas acquisition of raw material by the Indian fertilizer companies and role of the government was undertaken. The study looked into (*i*) the overall fertilizer's availability scenario, India's import dependence both at present and in future likely scenario, (*ii*) import mechanism and international market scenario of import of fertilizers, their raw materials, feedstock, natural gas and intermediaries, (*iii*) comparable policies/policy framework of any other department of GoI and international practices, (*iv*) develop a policy framework that aims at encouraging international co-operation, and



Note: OTA– Offtake Agreement, JTC– Joint Trade Comission, JV– Joint Ventures, LTA– Long Term Agreement, MoU– Memorandum of Understanding, DoF– Department of Fertilizer, MoPNG– Ministry of Petroleum and Natural Gas.

(*v*) possibility and desirable of the revival of either reviving UVL or SPV for international co-operation. The study discussed various approaches such as Joint Venture, Long Term Agreement and direct market purchase for acquiring raw materials and finished products of fertilizers. The study also discussed policies for supporting and encouraging these approaches. The study recommended that Department of Fertilizer should play a facilitator role for both public and private entities (non-discriminatory) for exploring these approaches.

Agricultural input markets in India: **Recent policy reforms and ways forward**: The study reviewed the policies in three major input sectors: seeds, pesticides and fertilizers. The agriculture input markets in India are undergoing numerous changes in terms of scale of operation, participation, and diversification. Various new policy reforms such as nutrient based subsidy scheme 2010, Neem coated urea 2015, Direct benefit transfer (2017) in fertilizers sector, Price control order of *bt*-cotton 2015, Seed Bill 2011 (pending) in case of seed sector, and the proposed Pesticide management bill 2008 and Insecticides (Amendment) Draft Rules 2017 in case of pesticides were intended to have greater implications on restructuring the sector. The new policies and regulations were tailored for the changing dynamics in the input sector and were intended to have greater implications on restructuring the sector. The input sectors are governed by different actors and roles. A sector wise discussion on policies, challenges and way forward were analysed. The study concluded that considering the dynamic nature of the sector, policies need to be realigned and reformed in a faster pace. There is a need to strengthen policies to build partnership; public–private partnership, for R&D in case of seed, for quality control in case of pesticides, and for foreign joint ventures in case of fertilizers.

Doubling of farmers' income in India: The Government of India is committed to doubling of farmers' income (DFI) by 2022 with DFI strategies now under implementation. The committee considered the year 2015–16 as the base year, and extrapolated the average income for that year by using NSSO, 2012–13 farmer income estimates. The next income estimates by NSSO are expected soon. Pending this, ICAR-NIAP estimated the interim growth rates in income for effective monitoring of DFI strategies. The income assessment was done using the seven sources of growth. The real income growth was estimated from 2015–16 to 2018–19. The estimates indicated a positive direction of change. Several initiatives of the Government are seen to be yielding positive results, and the growth momentum can be expected to pick up further.

Crop productivity and resource use efficiency were considered to indicate increase in agricultural output per unit of land. Aggregate estimates of crop productivity were obtained as area weighted productivity estimates. Production function approach was followed by using crop productivity as the output variable and considering major farm inputs as the input variables. The elasticity coefficients were obtained based on production function and used for assigning the sub-indicator weights within the major sources of growth. Diversification towards high-value crops is producing encouraging results. The terms of trade showed a positive increase during 2015/16 to 2018/19. Cropping intensity was used for evaluating the change in income and there is an increase in cropping intensity from 149% in 2015–16 to 154% in 2018–19. Livestock and fish production was considered keeping in view its important role in enhancing farmers' income.

Policy imperatives for promoting value chains of agricultural commodities in India

Buffalo meat: This study assessed the performance of buffalo value chain in terms of transaction costs and distribution of benefits realised by various chain actors. Further, risk analysis was carried out to identify the disease risk hotspots in the value chain. The quantitative mapping showed that aggregators constituted the main link between farmers and live animal markets and accounted for 72% of the total flow of buffaloes to livestock markets. Of the total meat produced, 71% is shipped directly to importing countries and the rest to local markets. The risk analysis across value chain revealed the 8 risk hotspots in the value chains. These are overstocking of vehicles by traders, irregular ante-mortem examination in livestock markets, animals transported for long distances without health certificates, no measure for pre and post-movement isolation and testing, non-cleaning/disinfection of vehicles after each trip, no measure for check for pathogens at slaughter houses, lack of hygienic practices at retail outlets, and use of contaminated meat cutting wooden slabs.

The findings of value chain identified structural deficiencies and vulnerabilities and provided the framework for intervention policies that can improve system efficiency. These may be helpful in streamlining the animal preservation acts in the country to promote scientific practices of meat animal production, rejuvenating the scheme on salvaging and rearing of male calves for meat production and implementation of integrated and inclusive contract farming system for meat buffalo production.

Dairy start-ups: The value chain of dairy entrepreneurs was mapped based on data from 48 startups covering states of Haryana, Punjab, Uttar Pradesh, Rajasthan, Andhra Pradesh, Delhi, Uttarakhand, Gujarat and Jharkhand. It is evident that informal sector dominates in the dairy industry and 48.15% of dairy start-ups adopted direct selling of milk from producer to consumer. This could be due to realization of higher profits. These startups were focusing on quality milk supply mainly to urban dwellers in hygienic conditions like selling raw milk in clean glass bottles and few of them were selling milk of indigenous cow (Sahiwal, Gir, Kankrej) which fetched higher price ranging from ₹ 60 in Ganganagar (Rajasthan) to ₹ 110/litre in National Capital Region (Delhi, Faridabad and Noida). The consumers also preferred raw fresh milk over pasteurised pouch milk. Other channels identified were selling milk

to aggregator vendor and cooperative society. Majority of the farmers had adopted multiple channels to avoid marketing risk, to manage fluctuations in milk production and to efficiently manage fluctuating demand in the market for milk and milk products. The value addition along the chain and profits were realised higher in the value chain of integrated production and processing system.

The study developed food safety adoption index by considering 68 scientific practices adopted by different stakeholders in the milk value chain. The regression analysis between food safety index and its determinants revealed positive association between adoption of food safety measures in the value chain and milk prices.

Organic spices: A value chain analysis of three major spices–ginger, turmeric, and chilli in the north-eastern region–was done to work out comparative costs and returns, mapping of value chain actors and estimation of compliance cost, investment and margins along the value chains. The states having the highest areas under the selected spices were selected and compared with the state adopting organic production practices. Sikkim was purposively chosen as control state as it has largest area under organic production.

In north-eastern region, ginger is grown in three farm situation—upland, terrace and *jhum*/*shifting* cultivation. The non-adopter states of Meghalaya, Mizoram, Arunachal Pradesh and adopter state, Sikkim were selected for the study. Major collection centres were identified in the selected states. The per hectare cost of cultivation of ginger in organic state was high due to the relatively higher price of organic rhizomes than in the non-adopter states. The net returns, however was highest in the organic adopter state. A huge return gap of 60.98%, 77.83% and 64.85% was observed between the states of Meghalaya, Mizoram, Arunachal Pradesh with Sikkim. These evidences implied that cultivation of organic ginger fetches premium prices. The producers' share in the consumer rupee for the organic adopted state was fairly higher than the non-adopted states.

STATISTICS AND COMPUTER APPLICATIONS

Latin hypercube designs: Latin hypercube designs (LHDs) are commonly used in designing complex computer models. A new type of Latin hypercube design known as Sliced LHD (SLHD) are now a days gaining importance in the field of computer experiments. SLHDs are a special type of LHDs, which can be further partitioned into different slices and act as batches of smaller Latin hypercube designs. Developed methods of construction of sliced Latin hypercube designs and sliced orthogonal Latin hypercube designs with both equal and unequal batch (slice) for up to three slices.

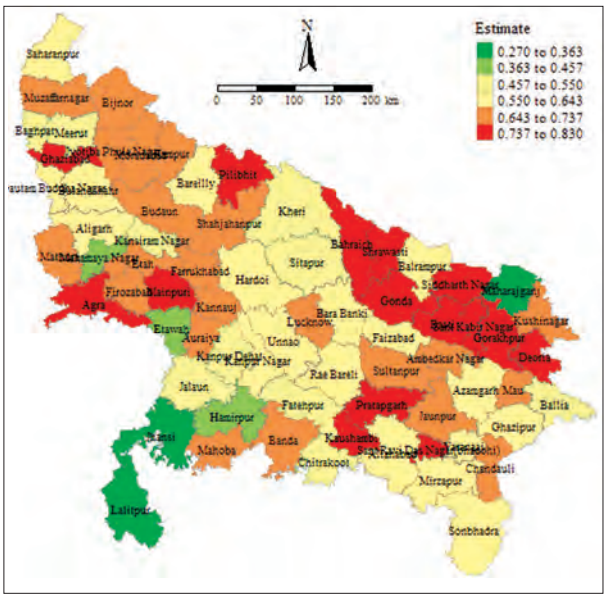
Modelling and forecasting of drought index using machine learning techniques: Multiple kernel extreme learning machine (MK-ELM) and wavelet based MK-ELM (W-MK-ELM) algorithms were implemented for forecasting of effective drought index (EDI). For drought model development, 52 years of data of Sagar and Chattarpur districts of Bundelkhand region were used. The forecasting capability of MK-ELM and W-MK-ELM is benchmarked with Extreme Learning Machine (ELM), artificial neural network (ANN), least squares support vector regression (LSSVR) models and was found to be superior.

Machine learning techniques based hybrid model for forecasting in agriculture: Agricultural dataset are mostly nonlinear, nonstationary and leptokurtic in nature. These properties of dataset pose a variety of problems in forecasting. Precise forecasting helps both farming community and policy makers to undertake informed decisions. Three different hybrid models, i.e. empirical mode decomposition based support vector regression (EMD-SVR), time delay neural network with error correction term (TDNN-ECT) and multivariate adaptive regression splines based artificial neural network (MARS-ANN) models were proposed. The EMD-SVR model has the capability of smoothing and reducing the noise (inherited from EMD) and the capability of filtering dataset and improving forecasting performance (inherited from SVR). TDNN-ECT uses the error correction term from the two co-integrated series as auxiliary variable. The auxiliary information in the form of ECT improves the forecasting accuracy. MARS-ANN hybrid model was developed in which the MARS algorithms were employed to extract important factors determining crop yield, and the extracted factors were used for yield prediction using ANN methodology. The performance of proposed hybrid models was evaluated with individual forecasting models using three different agricultural datasets. The results indicated that the performances of the proposed hybrid models are substantially superior as compared to the individual forecasting model.

Regression analysis from sample survey data using calibration approach: The calibration approach is commonly employed in survey estimation to modify the sampling design weights using auxiliary information to produce efficient estimator for the finite population parameters. Efficient estimator of regression coefficients were developed by extending the calibration approach. In particular, calibrated estimators developed based upon the auxiliary variable(s) correlated with the dependent and/or explanatory variable. The estimators of variance of proposed estimators were also developed using two approaches, viz. analytical and bootstrap. The performance of the proposed estimators along with its corresponding variance estimators were evaluated through simulation studies. The empirical results based on simulation studies using both synthetic population and real data showed that the developed estimators performed better than the existing estimator. Further, the empirical results revealed that both analytical and bootstrap variance estimators perform reasonably well.

Robust technique of association for genome wide case-control study: Analysis of SNPs and haplotypes offer a promising new research avenue for finding

association of genes with complex diseases. Prospective and retrospective likelihoods are two common approaches used to study this association in SNPs. A method based on preliminary test was proposed for SNPs, which is more efficient than prospective approach by exploiting model assumptions of Hardy Weinberg Equilibrium (HWE) and robust against failure of model assumptions as compared to retrospective approach. Association analysis using haplotypes is also gaining importance. Model-free and model-based methods are the two commonly followed approaches for the analysis of haplotype data. A preliminary test estimator for the analysis of haplotype data was proposed by utilizing model free and model based method.



Spatial distribution of incidence of food insecurity by districts in rural area of Uttar Pradesh

Robust and efficient small area estimation methods for agricultural and socio-economic surveys: Food security is one of the highest priorities of the Government of India to achieve the Sustainable Development Goal 2 (SDG-2). In India, the estimates of food insecurity indicators are not available at local area or small/lower administrative units like at district level in the country because the sample sizes for such small areas in the existing large scale survey data are often very small or even zero. The small area estimation (SAE) methodology provides a viable and cost effective solution to this problem of small sample sizes at lower administrative level. The SAE method was applied to estimate the incidence of food insecurity in different districts of rural areas of the state of Uttar Pradesh by linking data from the latest available 2011–12 Household Consumer Expenditure Survey collected by the National Sample Survey Office of India and the 2011 Population Census. A map showing district level inequalities in the distribution of food insecure households in Uttar Pradesh was also produced which provided an important information for analysis of spatial distribution of food insecurity in the state.

Estimating the sub-state level estimate of socio-economic indicators of Uttar Pradesh using small area estimation techniques: The disparities among the households both rural and urban areas with their standard of living in the state of Uttar Pradesh for different household categories such as land holding size and social group categories were studied. The district-wise estimates of average household monthly per capita consumer and expenditure (MPCE) as well as the measure of reliability (defined by the per cent coefficient of variation of the estimates) were produced for different household categories for rural and urban areas. In the latest available 2011–12 Household Consumer Expenditure Survey data, a total of 5,916 rural and 3,102 urban households from the 71 districts of Uttar Pradesh were surveyed. The district sample sizes for rural areas ranged from 32 to 128 with average of 83. Similarly the district sample sizes for urban areas varied from 30 to 128 with average of 44. The district specific sample sizes reduced further in case of further disaggregation such as district by land categories etc. Therefore, it is difficult to generate reliable district level direct survey estimates with associated standard errors from this survey. This small sample size problem was resolved by using small area estimation (SAE) approach. District-wise estimates of MPCE were also obtained for both rural and urban sectors of Uttar Pradesh using SAE method. District-wise maps of average household MPCE (living condition) for both rural and urban sector of Uttar Pradesh were also produced. The results clearly indicated the disparities within the state with respect to different household categories. The results also identified the regions and household categories with low and high MPCE estimates.

Developing state level estimates of crop area and production: A suitable sampling methodology for producing state level estimates of crop area and yield on the basis of sample sizes recommended by Professor Vaidyanathan Committee to generate quick estimate of crop area and yield was developed. Mobile Assisted Personal Interview (MAPI) software was also developed for collection of survey data using android smart phones in addition to traditional Paper Assisted Personal Interviewing (PAPI). Pilot survey was implemented in five states. viz. Assam, Odisha, Uttar Pradesh, Karnataka and Gujarat. The analysis revealed that MAPI is more efficient than PAPI both in terms of time and accuracy. The empirical results further revealed that sample size recommended by Committee was reasonable to provide the district level estimates of crop yield, and the estimates were comparable with those generated through general crop estimation survey with larger sample size.

Integrated sample survey solutions for major livestock products: Towards providing integrated sample survey (ISS) solutions for major livestock products, a web portal, **ISS Web Portal** (https://iss.icar.gov.in) was developed for milk, meat, egg and wool with three modules, viz. sample selection module, data entry and analysis module, and GIS map module.

ISS Web Portal – Home/Login

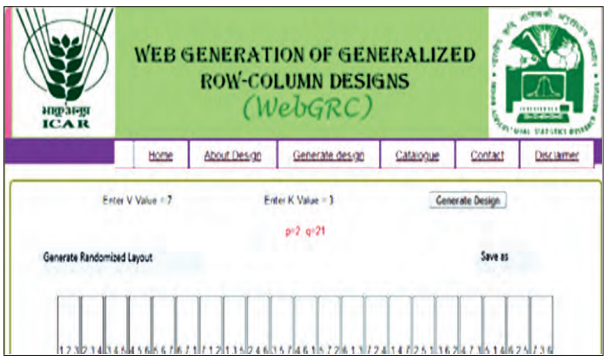
Sample selection module is fully functional which allowed states to draw sample for complete enumeration and detailed survey for all three seasons (summer, rainy and winter) in a year according to the ISS methodology for estimation of production and number of all four livestock commodities (milk, meat, egg, wool).

R-packages developed: Following R-packages were developed (i) **OGS**: Outlier in Genomics Data, GitHub repository (https://github.com/BudhlakotiN/OGS); (*ii*) **EDI**: Calculation of Effective Drought Index (EDI), GitHub repository (URL: https://github.com/rrk4910/EDI); (*iii*) **IGST**: Informative Gene Selection Tool (https://CRAN.R-project.org/package=IGST); (*iv*) **PredCRG**: for prediction of circadian proteins encoded by circadian genes (https://cran.r-project.org/web/packages/PredCRG/index.html); (*v*) **BayesARIMA**: to estimate the ARIMAX model using Bayesian framework (https://CRAN.R-project.org/package=BayesARIMAX); (*vi*) **varEst**: to estimate error variance of fitted genomic selection models from ultrahigh dimensional genomic datasets (https://CRAN.R-project.org/package=varEst); (*vii*) **GSelection**: contains seven functions to select important genetic markers and predict phenotype on the basis of fitted training data using integrated model framework (https://CRAN.R-project.org/package=GSelection); (*viii*) **STGS**: genomic selection using single trait using whole genome markers information to predict genetic merit of individuals in a practical breeding programme (https://CRAN.R-project.org/package=STGS); (*ix*) **MTGS**: genomic selection using multiple traits for genomic predictions by estimating marker effects (https://CRAN.R-project.org/package=MTGS).

For dissemination, e-learning and e-advisory in designed experiments, strengthened the Design Resources Server (https://drs.icar.gov.in) and other web resources.

Developed following web resources as R Module for (*a*) Construction of Orthogonal and Nested Orthogonal Latin Hypercube Designs (http://drsr.icar.gov.in/OLH/) consisting of four different modules for generation, viz (*i*) 1st order OLH design, (*ii*) 2nd order OLH design, (*iii*) Nested OLH design, and (*iv*) OLH design with good space filling property; and (b) Incomplete Split Plot Designs: Construction and Analysis (http://drsr.icar.gov.in/ISPD/). This web service gives facility to construct an incomplete split plot designs for three situations namely (*i*) when blocks are complete with respect to whole plot treatments and whole plots are incomplete with respect to subplot treatments, (*ii*) when blocks are incomplete with respect to whole plot treatments and whole plots are complete with respect to subplot treatments, and (*iii*) when blocks are incomplete with respect to whole plot treatments, and whole plots are incomplete with respect to subplot treatments. There is also facility to analyse data from experiments conducted using each of the above three types of incomplete split plot designs.

Developed a module for online generation of Generalized Row-Column Designs (WebGRC). Computer modules for generating four series of structurally incomplete GRC designs along with randomized layout have been developed.



Screen-shot of web generation of Generalized-Row-Column-Designs

Comparative analysis of publications in Web of Science: A comparative publication analysis of ICAR vis-à-vis CIMMYT, IRRI, ICRISAT, INRAE, France; CAAS, China; EMBRAPA, Brazil; AAFC, Canada and CSIRO, Australia during 2010–2019 was carried out using the data retrieved from Web of Science Core Collection Citation Indexes (http://webofknowledge.com) as on 16.04.2020 and 29.05.2020. The report consisted of number of publications, average citations, h-index year-wise as well as for two quinquennial periods (2010–14; 2015-19). The number of publications with at least 100 or 50 citations was obtained. This also includes comparison (*a*) based on 500 most cited papers each year, 1,000 most cited papers and 2,025 most cited papers; (*b*) Average citation(s) per publication of (*i*) 2,000 publications by taking 200 most cited papers per year; and (*ii*) 5,000 publications by taking 500 most cited papers per year. The study was carried out by ICAR-IASRI and ICAR-NAARM jointly.

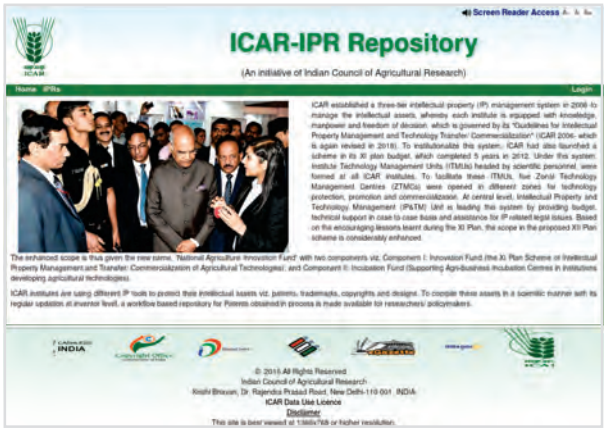
ICAR research data repository for knowledge management: KRISHI-Agricultural Knowledge Resources and Information System Hub for Innovation portal is serving as a gateway to online resources available at different ICAR Institutes to enhance visibility and easy access of digital outputs of ICAR to stakeholders.

Developed CMS based website of (1) AICRP on Arid Zone Fruits (https://aicrp.icar.gov.in/azf/); (2) AICRP on

Potato (https://aicrp.icar.gov.in/potato/); (3) AICRP on Pesticide Residues (https://aicrp.icar.gov.in/Pesticide/) (4) All India Network Project on Soil Biodiversity Biofertilizers (https://aicrp.icar.gov.in/Biofertilizers); (5) AICRP on Biological Control of Crop Pests and Diseases (https://aicrp.icar.gov.in/biocontrol/); (6) AICRP on Medicinal and Aromatic Plants including Betelvine (https://aicrp.icar.gov.in/map/); (7) All India Network Project on Honey Bee Research and Training (https://aicrp.icar.gov.in/honeybee/); and (8) All India Coordinated Research Network on Potential Crops (https://aicrp.icar.gov.in/potentialcrop/); (9) AICRP on Tobacco (https://aicrp.icar.gov.in/tobacco/); (10) AICRP on Groundnut (https://aicrp.icar.gov.in/gnut/); (11) AICRP on STCR (https://aicrp.icar.gov.in/stcr/); (12) AICRP on Nematode (https://aicrp.icar.gov.in/nematodes/); (13) AICRP on Agroforestery (https://aicrp.icar.gov.in/Agroforestry/); (14) AICRP on Goat (https://aicrp.icar.gov.in/goat/); (vii) AICRP on Castor, Safflower and Sunflower (https://aicrp.icar.gov.in/css/); and hosted on KRISHI Portal.

Information systems for AICRPs: Developed Information System for (*i*) AICRP on Pearl millet and (*ii*) AICRP on Castor, Safflower and Sunflower; (*iii*) AICRP on Small Millets to plan and design experiments, generate data, analyze data and prepare report of AICRP experiments. It is also useful for creation of research data repository and standardization of analysis and reporting of experiments.

ICAR IPR repository: ICAR institutes are using different IP tools to protect their intellectual assets, viz. patents, trademarks, copyrights and designs. To compile intellectual assets in a scientific manner with its regular update at inventor level, developed an integrated workflow based application on Patents, Copyrights and Varieties registered with PPVFRA.



Spatial meta data repository: Geospatial Metadata consists of metadata elements of spatial data in a documented and structured format. Geo-spatial metadata provides the geospatial data producers with the format and content for properly describing their data, allowing users to evaluate the usefulness of the data in addressing their specific needs. Geo-spatial metadata serves two major purposes both for the spatial data generator and for the spatial data user. For the generator, the metadata provides a framework to document the spatial data and declare its content for users. For the user, metadata serves many important purposes, including finding the spatial data as per need; browsing spatial data; deciding on whether the spatial data will meet the application needs and finding how the spatial data can be accessed. Developed a workflow based application for geo-metadata.

ICAR video and audio gallery

For providing single window access of all the videos, audios, mobile apps of ICAR institutes, developed version 2 of (*i*) ICAR Video Gallery, (*ii*) ICAR Audio Gallery and (*iii*) Mobile App Galleries separately using Angular JS with CAS Spring web App and hosted at https://krishi.icar.gov.in/video; https://krishi.icar.gov.in/audio and https://krishi.icar.gov.in/mobileapp/ respectively. At present 2000+ videos, 70+ Audios and 250+ mobile apps are available in this gallery. Search can be made using keyword(s) or SMD, institute and language with drop down filters. Links of the videos of CG Centres; AAFC, Canada; CAAS, China; Emprapa, Brazil, INRAE, France; CSIRO, Australia; DD KISAN; KRISHI Darshan, etc. are also provided on this gallery.

Academic management system (AMS): Academic Management system (AMS) Version 2.0 was developed and customized under the NAHEP Component 2 for its implementation at various agricultural universities. It is a web enabled system for management of all the various academic activities of a university. The system caters to the needs of different users: Dean, Registrar, Professor, Head, Guide, Faculty, Teacher, Student, Administrators and Officials for performing their assigned tasks. The system was designed in a modular approach with in-built work flows. System ensures that the individuals responsible for the next task are notified and receive the data they need to execute at their stage of process. At present five modules were envisaged, viz. Student Management, Faculty Management, Course Management, Administration Management and E-Learning. Thus, AMS facilitates in automation of various academic processes of the University and enhances the transparency and efficiency of the overall system by saving time and efforts involved in manual processes. At present, the system is operational in 30 agricultural universities and implementation was initiated in another 22 universities.

KRISHI-MEGH (NARES Cloud Infrastructure and Services): With the endeavour to modernize and digitize the agricultural sector in the country, the National Agricultural Research and Information System- Cloud Infrastructure and Services named KRISHI-MEGH was initiated. This platform is established by ICAR-IASRI under the ICAR-World Bank's National Agricultural Higher Education Project's (NAHEP) with the core objectives of improving access of agricultural universities to the ICAR Data Centre using sophisticated IT solutions.

KrishiMegh was strategically established at NAARM, Hyderabad, due to its suitable geographical and climatic disposition. KrishiMegh integrates the ICAR Data Centre at ICAR-Indian Agricultural Statistics Research Institute (IASRI), New Delhi with the Disaster Recovery Centre at the ICAR-National Academy of Agricultural Research Management (NAARM), Hyderabad. The platform is equipped with latest Artificial Intelligence (AI)/Deep-Learning Software/toolkits that enable development and execution of deep learning-based applications for agricultural research and development in the country.

Union Minister of Agriculture and Farmers Welfare launched KrishiMegh. The platform was well received, and is also in consonance with the New Education Policy 2020 that beckons provision of relevant and high-quality educational resources to Agricultural University students in India.

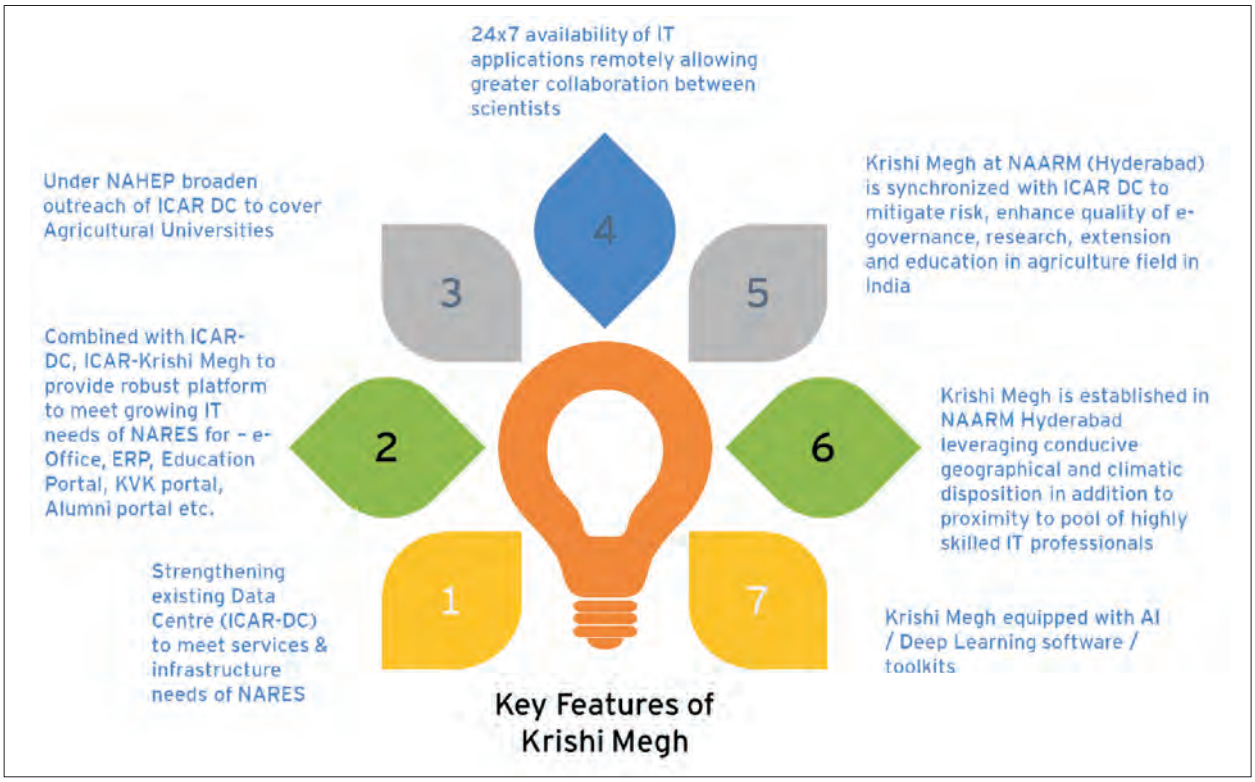
Krishi Vishwavidyalaya Chhatr Alumni Network– KVC ALUNET: Krishi Vishwavidyalaya Chhatr Alumni Network– KVC ALUNET was developed by ICAR-IASRI under NAHEP-component-2. This digital alumni platform will foster the development of a vibrant multicultural Alumni association wherein alumni can contribute towards strengthening their existing networks, interact in real time and participate in university level events.

KVC ALUNET was established to facilitate alumni from 74 agricultural universities onto a common platform. Furthermore, this platform will help current students' network with alumni for internships and placements. Finally, the platform will allow alumni to explore various on-going research activities and collaborate with faculty and students. KVC ALUNET has the potential to strengthen the network of agri-practitioners, researchers and students through the positive power of digital technology. It can promote greater access to resources and increase equity especially with respect to student employment. The platform can be access on http://alumni.icar.gov.in.

Accreditation portal for higher agriculture education institutions (HAEI): A national platform for accreditation of HAEIs was developed by ICAR-IASRI under NAHEP-component-2 to allow HAEIs apply for ICAR accreditation online. This portal will allow both government and private HAEIs to apply for accreditation online. This is an important development in agricultural education provisioning in the country. The portal will facilitate improvements in quality education by enabling universities and colleges to comply with specific norms and regulations, prescribed by ICAR. Moreover, the portal itself will ensure smoother transactions during the process of accreditation, in turn fostering time efficiency, transparency and greater accountability.

Any HAEI wanting to become accredited by ICAR will have to first submit a Letter of Intent (LOI) along with Institutional Eligibility for Accreditation (IEA) and Statement of Compliance (SoC) to the National Agricultural Education Accreditation Board (NAEAB) Secretariat. Next, once these documents are accepted, the HAEI will be requested to submit a Self-Study Report (SSR) to the respective Regional Centre of NAEAB through the portal. Regional Centres will examine SSR to determine compliance with NAEAB guidelines. Upon receiving a satisfactory assessment by the Regional Centre, the HAEI will be accredited by ICAR.

Online agricultural university ranking system: In line with the National Initiative on Ranking of Indian



Institutions, ranking of agricultural universities was initiated by ICAR with a larger objective to drive the universities towards improving quality standards and enhance their visibility to enable them for participation in global rankings. The ranking status allows the students to make informed choices for university placement. Further, the ranking process is expected to help the universities to self-assess themselves on the quality and enhance their abilities. It also tends to improve healthy competition among universities.

So far, the ranking has been done for the last three years based on the information received from the universities in the prescribed Performa through hard copies. In view of the COVID-19 pandemic situation, it was decided to obtain the required information from the universities through online. Accordingly, an Agricultural University Ranking System (AURS) was developed by ICAR-IASRI, New Delhi to enable the submission of the required data by the universities and the evaluation/ verification by the Committee through online. Further, the uploaded information shall be made available in the public domain for bringing transparency to the entire ranking process. AURS can be accessed at https:// education.icar.gov.in/auranking/.

E-office implementation at ICAR institutes: E-office, an online solution to increase the efficiency and transparency of day to day working was implemented at all ICAR institutes. The e-Office system is hosted at ICAR Data Center, ICAR-IASRI as a single instance for all 113 institutes.

The single instance facilitates seamless movement of files between ICAR Hq. and all ICAR institutes. Trainings in online and offline mode were imparted to all ICAR institutes for the development of Employee Master Data as well as for File Management modules. Nodal Officers were nominated by each institute to implement the e-office in their institutes. A help desk team at ICAR-IASRI was established that supports the overall implementation of e-office and takes care of server side and security issues. The e-Office contributed significantly during the COVID-19 pandemic situation especially during the lockdown phase, as it allowed all the employees to work from their home and as a result work could be done in time.

Wheat drought root transcriptome database (WDRoTDb): Computational approach for genomic resource improvement and precision phenotyping of less explored yield traits in wheat was attempted. Two contrasting genotypes, viz. NI5439 41 (drought tolerant) and WL711 (drought susceptible) were used to generate ~78.2 GB data for the responses of wheat roots to drought. For effective future use of findings, web genomic resource, wheat drought root transcriptome database (WDRoTDb) was developed (http://webtom.cabgrid.res.in/wdrotdb/). WDRoTDb will serve as valuable resources for new genes discovery as well as developing SSR markers.

Bioinformatics Web-server/Web-tools/Database/ tools developed

FMDISC (http://bioinformatics.iasri.res.in/fmdisc/team.php): Developed a database which is an information system on Foot and Mouth disease of cattle.

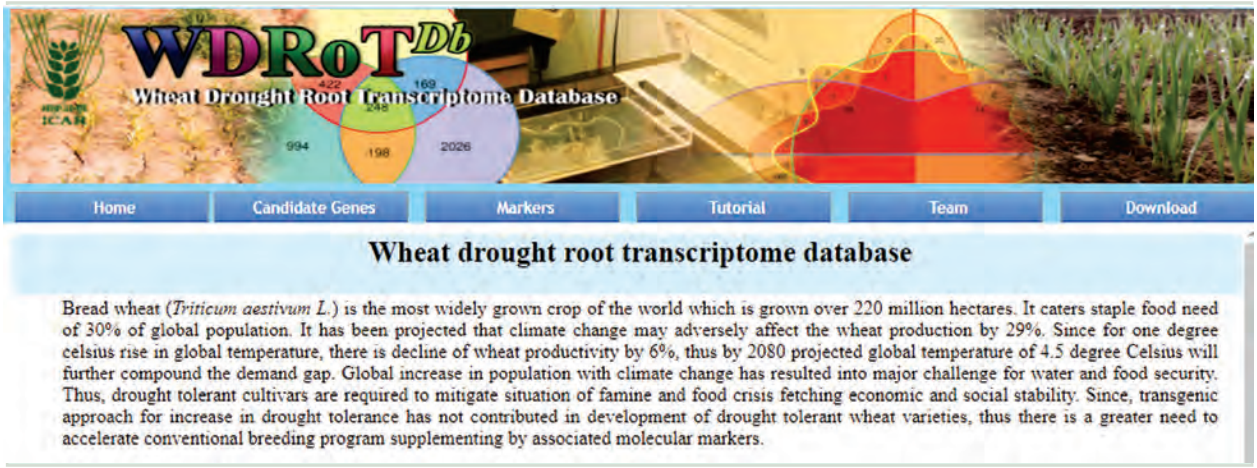
WBMSTDb (http://webtom.cabgrid.res.in/wbmstdb/): Developed Water Buffalo Mastitis Database. This web resource catalogues the information of mastitis associated genes, their annotation, functions, pathways, SNPs and INDELS in buffalo.

ASRpro (https://github.com/meher861982/ASRpro): A supervised learning based methodology named **ASRpro** for multi-label prediction of abiotic stress responsive proteins was developed.

GIpred (http://cabgrid.res.in:8080/gipred/): A machine learning-based method for prediction of GIGANTEA proteins was developed. Based on the proposed model, the web server "**GIpred**" was established.

Mobile App developed

IVRI-Zoonoses-App: This app aims at providing basic information about important zoonotic infections including their modes of transmission, symptoms, prevention and control measures. The list of national disease control programmes w.r.t. zoonotic diseases was also included along with the list of notifiable diseases in animals. This app will be useful to students of veterinary



and medical degree programmes, practicing veterinarians, health care workers and general public.

IVRI-Veterinary Clinical Care-App: This app targets to impart knowledge and skills to Graduating Veterinarians and Field veterinary Officers about most frequent clinical conditions encountered in field conditions related to medicine, gynecology and surgery. The App covers information about each of these conditions under the various subheads, viz. About, Symptoms, Diagnosis, Treatment and Prevention, and Control.

Mobile App for ICAR-Technologies: Technology Mobile App developed based on the Technology Repository which consists of proven technologies/ methodologies generated by ICAR institutions. The mobile app provides the information on the selection on commodity, major resource, technology group and technology related particular field. It also provides search facility based on key word. More than 1,270 technologies are available in open access.

WOMEN EMPOWERMENT

ICAR-Central Institute for Women in Agriculture (ICAR-CIWA) is an institution first of its kind in the world that is exclusively devoted to gender related research in agriculture. ICAR-CIWA has a mandate of undertaking research on gender issues in agriculture and allied fields, gender-equitable agricultural policies/ programmes and gender-sensitive agricultural-sector responses and co-ordinating research through its AICRP centres spread across 12 states in India. The Institute's primary activities include standardization of methodologies for livelihood analysis and developing vulnerability framework for farm women, community and NRM based technological interventions for livelihood security, skill and entrepreneurship development of women, management of operational drudgery for farm women and striving for food and nutritional security of farm families including water, health and sanitation.

Extension systems, grass-root institution and capacity building: The institute has taken an initiative to develop the technology hub and gender sensitization micro-lab to highlight the contribution of women in agriculture, work participation and malnutrition scenario, photo gallery of rural women, daily activity clock, women centric government initiatives, technologies in drudgery reduction and success stories through Voice of Women. Designing and development of Gender Sensitive Agri-Nutri (GSAN) farming system model was undertaken and it could be observed that most of the problems were related to state departments, hence, it is suggested that necessary policy measures may be taken up by the government to address the farm women's problems and issues. A gender-sensitive model for doubling farmers' income was evolved by addressing gender concerns and technological gap. A web based dynamic database was developed for generating data tables related to state-wise and district-wise gender work participation in agriculture. Female agriculture work participation (as percent of population) was calculated for all the 640 districts and thematic maps were generated using QGIS3.10. Thematic map for female agriculture work participation was overlaid with 15 agro-climatic regions (ACR) for analysing the spatial distribution of female agricultural workers across different ACR. Under the extramural research project on development of gender sensitive entrepreneurship model, three major sectors, viz. horticulture, dairy and farm implements for establishing institute-industry-women farmers' linkage were identified and a survey of participating 100 farm women from each sectors was conducted on their role performance, needs, perceptions to understand the women and gender issues in selected agro-based industries.

Livelihood and socio-economic policy for food and nutritional security: With an aim to develop gender sensitive model for doubling farmers' income, technological and developmental gaps were analysed by experts and logical technological modules were designed. The need based modules were demonstrated through training, demonstrations, capacity building programmes, input support and advisory services, promoting high yielding varieties and hybrids through 16 programmes covering 125 farm families. Nutritional interventions for enhancing the protein consumption of farm families of Semla village of Umarkote Block, Nabrangapur, an aspirational district was made by introducing the cultivation of high yielding variety of black gram PU 31 to capitalize on the residue moisture available after paddy cultivation as paira cropping. The intervention had a positive impact on the Chronic Energy Deficiency where it showed a decrease to the tune of 4.53% and 6.59% in women and men, respectively. To improve women's health condition involved in household chores, terafil water filter and smokeless *chulhas* were also distributed. To understand the impact of establishment of milk producers' cooperative, Khalagaon Milk Producer Co-operative Society (MPCS) was selected and its activities were analyzed and mapped. The Khalagaon MPCS has a total of 161 members of which only 10 were female. The society generated revenue of ₹ 62.76 lakh for its members by collecting 2.37 lakh litres of milk (2018–19). On an average, the members earned ₹ 5,082/month. The average milk price was ₹ 26.48/litre.

Under the IRRI-CIWA collaborative project, 8 producer groups mobilizing 1,000 women farmers processed and marketed aromatic rice through Chitri Dora farmers Producer Company in Koraput district of Odisha. Under the DSIR funded project on adding value to fish, consumer perception on value added products (VAP) were studied by conducting a survey of 150 urban consumers of Odisha. Thirty per cent consumers opined that they are willing to buy VAP products of fish if they are available in prices comparable to that of chicken/veg products. Perceived occupational needs of fisherwomen were studied through survey of 200 fisherwomen selected from 20 different SHG groups from Astaranga and Puri

Sadar blocks of Puri district, Odisha, in which credit was noted as the most important need by 100% women. Recipes of prawn pickle and other value added fish products were standardized. Market link developed for the brand Fishlikes prepared by women SHG groups. The penetration of the product into the market growing with sales through 4 falcon fresh stores and local shops. women getting a profit of ₹ 130–150/kg of pickle. The ICAR-CIWA facilitated for procurement of FSSAI license and GST and also trade license from Bhubaneswar Municipal Corporation under the trade name Fishlikes.

Technology assessment and refinement: Various intercropping models suitable for mango orchards were demonstrated in a participatory mode to cater to the financial and nutritional requirements of 55 farm families in 2 villages of aspirational district Mayurbhanj. A sustainable livelihood index was developed in which pineapple as intercrop got the highest score (86.6). Pineapple proved to be the best intercrop in terms of environmental conservation, input recycling, employment generation and income enhancement. A field study was conducted to assess the effect of critical supplementation of mineral mixture in lactating crossbred and it resulted in improved milk yield by 14.5% with significantly enhanced reproductive efficiency. The net return over feed cost and feed efficiency was improved by 21 and 12% in mineral supplemented group, respectively. A similar study was conducted in goats which resulted in improved number of services per pregnancy, reduced post parturient complications predominantly abortion (30%), retention of placenta and dystokia (10%) in mineral mixture supplemented group.

The analysis of gender roles and needs in the homestead aquaculture was analysed and social acceptance, support from counterpart/ family members, technological knowhow on polyculture of small indigenous fishes with Indian major carps, timely availability of quality seed and availability of credit were perceived as most important by all the women farmers. In polyculture of Indian major carps with small indigenous fishes, an average production of 298.2 kg of IMC was obtained from 0.17 ha water area (which was around 80–130 kg/0.17 ha prior to project) and a net profit of ₹ 20,560. On an average, 174 kg vegetables were harvested from the trellis system around ponds and pond bunds with a monthly income of ₹ 6,419 (pond area ranging from 0.08 to 0.22 ha). Women friendly gill nets introduced to facilitate regular biweekly harvesting of small indigenous fishes resulted in a harvest of 200–750 g/15 days which was entirely used for home consumption. A study was conducted to study the effect of supplementary feeding on production performance of Vanaraja laying hens and income of farm women reared under extensive system of production. Supplementary feeding @ 35 g/bird/day during 16-40 weeks of age resulted in significantly higher egg production and egg size. Calculating the feed cost at ₹ 20/kg, the net return was higher by ₹ 1,790 per beneficiary (n=20) due to supplementary feeding. A family poultry production model was developed for enhancing income and improving nutrition security of farm families through working with a cluster of 40 farm families in Chanrapada and Parichanrapada villages of Nimapada block of Puri district, Odisha.

Drudgery and vulnerability: The existing technologies related to fish processing developed by ICAR and other national institutions were documented and also assessed the gender based drudgery prone activities, testing the solution through available/ refined technologies in fish processing. Drudgery experienced by women was assessed on a 5 point scale, with the highest score given to drudgery experience during marketing of fish (28.01). Two model prototypes of disc ridger based on the anthropometry and strength of farm women were developed and tested. As a part of livelihood improvement of tribal farm women through secondary agriculture, technological interventions in the processing of ragi, mango, tomato and cashew nut was given to tribal women of Ganjam district and a schematic model for establishing small scale enterprise was developed.

Under the collaborative project of ICAR-CIWA and Mahindra and Mahindra, custom hiring centre was set up by the cluster or village level organization in 42 villages in districts Mayurbhanj and Koraput. On-farm skill demonstration through resource farmers, refresher trainings at cluster level, interactive session with scientists, exposure visits and linkage with service/ repair centres was imparted by ICAR-CIWA. Drudgery reducing tool kits were distributed to 360 women farmers and effectiveness was also studied. Under AICRP on Ergonomics and Safety in Agriculture, a pre- and post-perception study, physiological test and postural analysis was done for newly developed harvest bag. Performance evaluation and economic analysis of the women friendly power operated groundnut stripper-cum-decorticator showed stripping output capacity of 12.12 kg/h, reduction in stripping cost of ₹ 0.37/kg compared to manual stripper and 50% reduction in cost of equipment as compared to existing decorticator which performs only one operation. A questionnaire to develop a scale for assessing level of mechanisation among farm women was developed.

All India Coordinated Research Project (AICRP) on Home Science: The research projects under AICRP on Home Science were carried out through five components within the micro and macro ecosystems to bring about qualitative changes in family life of rural households. A total of 362 foods from different food groups having low Glycemic Index (GI) were documented and a database on low GI foods for the management of diabetes was prepared which were effective in maintaining blood sugar levels within normal levels and in reverting pre-diabetic status. The products of high fibre multigrain mix were formulated from locally available functional food ingredients for management of over nutrition/obesity. Region specific nutri-dense ready to use mix with focus on high calorie, high protein and micronutrient rich, Convenience mix was developed from locally available food systems for management of under nutrition. The nutridense food mix products increased the body weight of experimental group. Two MoUs were signed for commercialization of high fibre food mix. A mobile app on diet for diabetic persons was developed by AAU, Jorhat Centre.

An effort was made to design and develop products for various end uses using locally available underutilized fibres under textile component. Products of the eco-based fabric such as clothing and gadgets for sportech, hygiene products were designed, developed and evaluated for functional performance and found that treated fabrics have no adverse effects on wearers. A patent on Biodegradable Mesta Composite Pots for Nurseries invented by AICRP on HS, UAS, Dharwad, was filed and published. A study on promoting Farm Women Knowledge Groups (FWKGs) for enhanced use of ICT in agriculture and allied sectors was undertaken and to enhance the use of ICT tools in these activities, capacity building programmes organized, intervention packages were validated and tested for their effectiveness. Based on the constraints faced by the farm women due to the effects of climate change, different region specific climate interventions were provided.

Drudgery was characterized and field trials were conducted for promotion of gender friendly technologies in different production systems. Fifty one (51) improved technologies were recommended for farm women in 11 production systems, which can enhance the production and efficiency and reducing drudgery. Ergonomic assessment was carried out in different selected agro enterprises, where the extent of involvement of women was significant. Twenty one (21) technologies were developed for reduction of drudgery of women workers in the selected enterprises. A package on Reproductive health care for psychological wellbeing of married women, was developed. For development of Parenting Index for Rural Families (PIRF), data were collected from 6,428 families by considering different parameters analysed for making Index. Effect of parenting practices on developmental outcomes of the children was also assessed. A mobile app on parenting was developed by UAS, Dharwad Centre and another mobile App on Menopause and Health was developed by CSKHPKV, Palampur Centre.

❑

"हम आधुनिक वैज्ञानिक तरीके से खेती करना शुरू करें तो हम देश की अर्थव्यवस्था को भी बहुत बड़ा बल दे सकते हैं।"

— नरेन्द्र मोदी

13. Information, Communication and Publicity Services

The Directorate of Knowledge management in Agriculture (DKMA) is mandated to showcase ICAR's technologies, policies and other activities through state of the art dissemination methods that cater various stakeholders in the field of agriculture. In the fast changing knowledge intensive era, the DKMA is committed to promote ICT-driven technology and information dissemination system for quicker and more effective out reach. The ICAR-DKMA publishes periodicals, books, handbooks, annual reports, newsletters, bulletins, monographs, e-books, media columns, social media contents, advisories, etc. The knowledge banks are available in open access as well as in closed access models to the stakeholders in agriculture. ICAR-DKMA has already taken steps to disseminate knowledge by using up-to-date most popular ICT tools for benefitting the national as well as global agricultural world. The Directorate makes sincere efforts to take the knowledge through mass media for enhancing the knowledge of the people. ICAR-DKMA maintains knowledge in the Consortium of e-Resources in Agriculture (CeRA), Library Management and Open Access National E-Library on Agriculture (e-pubs).

Knowledge and information products

The Indian Journal of Agricultural Sciences and *The Indian Journal of Animal Sciences*, the prestigious monthly research journals with international impact factor are available in the open access mode (http://epubs.icar.org.in/ejournal). The in-house publications like *ICAR Reporter* and *ICAR News* are also available on ICAR website for wider global reach. These are viewed in about 140 countries the world over. The popular periodicals like *Indian Farming* and *Indian Horticulture* in English and *Phal Phool* and *Kheti* in Hindi were brought out to disseminate up-to-date knowledge and technologies to the stakeholders involved in agricultural production and processing in the country and at global level having similar climatic conditions and geographical similarities.

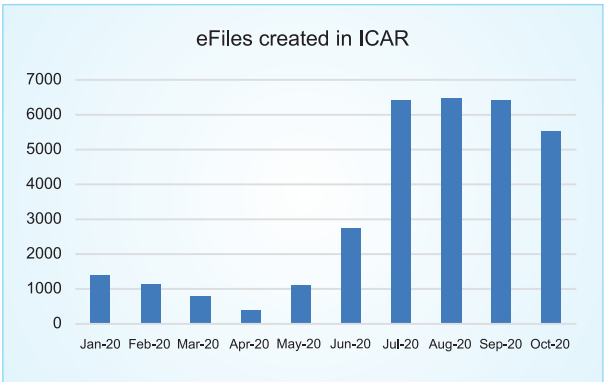
The Business Unit is playing a pivotal role in revenue generation for Directorate of Knowledge Management in Agriculture by adopting new marketing strategies. This Unit is responsible for distributing important publications like *DARE/ICAR Annual Report, ICAR Budget Book, ICAR Reporter*, *ICAR News* and other important publications to all the officers of ICAR Institutes, Project Directors, Co-ordinators, Vice-Chancellors, SAUs, NGOs, Scientists, Extension Workers, Members of Parliament and other important dignitaries regularly. Apart from this, the unit is responsible for taking initiatives for marketing and timely distribution of monthly magazines/journals namely *Indian Farming*, *Kheti*, *The Indian Journal of Agricultural Sciences* and *The Indian Journal of Animal Sciences* and bi-monthly popular magazines *Phal Phool* and *Indian Horticulture* to the subscribers and stakeholders. DKMA could not organize/participate in any exhibition for showcasing ICAR technologies and publications due to COVID19 pandemic during the period April to December 2020. Achieved the revenue of approximately 21 lakh from the sale of publications and e-products during the year April to December 2020.

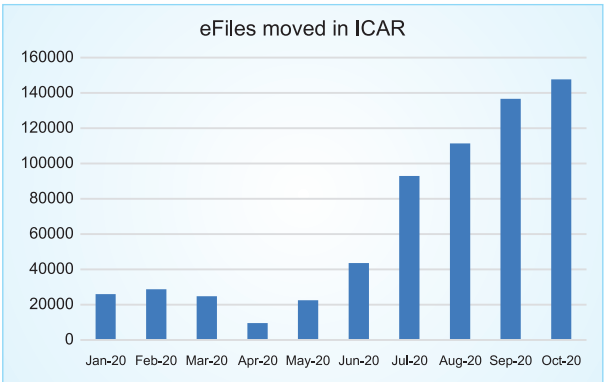
Social media

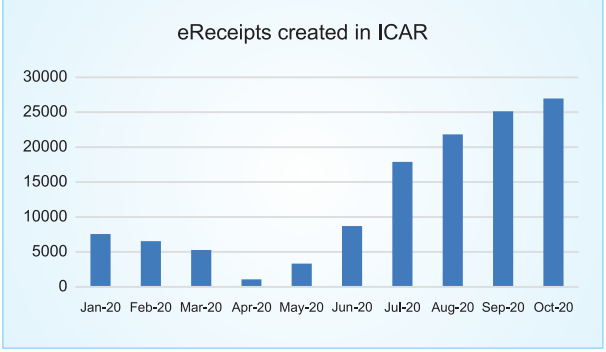
In order to disseminate information in real-time and also the last time, the ICAR website is updated on regular basis, and in total 3,965 pages were updated, and page-views 7,284,515 from more than 200 countries. Knowledge seekers across the globe visited the website. The top five countries visiting the website include India, United States of America, United Kingdom, United Arab Emirates, and Nepal. On ICAR facebook total 399 posts were published and it has 220,207 followers. ICAR twitter handle https://twitter.com/icarindia has more than 120,970 followers. On an average one tweet is posted every day, there are total 409 tweets. The YouTube Channel of ICAR has video films, animations, lectures/interviews by dignitaries and eminent scientists, proceedings of national and international events, etc. It has 54,800 subscribers.

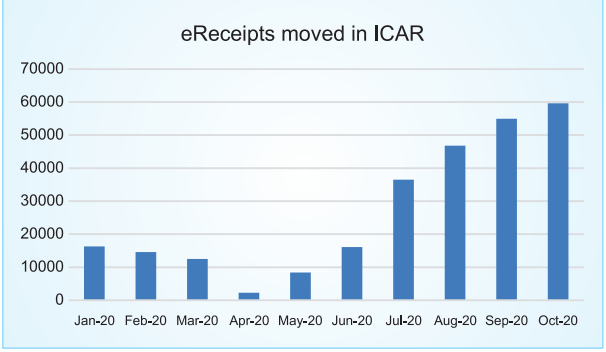
ICT and E-Governance in ICAR

The ICT Roadmap of ICAR was prepared for development and implementation of various software, IT tools, databases and e-Governance software in line of Digital India Mission of the country. This ICT roadmap envisaged short term and long-term ICT/IT activities which is needed for undertaking ICT/IT projects based on disruptive ICT technologies such as Precision Agriculture, Dynamic Decision Support and advisory system, e-governance software using AI, DL, ML, block chain and big data analytical techniques. This will not only help in increasing farmer's income through increasing agricultural productivity by use of optimum agricultural inputs but also help for smooth functioning of the Council. In this ICT roadmap, five functional groups were created to cater different ICT/IT development and implementation requirement of different databases/software/tools/mobile and Web services. Also, in order to implement this roadmap, a separate IT unit was created in ICAR-IASRI, New Delhi. Further, e-Governance Division of ICAR Headquarters was renamed as ICT Unit. This ICT Unit of ICAR



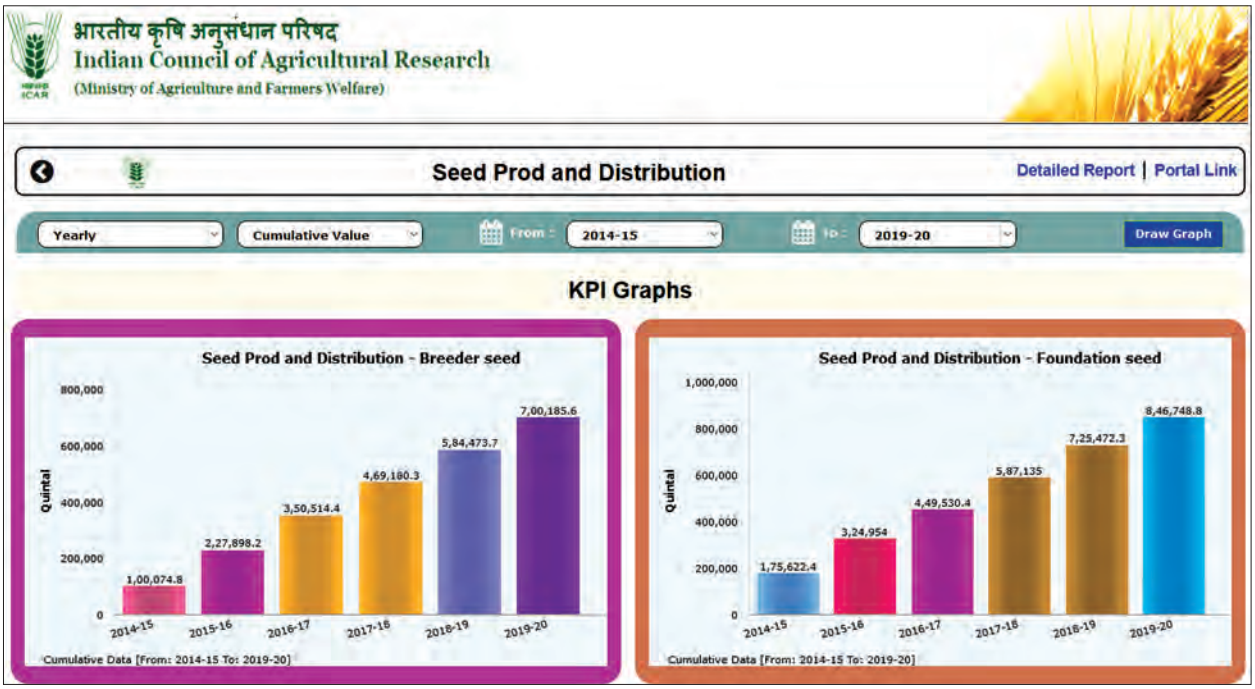


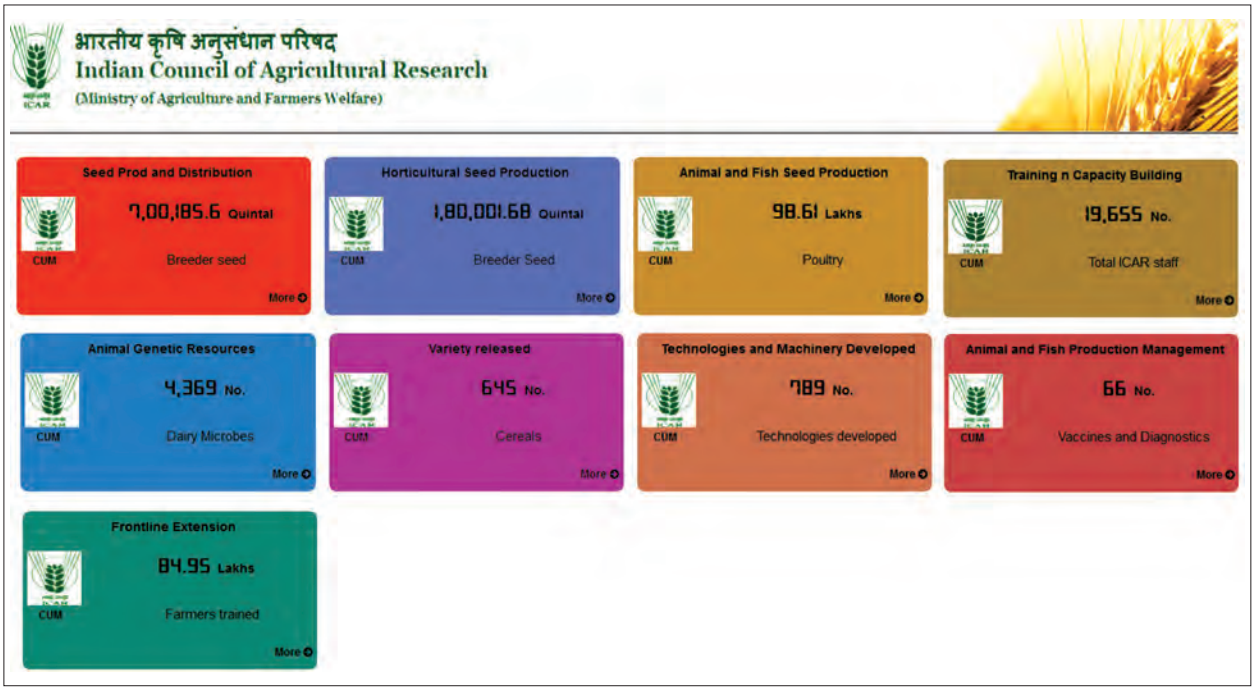




Headquarters was further strengthened by merging Agriculture Knowledge Management Unit (AKMU) of ICAR Headquarters. In order to make paperless/ environmental friendly office, e-office software developed by NIC was implemented across 112 ICAR Institutes along with their Regional Stations/Sub-Stations in the country by 15 July 2020. This is not only a major step forward of the Council towards National Digital India Mission but it also brought more efficiency, transparency, accountability in the overall working of the Council for agricultural research and development. This e-office platform, which is being developed by NIC is implemented in the Council by hosting it in fully secured ICAR data center at ICAR-IASRI, New Delhi. There is more than 13 times increase in number of e-files created, e-receipt generated and movements of files/ receipts from January 2020 to October 2020 in all ICAR institutes.

A DARPAN Dashboard was developed by NIC and hosted on common framework in the Country. This





provides centralized, easy-to-access platform for display and access of data from multiple sources. In this Dashboard, Manual/real time data on Key Performance Indicators (KPIs) is presented for selected Schemes/ Projects in tabular as well as in graphical form which indicates (*i*) success, (*ii*) helps in policy formulations and (*iii*) identification in areas for improvement by implementing Department/Agency. It has major analytical capacities including drill down/rollup both in tabular and graphical format. It is accessible through Web on any browser and device. An Integrated dashboard of ICAR was developed (https://icar.dashboard.nic.in) under nine different themes (*i*) Crop Seed Production and Distribution, (*ii*) Horticultural Seed Production, (*iii*) Animal and Fish Seed Production, (*iv*) Training and Capacity Building, (*v*)Animal Genetic Resources, (*vi*) Variety released, (*vii*) Technologies and Machinery developed, (*viii*) Animal and Fish Production Management, and (*ix*) Frontline Extension.

Apart from this**,** the National Career Service (NCS) portal (www.ncs.gov.in), an integrated platform to connect career opportunities with aspirations of the youth developed by Directorate General of Employment, Ministry of Labour and Employment, was implemented in all ICAR institutes. The NCS portal brings together various stakeholders like Job Seekers, employers, government organizations, skill providers, career advisors, local service providers etc., to facilitate job postings, job search, shortlisting of candidates based on various parameters like qualification, college, city, state etc. Further, in Personal Management System (https://pms.icar.gov.in/) of ICAR recent transfer policy was implemented and it is open for transfer of scientists within ICAR institute. This makes the transfer of scientist based on objective criteria and it is completely transparent and highly efficient. Also, now scientist can seek direct transfer at different Regional Station of ICAR institute. Further, implementation of Learning Management System (LMS) (https://icar.lms.gov.in) and DigiLocker developed by MeitY were initiated in the Council in related institutions. Also, due to COVID-19 pandemic situation, different meeting and conferences were organized using ICT through Virtual Meeting Tools. ❑

"सूक्ष्म सिंचाई से जल संरक्षण और 'प्रति बूँद अधिक फसल' की परिकल्पना के साथ-साथ किसानों की आय में वृद्धि संभव।"

— नरेन्द्र मोदी

14.

Technology Assessment, Demonstration and Capacity Development

Krishi Vigyan Kendras (KVKs), part of frontline extension system, are mandated for technology assessment and demonstration for its application and capacity development under different farming situations across the country. During the reported year, 12 new KVKs were established taking the total number of KVKs to 722 in the country. Besides lab-to-land activities for outreach, important programmes such as Farmers FIRST, Attracting and Retaining Youth in Agriculture (ARYA), Cluster Frontline Demonstration of pulses and oilseeds, Cereal Systems Initiatives for South Asia (CSISA), National Innovations in Climate Resilient Agriculture (NICRA), Pulses Seed hubs, Mera Gaon Mera Gaurav and Awareness creation on government schemes, etc. were taken up to address various challenges of engaging youth in agriculture, brining self-sufficiency in production of pulses and oilseeds, sustainable agriculture, etc.

Technology assessment

Technology assessment is one of the main activities of KVKs to identify the location specificity of agricultural technologies developed by National Agricultural Research Systems (NARS) under various farming systems. The details of technologies assessed at different locations are discussed here.

Crops: A total of 5,421 technologies of various crops were assessed at 13,094 locations by KVKs through conduct of 25,357 trails on the farmers' field under different thematic areas, namely cropping systems, drudgery reduction, farm machineries, integrated crop management, integrated disease management, integrated nutrient management, integrated pest management, integrated weed management, processing and value addition, resource conservation technologies, seeds and planting materials production, storage techniques besides varietal assessment for cereals, pulses, oilseeds, fruits, vegetable and commercial crops. Varietal evaluation was the major theme of technology assessment with 1,442 technologies assessed through 5,550 trials. Other major themes on which technology assessment was made include integrated nutrient management (788 technologies, 3,169 trials, 1,852 locations) and integrated pest management (767 technologies, 3,070 trials, 1,924 locations).

Livestock: Under livestock, 1,034 technological interventions across 3,338 locations covering 5,156 trials on animals under the thematic areas of disease management, evaluation of breeds, feed and fodder management, nutrition management, production management, as well as processing and value addition were taken up for assessment. The major theme was Feed and Fodder Management with 202 technologies and 774 trials at 719 locations. The major livestock species covered were cow, buffalo, sheep, goat, poultry, pig and fish.

Other enterprises: Under other enterprises category, 363 technologies were tested at 1,172 locations through 2,971 trials. Major thematic areas under enterprises were mechanization, processing and value-addition, drudgery reduction, small-scale income generation, storage techniques, health and nutrition, energy conservation, household food security, organic farming, agro-forestry management and resource conservation technology. The major enterprises also included mushroom cultivation, vermi-compost production, processing of fruits and vegetables, nutritional garden and rural craft.

Women empowerment: Farm women related 280 technologies were assessed through 2,797 trials at 699 locations. Major themes under this category were drudgery reduction (technologies 92, trials 880, locations 126), and health and nutrition (technologies 59, trials 492, locations 74).

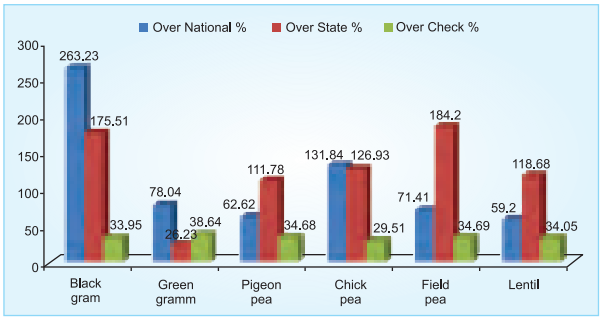
Frontline demonstrations

Cluster frontline demonstration

The Indian Council of Agricultural Research, New Delhi initiated national level Cluster Frontline Demonstration (CFLDs) on Pulses and Oilseeds with funding support from Department of Agriculture, Cooperation and Farmers' Welfare with main objective to demonstrate the production potential of new varieties and the related technologies. The project also aimed for enhancing the pulses and oilseeds production in the country.

Pulses: Out of a total of 23,245.00 ha area planned, 22,329.53 ha area was covered by conducting 60,166 demonstrations across the country. A total of 8,175.59 ha area (22,421 demonstrations) was covered in *kharif*, 10,834.04 ha area (29,440 demonstrations) in *rabi* and 3,319.90 ha (8,305 demonstrations) in summer season.

There was 263.23, 175.51 and 33.95% increase in yield over national average yield, state average yield and local check yield, respectively, in blackgram; 78.04, 26.23 and 38.64% in green gram; 62.62, 111.78 and 34.68% in pigeon pea; 131.84, 126.93 and 29.51% in chickpea; 71.41, 184.20 and 34.69% in fieldpea; 59.20, 118.68 and 34.05% in lentil; and 4.35, 77.90 and



Yield advantage through CFLDs on pulses over National, State and Check yield

37.72% in summer green gram under CFLDs on pulses.

Oilseeds: Out of a total of 13,543 ha area planned, 12,483.40 ha area was covered under 28,236 demonstrations across the country under CFLDs on oilseeds. Season wise, 4,475.30 ha area (11,504 demonstrations) were covered in *kharif*, 6,750.90 ha area (13,159 demonstrations) in *rabi* and 1,257.20 ha (3,573 demonstrations) in summer season.

On national level, the yield advantage in oilseed crops over the farmer's practice was recorded highest in *kharif* groundnut (40.35%) followed by *rabi* sunflower (38.48%), soybean (34.80%), *rabi* groundnut (40.35%), linseed (32.72%), and mustard (25.89%). This was due to suitable technology interventions and skilling of farmer.

Other frontline demonstrations

A total of 128,555 frontline demonstrations (FLDs) other than CFLDs including 83,188 FLDs on crops covering 24,571.94 ha area, 9,706 demonstrations on farm machineries covering 3,211.47 ha area, 17,109 FLDs on livestock and fisheries, 15,126 demonstrations on other enterprises and 3,426 FLDs on gender-specific technologies for women empowerment were organized.

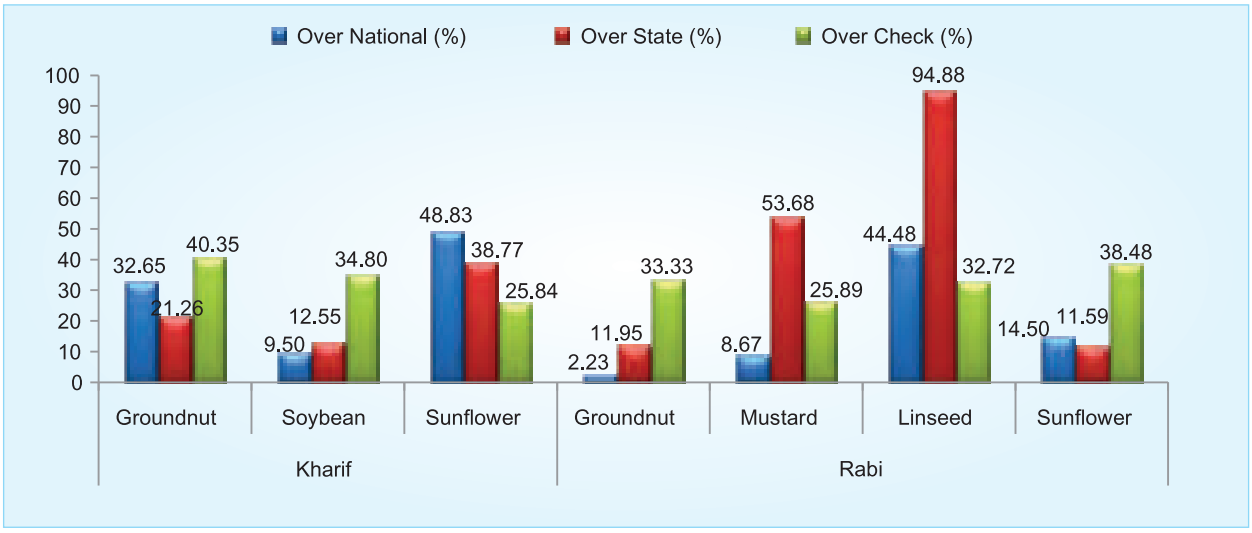
Cereals: In rice, wheat, maize, and barley 27,162 demonstrations were conducted, covering an area of 9,447.48 ha. An average yield increase of 15.69% was observed in 13,400 demonstrations on rice, 12% yield increase in 9,645 demonstrations on wheat and 25.95% yield increase in 2,415 demonstrations on maize.

Millets: Demonstrations were conducted on millets in 2,068 farmers' fields covering an area of 693.7 ha during the year. The highest number of 778 demonstrations were on finger millet where the average yield increase was 27.30% followed by 370 demonstrations on pearl millet with 23.86% yield increase.

Pulses (other than CFLDs): A total of 12,884 demonstrations were conducted on pulses (other than CLFDs) covering an area of 3,925.96 ha on various pulses. The highest number of demonstrations were on chickpea (2,824) in 1,088.73 ha followed by blackgram (2,530 demonstrations in 829.54 ha), pigeon pea (2,279 demonstrations in 671.85 ha) and green gram (2,092 demonstrations in 739.3 ha). The yield increase observed were 23.97, 31.48, 25.51 and 23.56% in chickpea, blackgram, pigeon pea and green gram, respectively, over farmers' practices.

Oilseeds (other than CFLDs): A total of 7,869 cluster frontline demonstrations were conducted on oil seed crops (other than CFLDs) covering an area of 3,052.08 ha. The highest number of 2,214 demonstrations were conducted on soybean in an area of 713 ha followed by groundnut (1,581 demonstrations in 609.5 ha) and sesame (1,046 demonstrations in 423.28 ha). A total of 2,036 demonstrations were conducted in 892.2 ha on gobhi sarson, mustard, rapeseed and toria. The yield increase in demonstrations over farmers' practice were 22.7, 21.36 and 29.12% in soybean, groundnut and sesame, respectively.

Horticultural crops: Altogether, 22,798 demonstrations on horticultural crops comprising vegetables (14,906), fruits (3,051), flowers (550), spices and condiments (2,505), plantation crops (522), medicinal and aromatic plants (107) and coconut (35) were conducted in 4,254.39 ha area in the country.



Yield advantage through CFLDs on oilseeds over national, state and check yield

The increase in yield recorded under FLDs as compared to farmers' practice was 47.10% in vegetables, 19.58% in fruits, 37.41% in flowers, 38.30% in spices and condiments, and 17.46% in plantation crops over the farmers' practices.

Commercial crops: Across the country, 416 demonstrations were conducted in an area of 163.5 ha through KVKs. The yield increase in FLDs was 32.74% in sugarcane and 8.38% in cotton as compared to local checks.

Fibre crops: In all, 1,129 demonstrations were conducted on different fibre crops in an area of 468.50 ha area through KVKs. The yield increase in FLDs was 15.16% in cotton and 18.41% in jute as compared to local checks.

Fodder crops: Demonstrations on crops such as berseem, maize, sorghum, Napier grass, etc., were conducted in 2,838 farmers' fields covering an area of 454.92 ha. The yield increase in fodder oats was 40.52% over farmers' practice. Berseem recorded yield increase of 29.52%, fodder grass 36.49% and fodder maize 31.12% in the demonstrations over their respective farmers' practices.

Hybrids: To achieve higher harvest index in crops, KVKs conducted 6,024 demonstrations on hybrids covering an area of 2,111.41 ha in cereals, millets, oilseeds, pulses, fodder crops, commercial crops and horticultural crops. Demonstrations on hybrids of oilseeds were conducted across the country covering 226.53 ha and a total of 2,280 demonstrations were conducted on various vegetables, fruits, flowers and spices in 669.5 ha area.

Farm mechanization: Demonstrations (9,706) were conducted on improved tools and farm implements including drudgery reduction technologies covering an area of 3,211.47 ha.

Livestock and fisheries: Demonstrations on dairy animals, poultry, sheep and goat, poultry including chicken, quail turkey and duck, piggery, rabbit, etc., were carried out at 15,533 farmer's locations and 1,576 demonstrations were conducted on fisheries.

Enterprises: Demonstrations on 20 enterprises like mushroom cultivation, apiary, sericulture, value-addition, vermicompost, nursery, etc., were conducted involving 1,7159.15 units in which 15,126 farmers benefitted. On women and children, 3,426 demonstrations were conducted on various enterprises like value addition, kitchen garden, nutrition, etc.

Capacity development

A total of 17.27 lakh farmers/farm women, rural youth and extension personnel were trained on various aspects through 57,879 training programmes including the sponsored training courses.

Farmers and farm women: Training courses (45,636) on various technologies benefitted 13.86 lakh farmers and farm women out of which 8.83 lakh (64%) participants were from other classes while 5.03 lakh (36%) were from SC/ST category. These courses targeted productivity enhancement and cost reduction of field crops (23.01%), horticultural crops (14.88%), plant protection (13.42%), livestock production and management (10.81%), soil health and fertility management (10.14%), empowerment of rural women including home science (11.74%), agricultural engineering (3.93%), capacity building for group actions (4.88%), production of inputs (3.54%), fisheries (2.37%) and others including agro-forestry (1.29%). Out of these training courses 41.25% were organized on-farm while rest (58.75%) were organized off-campus. Within field crops, integrated crop management was the leading theme in which 23.64% of courses were organized followed by weed management (8.96%), seed production (8.81%), cropping systems (7.16%), integrated farming (5.48%), resource conservation technologies (7.85%), nursery management (3.48%), crop diversification (5.35%), water management (2.86%) and production of organic inputs (4.70%). Among the training courses on horticulture, vegetable crops constituted 47.97% while proportion of courses on fruits was 29.29%. However, the respective share of training courses on medicinal and aromatic plants, spices, tuber crops, plantation crops and ornamental plants was less than 7%.

Rural youth: Training courses (7,309) for the skill development of rural youth were organized for 1.90 lakh participants out of which 69,345 (36.48%) were the young women during this year. The highest proportion of training courses under this category were imparted on mushroom production (9.34%) followed by value addition (7.13%), seed production (5.88%), bee keeping (5.01%), nursery management of horticultural crops (4.32%), poultry production (4.27%), vermi-culture (4.08%), integrated farming (4.04%), production of organic inputs (3.86%), dairying (3.67%), protected cultivation of vegetable crops (3.22%), sheep and goat rearing (2.90%), post-harvest technology (2.79%) and repair and maintenance of farm machinery and implements (2.52%). There were other areas on which relatively smaller number of training courses was organized for the rural youth. These trainings were conducted mainly on-campus (62.01%).

Extension personnel: Capacity development of 1.51 lakh extension personnel was carried out through 4,934 courses in the country. The proportion of female participants in these programmes was 26.33%. Different extension functionaries working both in government and non-government organizations for the development of agricultural sector in the country were included in these training programmes. The trainings mainly focussed on agricultural technologies aimed at productivity enhancement in field crops (13.21%), integrated pest management (12.53%), integrated nutrient management (8.51%), management of farm animals (4.50%), protected cultivation technology (4.13%), production and use of organic inputs (3.99%), livestock feed and fodder production (3.71%), women and child care (3.65%), capacity building on ICT

application (3.04%), care and maintenance of farm machinery and implements (2.61%), rejuvenation of old orchards (2.57%), low cost and nutrient efficient diet designing (2.21%), group dynamics and farmers organization (2.19%), formation and management of SHGs (2.09%), household food security (1.93%), information networking among farmers (1.82%) and gender mainstreaming through SHGs (1.22%). Higher proportion of trainings for extension personnel were organised on-campus (69.96%) compared to the off-campus (31.04%).

Sponsored training programmes: With a specialized focus, 5,608 sponsored training courses were organized for 2.48 lakh participants mainly comprised farmers, farm-women, rural youth and extension personnel. The women participants constituted 26.57% of the total in these training programmes. The sponsored programmes were mainly focussed on crop production and management (51.01%), livestock and fisheries (14.08%), home science (6.43%), agricultural extension (19.84%), farm machinery (2.97%) and miscellaneous (5.68%). Similarly, there were 3,534 sponsored training for vocational courses which benefitted 80,573 rural youth of the country.

Extension programmes

KVKs organized 6.60 lakh extension programmes/ activities in the form of advisory services, diagnostic and clinic service, celebration of important days, exhibitions, exposure visit, ex-trainees sammelan, farm science club conveners' meet, farmers' seminar, farmers' visit to KVK, field days, film shows, group meeting, kisan goshthi, kisan melas, lectures delivered as resource persons, mahila mandal conveners' meetings, method demonstrations, plant/animal health camps, scientists' visit to farmers' fields, self-help group meetings, soil health camps, soil-test campaigns, workshop and others to create awareness among farmers, extension personnel, other stakeholders and public about various technologies in agriculture and allied sectors. These programmes were attended by 402.21 lakh participants of which 397.61 lakh were farmers and 4.60 lakh were extension personnel.

Besides, a total of 2.69 lakh mass contact extension activities were conducted in the form of TV programmes, radio talks, CDs/DVDs and print media, viz. extension literature, newspaper coverage, popular articles, research articles, training manuals, technical bulletins, leaflets, folders and books/booklets. Large number of activities were covered through extension literature (1,44,974). About 19.57 lakh farmers made their footfall to KVK and 25,753 news items were published in local and national dailies. Scientists of KVKs published 4,620 popular articles besides 4,088 radio talks and 2,608 TV talks.

Production of technological products

KVKs produced technological products like seeds and planting materials of improved varieties and hybrids, bio-products and elite species of livestock, poultry and fish which benefitted 26.37 lakh farmers in the country.

Seeds: During the year, 1.70 lakh quintal seeds of improved varieties and hybrids of cereals, oilseeds, pulses, commercial crops, vegetables, flowers, fruits, spices, fodder, forest species, medicinal plants and fibre crops were produced and provided to 9.22 lakh farmers.

Planting materials: Total of 436.99 lakh quality planting materials of elite species of commercial crops, vegetables, fruits, ornamental, medicinal and aromatic crops, plantation crops, spices, tuber crops, fodder and forest species were produced and provided to 6.05 lakh farmers.

Bio-products: Bio-products, namely, bio-agents (19,569.94 q), bio-pesticides (1,664.62 q), bio-fertilizers (29,859.16 q) and other bio-products (12,985.42 q) including vermi-compost, mineral mixture, etc., were produced. Thus, a total of 64,079.15 q bio-products were produced and supplied to 10.26 lakh farmers.

Livestock strains and fish fingerlings: In all, 8,234 animals of improved breeds of cow, sheep, goat, buffalo and breeding bull were produced and supplied to 11,766 farmers. Similarly, 6.12 lakh strains/breeds/eggs of poultry birds (chickens, quails, ducks and turkey) were provided to 40,808 farmers. Improved breeds of pigs (2,922) were provided to 1,193 farmers. KVKs also enabled 46 farmers to establish small rabbit rearing units by providing 293 rabbits. Fish fingerlings (110.59 lakh) were produced and supplied to 29,690 farmers. Thus, a total of 116.82 lakh livestock strains and fish fingerlings were produced and supplied to 83,503 farmers.

Soil, water and plant analysis

Soil, water, plant and manure samples brought by farmers were analysed at KVKs and suitable advisories based on analysis were provided to them. During the reporting period, 3.98 lakh samples comprising 3.65 lakh soil samples, 0.28 lakh water samples, 0.05 lakh plant samples and 0.003 lakh manure samples were analysed by KVKs covering 5.34 lakh farmers belonging to 0.69 lakh villages across the country and the revenue generated was ₹ 297.13 lakh. Soil health cards (4.56 lakh) were also issued to the farmers by KVKs.

Mobile advisory services: For providing timely and need based information to farming community, the KVKs send agro-advisories to the farmers on their mobiles through mKisan portal of Department of Agriculture, Cooperation and Farmers' Welfare. Information on weather, market, various farm operations, outbreak of pest and disease incidence and their control measures are given to farmers through Short Message Service (SMS). Advisories on various aspects of agriculture, animal husbandry and other allied sectors were sent by KVKs through 6,457.76 lakh messages during the reporting period.

Technology backstopping to KVKs

The Directorates of Extension Education (DEEs) of the SAUs/CAUs (58) played pivotal role in technological backstopping to the staff of KVKs. They organized 559 capacity development programmes for updating the technical knowhow of the 17,932 KVK staff in the country. Besides, Agricultural Technology Application Research Institutes also upgraded the knowledge and skill of 2,881 KVK staff by organizing 70 training programmes. DEEs facilitated technological backstopping and information delivery for KVKs by conducting 2,266 training programmes, 975 field days, 2,099 FLDs, 934 OFTs, 9,258 farmer scientist interactions, 6,965 soil health camps, 279 Kisan melas, 302 kisan goshties and 219 technology week celebrations. Furthermore, monitoring of KVK interventions (364), *rabi* and *kharif* campaigns (198), animal health camps (757), diagnostic visits (1,057) and technology exhibitions (294) were also conducted by the DEEs. Officials of these directorates made 3,906 visits to the KVKs of their jurisdiction on various occasions to review and monitor the technology dissemination process at KVKs. The DEEs also undertook the technological backstopping by delivering 1,886 lectures, 175 TV talks, 288 radio talks and 3,198 news reports in newspapers. A total of 2.06 lakh farmers visited Directorate of SAUs/ CAUs for improved technology knowledge during the period.

Agricultural Technology Information Centre

Agricultural Technology Information Centres (ATICs; 47) are serving as single window delivery system in the country by providing technology information, advisory services and technological inputs to the farmers. During the reporting period, 5.81 lakh farmers visited ATICs for obtaining solutions related to their agricultural problems. ATICs provided information related to various aspects of farming to 2.2 lakh farmers, both through print and electronic media. Farmers (2.64 lakh) were provided 79,326 q disease free seed of various crops, 113.15 lakh improved planting material, 49,075 poultry birds and 5,779 q of bio-products by the ATICs. Besides these, 12.96 lakh farmers benefitted from technological services provided by the ATICs. Soil Health Cards (38,147 farmers), Kisan Call Centre (62,346 farmers' calls), Postal services to farmers (58,296), Mobile Agro Advisory (1.07 lakh) and special extension programmes (14,532) were also provided by ATICs.

Special programmes and projects

Attracting and retaining youth in agriculture: Attracting and Retaining Youth in Agriculture (ARYA) project is operational in 100 KVKs. During the year, 3,350 entrepreneurial units related to mushroom production, fruits and vegetable processing units, horticulture nursery, fish farming, poultry, goat farming, piggery, duck farming and bee keeping were established benefitting 7,953 rural youth. KVKs have organized 783 training programmes benefitting 15,796 youth. Nearly 31% trained rural youth established micro-entrepreneurial units in rural areas which benefited them to get net income ranged from ₹ 40,000 to ₹ 238,000/unit/annum across the different entrepreneurial units.

National Innovations on Climate Resilient Agriculture: Technology Demonstration Component (TDC) of National Innovations on Climate Resilient Agriculture (NICRA) is being implemented by KVKs in 121 vulnerable districts belonging to 28 states and 1 union territory. Demonstrations of proven location specific technologies related to natural resource management (NRM), crop production, livestock and fisheries were taken up for enhancing adaptation gains and imparting resilience against drought, flood, cyclone, heat stress, coastal salinity, etc. During the year, 13,210.95 ha and 9,967.15 ha was covered through 15,678 and 23,229 demonstrations in NRM and crop production modules, respectively. Besides, 12,754 demonstrations covering 720.51 ha area and 81,741 animals were also carried out on livestock and fisheries technologies. KVKs conducted 1,414 training programmes and 3,923 extension activities on successful climate resilient agriculture practices covering 38,170 and 77,639 farmers, respectively. The focus under TDS-NICRA over the last three years was on expanding the project activity to form NICRA village clusters and to saturate the adopted clusters with at least one successful resilient technology from NRM, crop and livestock modules. Emphasis under the project was also on scaling up of the climate smart technologies/ practices through stronger convergence with district development schemes.

Skill development training in agriculture: As per priority of the Government of India, KVKs/ICAR Institutes/Agricultural Universities organize National Skills Qualifications Framework (NSQF) aligned skills training programmes of 200 h or more duration with funding support from Department of Agriculture,

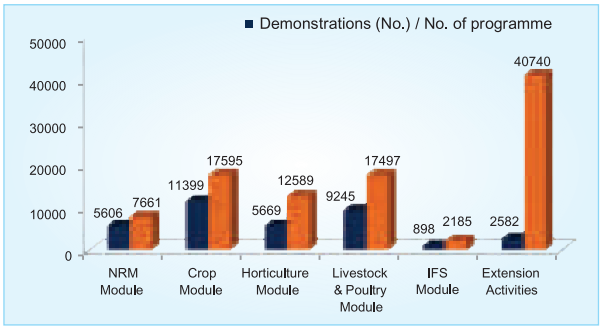
Success Story

Sunhemp seed production—Sustainable crop intensification

In Nacharam NICRA cluster villages of Khammam district, Telangana, farmers leave their fields fallow after *kharif* paddy due to low access to water during *rabi*. KVK, Khammam (Wyra) introduced seed production of sunhemp to intensify cropping with harvested rain water in farm ponds. This practice ensured additional net income of ₹ 30,750/ha and the practice was adopted by 60% farmers in the NICRA adopted village, and has scope for spread to all farm holdings with similar situation. Sunhemp being a legume enriches the soil and gives good yield even under limited moisture availability and has the additional advantage of guaranteed market for seed in Telangana. Thus, sustainable crop intensification with sunhemp after paddy ensured additional income and stabilized livelihood security even during climatically vulnerable years.

Cooperation and Farmers' Welfare. During the reporting period, as many as 821 skill training programmes were organized for 15,926 rural youth. Majority of trainings programmes were organized in the job roles of Mushroom grower, Nursery worker, Quality seed grower, organic grower, Small poultry farmer, Dairy farmer entrepreneur, Beekeeper, Assistant gardener, Agriculture extension service provider, Animal health worker, etc.

Farmer FIRST: Farmer FIRST Programme is a flagship programme initiated by ICAR to move beyond production and productivity; to privilege the smallholder agriculture; and complex, diverse and risk prone realities of majority of the farmers through enhancing farmers scientists interface. During the reporting period, a total of 32,817 demonstrations were conducted, 2,582 extension programmes were organized, 73,202 animals (livestock and poultry) were covered and 98,267 farm families were benefitted in all modules.



Module-wise number of demonstrations/programme and number of farm families under Farmer FIRST Programme

Out of the total demonstrations conducted, highest number of demonstrations (11,399) were conducted in crop module followed by 9,245 demonstrations in livestock and poultry; 5,669 demonstrations in horticulture module; 5,606 demonstrations in NRM module; and 898 demonstrations in IFS module.

Out of the total farm families, 17,595 farm families in crop module; 7,661 in NRM module; 12,589 in horticulture module; 17,497 in livestock and poultry module; 2,185 in IFS module; and 40,740 in extension activities, were benefitted.

Mera gaon Mera gaurav: An innovative initiative Mera Gaon Mera Gaurav (MGMG) aimed to promote the direct interface of scientists with the farmers to hasten the lab-to-land process. The objective of this scheme is to provide farmers with required information, knowledge and advisories on regular basis by adopting villages. A total of 117 institutions including ICAR institutes and SAUs implemented MGMG programme which is monitored by concerned ATARIs. During reporting year, total 4,861 scientists constituting 1,222 groups worked with 6,96,109 farmers of 5,615 villages to provide them with required information, knowledge and advisories on regular basis.

Pulses seed-hubs: Seed-hubs were set-up at 97 KVKs for production of quality seeds of major pulse crops. During the year, 39,659.52 q seeds of pigeon pea, blackgram, green gram, lentil, chickpea, field pea and lathyrus were produced and made available to farmers.

Crop residue management: The KVKs (60) are implementing the Information, Education and Communication (IEC) component of the Scheme on Promotion of agricultural mechanization for *in situ* management of crop residue in the state of Punjab, Haryana, Uttar Pradesh and NCT of Delhi to educate the farmers and other stakeholders about ill effects of crop residue burning. *In situ* management of crop residue was the prime focus of Government of India and ICAR during 2019. A total of 410 machines were procured by the KVKs in this period out of which Happy seeder assumed the lead role followed by zero till drill and rotavator, etc. Under this component 44 Kisan melas were organized in which 3.96 lakh participants were educated on the significance and urgency of CRM followed by 650 awareness programs targeting 71,392 participants, 543 schools and colleges mobilizing 46,386 students through essay, debate and painting competitions; 12,469 demonstrations focusing on 17,239 farmers; 194 training programs benefitting 7,423 participants; 175 exposure visits of 4,777 participants and 183 field/ harvest days to demonstrate results to 8,535 persons.

Other activities under IEC initiative of CRM project include distribution of 4.11 lakh publicity material (leaflets/ pamphlets etc.); placing 20,553 posters/ banners; 3,672 wall paintings; fixing of 1,187 hoardings at mandi/ road side/ market/ schools/ petrol pumps/ Panchayats, etc.; publication of 431 articles and news-items in the newspapers and magazines; 292 advertisements in the print media; and 81 TV programmes/ panel discussions on Doordarshan/ DD-Kisan and other private channels.

Nutri-sensitive Agricultural Resources and Innovation: Nutri-sensitive Agricultural Resources and Innovations (NARI) is a nutrition centric initiative by ICAR for improving their health and nutrition of rural mass. Under this programme, a total of 7,968 activities on nutritional garden, biofortified varieties of crops, value addition and other enterprises including 2,155 training programmes and 3,514 extension activities were conducted.

Out of the total activities, 6,125 activities on nutritional garden; 552 activities on bio-fortified varieties of crops, 914 activities on value addition and 377 activities on other enterprises were conducted. Out of the total participants (863,182), 18,490 participants in activities on nutritional garden; 3,689 participants in activities on bio-fortified varieties of crops; 11,922 participants in activities on value addition; 3,968 participants in activities on other enterprises; 59,117 participants in training programmes and 765,996 participants in extension activities were benefited.

Knowledge System and Homestead Agriculture Management in Tribal Areas: Knowledge System

and Homestead Agriculture Management in Tribal Areas (KSHAMTA) was initiated to channelize the Tribal Sub Plan fund of ICAR institutes for Development of Tribal Agriculture. KSHAMTA is being implemented in 125 tribal districts of the country through KVKs. The KVKs conducted 4,194 on-farm trials and 28,342 frontline demonstrations. Capacity development of 2.53 lakh farmers/farm women and 29 thousand extension personnel was done. Extension activities organized by the KVKs benefitted 11.23 lakh participants. The technological inputs like seeds (19,689.83 q), planting material (80.59 lakh) and livestock strains and fish fingerlings (38.43 lakh) were produced by KVKs. Besides analysing 43,498 samples of soil, water, plant and manure, mobile advisories were sent to 35.80 lakh farmers on various aspects of agriculture.

Success stories

Farmers participatory *rabi* onion seed and seedling production in district Bageshwar, Uttarakhand

Onion crop in Uttarakhand is grown in an area of 4.08 thousand ha area with the production of 41.6 thousand MT. But the productivity of onion in Uttarakhand is only 10.2 MT per ha, which is far below with respect to the average national productivity of 16.98 MT per ha. One of the major causes for this low productivity is bolting. ICAR-VPKAS, Almora has released a *rabi* season onion variety namely VL Piaz 3 which does not lead to bolting in the crop. But its expansion to the farmers' fields was slow, because of the limited availability of quality seed and planting material. Considering the importance of this variety for district Bageshwar, farmer to farmer extension approach was applied for the production and spreading of VL Piaz 3 seed and seedlings by KVK, Bageshwar by conducting various activities comprising training, demonstrations and field days by involving 684 farmers. The average yield of the farmers' practice was only 156 q/ha, whereas the onion yield of demonstration was 276 q/ha. Efforts of KVK for the past six years motivated 11 farmers from different villages to go for seed and seedlings production of *rabi* onion variety VL Piaz 3. All 11 farmers together produced 2.46 q of onion seed, 6,070,000 onion seedlings and sold to 6,302 farmers within the district and also adjoining districts of Bageshwar (Uttarakhand) thereby gained ₹ 659,800 as net income per season. Impact of these efforts reflected directly in the form of onion yield enhancement by 76% as well as reduced the problem of bolting.

Seed production of *Rabi* onion variety VL Piaz 3

Unemployed rural youth turned as entrepreneurs district Rangaareddy, Telangana

KVK, Rangareddy conducted skill training on Nursery workers during 2019–20. Skills were imparted to trainees on wide range of topics like laying out of nursery, input management, plant propagation structures, seed extraction and storage, sexual/asexual propagation techniques, micro-propagation, pest and disease management, irrigation and nutrition management, etc. The trainees were also taken on exposure visits to successful nurseries in the district.

Training to rural youth on the job role "Nursery worker"- KVK, Rangareddy, Telangana

Four enthusiastic youth among the trainees formed two groups of 2 each and established two nursery units (*Mana* nursery, Green Mithra Nursery) in March, 2020 immediately after getting certified and supplied quality planting material to the needy farmers and also for the "*Harithahaaram*" project of Telangana government on recommendation by department of Horticulture and Forestry. K. Madhukumar and K. Umamaheswari of *Mana* nursery produced 12,500 saplings of forest and multipurpose fruit trees and earned ₹ 124,000 through sale of 4,000 saplings in 4 months duration. Similarly, R. Tejaswini and R. Laxmi of Green Mithra Nursery produced 46,800 saplings/seedlings of fruit trees, forest trees, flower and vegetable crops and made a net profit of ₹ 235,000 since March through sale of about 31,500 plants. Three trainees got placement in commercial nurseries as a field supervisors.

International Convention on Perspectives to Face Contemporary Challenges of Agricultural Development was organized in collaboration of Bhartiya Kisan Sanghat NASC Complex, New Delhi during 18–19 February 2020 with participation of about 300 participants.

National Animal Disease Control program (NADCP) for FMD and Brucellosis and National Artificial insemination program: National Animal Disease Control Program (NADCP) for FMD and Brucellosis and Nationwide Artificial Insemination program was launched in 600 districts out of 637 district having less than 50% AI coverage. As part of the launch program, country-wide simultaneous workshops at 651 KVKs in 32 states/UTs were organized with topics on vaccination and disease management and artificial insemination (AI) and productivity. Vaccination and Artificial insemination were carried out to 65,262 animals.

Tree plantation campaign organized by KVKs: Tree plantation campaign was organized on 17 September 2019 by 649 KVKs in collaboration with

Sustainable livelihood diversified farming in Tribal village, district Bhilwara, Rajasthan

The Jahajpur Panchayat Samiti is a tribal area of Bhilwara district. In addition to poor economic status, farmers are having lack of knowledge in improved agriculture technology, breeding and feeding management of animals and rearing of local poultry breed. After purposeful selection of cluster comprising of Rawatkhera and Ramgarh in Jahajpur Panchayat Samiti under TSP activities, KVK Bhilwara started capacity building programme of the farmers through different activities like on and off campus training, field visits, frontline demonstrations, field days, animal health camps, gosthi, farm advisory services, etc. Technological interventions like farmers' participatory seed production on new varieties of wheat (Raj 4079), mustard (RH 406), gram (GNG 1581), barley (RD 2786), and breed improvement programme in cow and goat through Gir bull and Sirohi buck were initiated. KVK also demonstrated improved breed of poultry (Pratapdhan and Kadaknath), Azolla, vermicompost, vermiwash and waste decomposer.

Farming community of the village started to use improved variety seed and seed replacement rate of cereals, oilseeds and pulses was reached up to 27.80 % within span of three years. A total of 150 tribal farmers were covered by providing 20 chicks to each. Considering 10% mortality farmers are getting on an average egg production of 156 eggs/bird/year totalling to 374,400 eggs (150×156×16)/year. By selling of 370,000 eggs @ ₹ 8/egg they have obtained ₹ 2,960,000/year and generated revenue ₹ 2,810,000 after deducting the expenditure of ₹ 150,000. The net additional income generated per demonstration is ₹ 18,733/year. By the use of Azolla, the milk production (6–8%) as well as fat content also increased resulting in their income generation and nutritional security. Breeding efficiency in dairy animals was also improved. By the use of vermicompost in their field they are not only improving the fertility status of the soil but also reducing the input cost of fertilizer. The farmers are very much satisfied with the improved package of practices and adoption of the integrated farming system.

Successful cultivation of bio fortified wheat variety WB-02 in district Bijnor, Uttar Pradesh

The area under wheat is about 145,000 ha in Bijnor district, out of that about 75,000 ha area is under timely sown condition. The variety WB-02 is rich in zinc (42 ppm) and iron (40 ppm) in comparison to 32 ppm zinc and 28 ppm iron in other wheat varieties with maturity of 138–140 days, bold grained, resistant against yellow rust and leaf blight. WB-02 was introduced and demonstrated by KVK Bijnor during *rabi* 2017–18 and 2018–19 at 25 farmers' field through OFT and FLD. Average yield at farmers field recorded was 57.50 q/ha (63.75 q maximum yield per ha) with cost of cultivation of ₹ 46,345/ha and net profit ₹ 91,605/ha. The area under this variety has now spread to more than 850 ha in just two years. Farmers are satisfied with the yield of this variety and also claim that it is better for chapatti making with higher enrichment of zinc and iron. The successful farmer is Sri Satish Kumar belonging to Sidiyawali village in Noorpur block of Bijnor district.

Bee-keeping—An income generating enterprise for smallholder farmers, district North 24 Parganas, West Bengal

KVK, North 24 Parganas, Ashoknagar conducted 7 training courses on bee-keeping enterprise to train 120 rural youth and farmers from 10 different blocks of the district during the years 2016–19. Out of these, 25 adopted bee-keeping as a continued activity. Major expenditure was involved on the purchase of bee boxes, colonies, honey extracting machine, gloves, veil and other tools. Bee-keepers got income from sale of honey, wax and pollen. Small scale bee-keepers having average 28.75 colonies and medium scale bee-keepers having average 83.57 colonies could fetch annual average net return of ₹ 52,163.33 and ₹ 150,157.14, respectively, while large scale bee-keeping entrepreneurs with average 187.5 colonies could achieve annual average net return of ₹ 275,525. The net return of bee-keepers increased with the increase in the number of colonies.

IFFCO with the following activities:

Under the tree plantation programme at 649 KVKs, total 710,740 plants were planted with participation of 141,243 farmers, MPs, 50 MLAs and 2,000 other VIPS.

Production of vegetable seedlings in low cost poly houses in district East Singhbhum, Jharkhand

KVK, East Singhbhum trained 235 rural youth on low cost poly house management for vegetable seedlings production. Out of which, 25 trainees established vegetable seedlings unit under the technical guidance of KVK as an enterprise in the year 2019–20. Every youth possessed one low cost polyhouse. In this low cost poly house they grow vegetables seedling of tomato, brinjal, cauliflower and cabbage good for early vegetable production. Cucurbitaceous crop like bottle gourd, bitter gourd, and cucumber were grown in side poly house in poly tubes. Also used this poly house for the cultivation of leafy vegetable (spinach, coriander, *amaranthus*). Their average net annual income is ₹ 65,000 from polyhouse based vegetable cultivation.

❑

Horti-Animal Husbandry-Apiary IFS Model: A successful intervention by KVK, North Goa

Shri Vinod Gopal Barve, Satode, Valpoi, Sattari, Goa, is practising Horti-Animal Husbandry-Apiary integrated farming system model for last seven years under the technical guidance of KVK, North Goa. He has 6 ha area under Integrated Farming System model. The main component comprises arecanut 6,000 plants, banana 2,000 numbers, and black pepper 3,000 numbers, nutmeg 5 numbers and cinnamon 2 numbers. He has 4 indigenous cows which he mainly uses for production of organic manure. In addition, he has put up 8 honey bee boxes. Total annual production from this model is arecanut 12.9 tonnes, banana 135 tonnes, black pepper 4.7 tonnes, coconut 3,00,000 nuts, organic manure 3 tonnes and honey 15 kg. Net income obtained from this IFS model was ₹ 40.77 lakh/annum (₹ 6.80 lakh/ha).

"जय किसान, जय विज्ञान और जय अनुसंधान जब एक साथ एक मंच पर मिलकर काम करेंगे तो कृषि क्षेत्र में उन्नत बदलाव संभव हो पाएगा।"

— नरेन्द्र मोदी

15. Research for Tribal and Hill Regions

North-west Himalayas

Breeder seed production: During the period under report, 220.52 q breeder seed of 42 released varieties/ inbreds of 15 crops were produced. A total of 180.29q breeder seed was supplied to different seed producing agencies to take up further multiplication.

Quality seed production: During the period, 15.18 q Truthfully Labelled (TL) seeds of 25 varieties of 16 crops were produced. Including the carry-over stock of TL seed; a total of 39.95 q seed was supplied to different stakeholders. In addition, 142.52 q TL seed was also produced under farmers' participatory seed production programme.

Crop varieties released and notified

Variety	Area of adoption	Salient features
VL Sweet Corn Hybrid 2	Jammu and Kashmir, Himachal Pradesh, Uttarakhand (Hills) and Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura (North Eastern Hills Region)	• Green cob yield (dehusked): 103 q • Harvestable maturity (green cob): 75–77 days in mid-hills • Moderately resistant to turcicum and maydis leaf blight, banded leaf and amp; sheath blight and curvularia leaf spot • TSS: 14.5–15.3%
VL Masoor 148	NHZ comprising the states of Uttarakhand, Himachal Pradesh, J&K and NE hills	• Grain yield = 1,148 kg/ha, maturity in 147–163 days • MR against pod damage and aphids • Nutritionally superior with 30.46% protein in its grains
VL Bhat 202	Uttarakhand hills	• Grain yield = 1,596 kg/ha, maturity in 110–114 days • Resistant to FLS and MR against pod damage and aphids • High protein (39.19%) in its grains
VL Matar 61	Uttarakhand hills	• Grain yield: 1,130 kg/ha, maturity in 152–156 days • MR against wilt, powdery mildew, aphid incidence, pod damage and leaf minor damage

VL Sweet Corn Hybrid 2

VL Masoor 148

VL Bhat 202

VL Matar 61

CROP MANAGEMENT

Crop production

Substitution of chemical fertilizer through farmyard manure and vermicompost: Farmyard manure (FYM) and vermicompost (VC) were evaluated against the recommended chemical fertilizer (NPK) for rainfed soybean–wheat cropping system. The potential wheat equivalent yield of rainfed soybean–wheat cropping system through FYM and VC were 10,730 and 10,950 kg/ha, which could be achieved with application of 58.3 and 57 kg P/ha, respectively. These yield levels were 32 and 34% higher than the recommended NPK, respectively. The level of P required from FYM and VC to achieve the same yield level as recommended NPK for rainfed soybean–wheat cropping system were only 13.1 and 12.2 kg P/ha, respectively, which were very less compared to 24 kg P/ha (mean of 34.9 and 13.1 kg P/ha under recommended P through SSP for soybean and wheat crop, respectively). The level of N required from FYM and VC to achieve the same yield level as recommended NPK for soybean–wheat cropping system were only 58 and 54 kg N/ha, respectively. The level of FYM and VC on fresh weight basis required to achieve the same yield level as recommended NPK for rainfed soybean-wheat cropping system were only 14.7 and 8.8 t/ha, respectively.

Soil enzyme activity index: Soil enzyme activity index (SEAI) was developed to provide a single comprehensive unit-less value. Sustainable yield index (SYI) and SEAI of rainfed soybean–wheat cropping system were evaluated after 44 years with different nutrient management. Addition of 10 t FYM/ha with recommended NPK provided 24, 187 and 83% higher SEAI, sustainable yield index of soybean (SYI-S) and wheat (SYI-W) compared to the application of recommended chemical fertilizer only. As SEAI has a very good relationship with SYI-S and SYI-W, hence, the former strongly influence the later. This clarified SEAI is a good indicator of sustainability.

Crop protection

Phenotypic and genotypic characterization of blast R genes in rice: Sixty rice genotypes were evaluated for leaf and neck blast diseases under Uniform Blast Nursery (UBN) system. Four genotypes (VL 8654, A 57, GSR-125 and GSR-142) for leaf and five genotypes (VL 31817, VL 31851, VL 31916, VL 31997 and GSR-132) for neck blast were highly resistant, with 1 disease score on 0–9 scale. None of the entry showed highly susceptible reaction with 8 and 9 disease score against both the leaf and neck blast disease.

For molecular screening, these rice entries were genotyped for the presence of 13 blast resistance genes. A total of 18 markers available for these genes were used for molecular screening. The frequency of positive alleles of R gene ranged from 11 to 16 in the rice entries. Based on the field resistance score against leaf blast, entry VL 8567 showed maximum resistance with 16 numbers of positive alleles followed by Tetep with 13 numbers of positive alleles. For neck blast resistance, entry VL 8654 showed maximum resistance with 16 numbers of positive alleles followed by VL 31851 with 14 numbers of positive alleles. The characterization of 60 rice germplasm using 18 molecular markers linked to 13 major blast resistance *R* genes revealed that the markers corresponded to four major *R* genes, viz. *Piz*, *Pi9*, *Pi2* and *Pita/Pita2* were found significantly associated with blast disease resistance. The identified resistance sources can be deployed for effective management of blast disease

Species distribution and effective management of whiteflies: Survey was carried out in 26 locations comprising 3 states (Uttarakhand, Himachal Pradesh and Tripura) and 1 union territory (Delhi) to collect whitefly samples from both protected and open field conditions. Based on the morphological characters, two major whitefly species, viz. greenhouse whitefly (*Trialeurodes vaporariorum*) and cotton whitefly (*Bemisia tabaci*) were found distributed in the locations infecting 11 host plants. *Trialeurodes vaporariorum* was widely distributed in cold and temperate climates, whereas, *Bemisia tabaci* was distributed in hot and humid climates. Amongst the tested insecticides, the field populations of greenhouse whitefly was highly susceptible to Thiomethaxam > Imidacloprid > Pymetrozine with LC_{50} values 12.30, 18.62 and 22.38 ppm, respectively. Whereas, LC_{50} values of botanical insecticides neam seed kernel extract and nimbicidine were very high; 524.81 ppm and 4,365.16 ppm respectively, indicating their non-suitability for greenhouse whitefly management. Moreover, an entomopathogenic fungus, *Alternaria alternata* strain

Whiteflies infecting French bean

VLH1 found infecting greenhouse whiteflies on *Salvia divinorum* plants in ICAR-VPKAS, Experimental farm, Hawalbag (29.63°N and 79.63°E, 1250 amsl). The fungus was highly virulent against *T. vaporariorum* with LC_{50} values of 1.3×10^6 and 1.4×10^5 spores per mL against nymphs and adults, respectively.

SUCCESS STORY

Women empowerment through household food and nutritional security: A case study from high hills of Uttarakhand

Mrs Pooja Karki who hails from a tiny village of Baitholi in high hills of Berinaag block, Pithoragarh district in Uttarakhand has now become the role model for other farmers of the area. She improved the financial and nutritional situation of her family by adopting improved practices of vegetable cultivation, mushroom cultivation, vermicomposting, honey bee rearing and vegetable seedling production under protected conditions.


Like other farm families in the hill region of Uttarakhand, Mrs Pooja Karki was earlier practicing traditional subsistence farming and produced food enough to sustain the family for three to four months in a year and was dependent on the market for food for rest of the period of the year. The financial conditions of the family forced her husband to migrate from the village in search of livelihood, leaving behind the wife Pooja, two children and old parents. Now it was her responsibility to manage the family. She was engaged in agricultural activities such as producing wheat, rice, finger millet, soybean, colocasia along with livestock management for their livelihood like most of the other women in the village. As agricultural productivity was very low, she was forced to purchase most of the household needs like cereals, pulses and vegetables from the local market. She was growing very few vegetables of local variety in their backyard in a traditional way. Household dietary diversity was very low as cereals and roots and tubers were the main food groups consumed by them in their daily diet.

She came in contact with scientists of ICAR-VPKAS, Almora in 2018 and was trained in vegetable cultivation practices, mushroom cultivation, vermicomposting, honey bee rearing and vegetable seedling production under protected condition. Although she was educated only up to 8th standard, she was very eager to learn about nutrition, the importance of growing fruits-vegetables and other improved agricultural technologies to enhance nutritional status. Under the NMHS project "Strategies to improve health and nutritional status of hill farm women through technological interventions", nutri-gardens were designed for 100 m^2 to 200 m^2 of land in the backyard. Layout and crop allotment in nutri-gardens were modified depending on climatic and seasonal changes. More than 16 types of vegetables along with fruit plants rich in various micro-nutrients were grown in nutri-gardens. She took a keen interest in the demonstration of model nutri-garden in her back yard with a land area of 200 m^2 which is enough for meeting the daily micro-nutrient requirement of her family. She has worked almost single-handedly on her land to achieve the right mix of farming and other allied activities.

Now after getting trainings, Mrs Karki follows the proper scientific guidelines of growing vegetables. In the very first season she was able to obtain a good yield of vegetables more than sufficient for home consumption. She also sold vegetables in nearby local markets. Then gradually other nutrition-sensitive agricultural interventions were also introduced such as—vermicomposting, fruit plantation, honey bee rearing and mushroom cultivation. In the initial phase, women of the area were hesitant to grow and consume mushrooms due to their traditional thinking. Mrs Pooja Karki was one of the first women to grow mushroom at her home. She not only included it in her diet but also was able to produce enough for selling at local market. She encouraged other women of the area for the cultivation of mushroom and now most of the women of the area have adopted it. She has also started bee-keeping which will not only provide honey for nutritional security but will help in pollination to enhance vegetable productivity. Earlier farmers of the area used to purchase seedlings of inferior quality from local markets which has a very high mortality rate. She has learnt nursery preparation of vegetable crops and is instrumental in providing seedlings of improved varieties of vegetables to fellow farmers. She has installed HDPE vermicomposting bed in her backyard


to generate vermicompost from farm waste.

She is now able to sell a good quantity of individual fresh vegetables in the local market. According to her, she is harvesting 12–15 kg of particular vegetables in 2–3 days interval regularly in every season. By providing a fresh supply of vegetables, she easily got some fixed shops in the local market to dispose of her vegetables. Moreover, some families of nearby areas are also giving her advance demand for fresh vegetables. She can now sell vegetables to customers directly from her nutri-garden.


Poly-cement tank technology is boon for water harvesting and ensuring livelihood security

The Himalayan region faces acute water shortage during lean period (October to June) not only for agriculture but also for domestic and other uses despite the fact that region received sufficient rainfall and source of origin of several perennial rivers. Water springs are main source of water for domestic use and also to some extent used for irrigation but springs are getting dried due to unplanned construction activities, deforestation and extension to cultivation in unsafe slopes. The irrigation facilities are meagre (10% irrigated land in hills) and costly. However, hill climatic conditions are more suitable for growing off season vegetables. One of the effective ways to utilize available water from various sources like spring, surface run-off and rain water for crop production and/or harvest this water in storage tank and use for cultivating high value (vegetables, fruits, etc) crops. The *kaccha* tanks/ponds are not suitable viable option in hills due to high percolation losses (300 to 400 litre/m^2/day). The cement tanks are costly (₹ 10 to 15/litre water storage) and prone to damage by earthquake and landslides. The low cost (₹ 0.80 litre water storage) poly-lined tanks are another option to store water. But these poly-lined tanks are also prone to damage by children, wild animals, cattle's and decay of poly film under temperature stress. In view of the above scenario under project AICRP-IWM, ICAR-VPKAS, Almora centre carried out experiments (2011–2017)

Poly cement tank at farmer's field

Kiwi cultivation at farmer's field

to find out most appropriate tank construction technology. After experimentation a poly-cement tank technology was found suitable for storing water to be used for irrigation and other purposes. These tanks were developed by utilizing locally available resources (sand, gravels/stones), costing very low (₹ 1/litre water storage).

The technology was demonstrated in more than eleven villages, i.e. Kotli, Salla Rautela, Naula, Kasson, Jolly, Challar Musouli, Jud, Kaffon, Jogiadhunga, Bhagartola and Artola at the fields of 30 beneficiaries in Kumaun region of Uttarakhand. The tanks were made in participatory mode, farmers bore the cost of labour to dig the tanks, withdrawing of sand and gravels and block preparation and Institute provided silpaulin, pipes, cement and extended technical help for constructing tanks. The estimated contribution of farmers is ₹37,493 and Institute ₹ 52,636 for construction of tank size 21.3×5×1.5 m, which can store 1 lakh litre water. This is widely adopted technology by hill farmers. The same technology was adopted by the Himalayan Environmental Studies and Conservation Organization (HESCO) one of the NGO and they have constructed poly-cement tanks in different villages (Dotial Gaon, Bhakuna, Jairaj in Kumaun region and Jaun Sar area in Garhwal region) of Uttarakhand. A large tank (1.92 lakh litre) was constructed in ICAR-VPKAS, KVK Kafligare farm for demonstrating technology to the farmers.

One-litre water storage cost comes ₹ 1.20 of 25 m^3 tank and ₹ 0.70 of 500 m^3 tank lined with silpaulin and pitched with blocks and fenced with agroshed net using 15 mm square pipe. The fencing is done around those tanks used by farmers to cultivate fish. The tank construction is very economical in comparison to cement tank cost ₹ 7 and ferro cement ₹ 15/litre of water. Institute also used to construct tanks (20 to 100 m^3) by covering poly-film using round river boulders (cost around ₹ 1.30/litre of water). This technology although protects film but the extraction of round boulders is banned/prohibited activity and required permission of government. Moreover

this technology is suitable only in the areas near to river course. The cost of boulders increases if transported higher upland area located at distance from road head and river course. Therefore, present poly-cement tank can be constructed anywhere in upland areas by collecting sand and gravels/stones from the area and only cement can be transported from road head. So, these tanks are more economical than boulder tanks and poly-cement tanks is very easy to construct at any site of hills.

These tanks were found very useful for irrigation and fish cultivation. These tanks are able to tolerate earthquake tremors, temperature stresses and damage by physical factors. These are cost effective with longer life (more than 40 years) than poly lined or cement tanks. The tanks life estimated is based on tanks performance from last 10 years at ICAR-VPKAS Almora farm and farmers field. These tanks are working properly without damage from last ten years. The block covered lined tank is more economical than the polyline tank, as silpaulin lined tanks mostly get damaged every five years and LDPE lined in 3 years. Therefore, one need to repair and line tank eight time with silpaulin and 12 times with LDPE in 40 years, which is expected life of poly-cement tank. Therefore, 100 m^3 LDPE tank will require ₹ 2.32 lakh and silpaulin tank ₹ 2.40 lakh both are almost same and three times more than poly-cement tank.

Vermi-composting and Vermi-wash system in farmers field under tree sheds

The multiple water use model which include 100 m^3 water tanks for fish farming, irrigation, poultry farming, cattle rearing, fruit (kiwi), vegetables and *Azolla* cultivation. The estimated gross returns of ₹ 6 lakh from 4,000 m^2 land by adopting above package. Farmers earned (gross income) around ₹ 1 to 1.5 lakh through fish, vegetables and kiwi cultivation by constructing tanks. The kiwi cultivation in 1,000 m^2 and vermicomposting in 100 m^2 area will increase income of farmer manifolds and give a stabilized production. The livelihood security can be insured by constructing tank and by adopting multiple water use model.

North East Himalayas

Screening cultivated brinjal and wild relatives for resistance against Fusarium wilt: The pathogen *Fusarium oxysporum* f. sp. *melongenae* (Fom) causing fusarium wilt of brinjal is highly diverse and the identification of new sources of resistance for the incorporation of multiple and complementary resistance genes in the same cultivar is the best strategy for durable and stable resistance. The study was conducted to screen different accessions of cultivated eggplant (*Solanum melongena*) and its wild relative's crops

(WRC) for resistance against the virulent strain, Fom-Megh 1 isolated from Meghalaya. Forty-eight genotypes were used for screening the resistant genotypes during 2018–2019. Among all brinjal and WRC genotypes tested, high level of resistance was detected in WRC than cultivated varieties. Edible WRC of brinjal, *Solanum sisymbriifolium* (Man-1), *S. incanum* (MZBR-15), *S. macrocarapon* (*Sentiderm* -MZSEN-1), *S. underatum* (EC 790349) and *S. torvum* (MZTO-1) and *S. aethiopicum* var. *gilo* (Samtrok MZSAM-1, Samtrok MZSAM-2, and MZSAM-3) showed high level of resistance (R) with the least wilt disease index. All cultivated varieties of brinjal, Pusa Bhairav, Pusa Shyamla, Pusa Uphar, Pusa Ankur, Pusa Purple Round were highly susceptible to Fom Megh-1 in the north eastern region and recorded the maximum disease index (DI) up to 100% at fourth week after inoculation. These results are important for breeding resistant rootstocks and cultivars that can be used to manage this endemic disease.

Eco-friendly management practices for managing insect pests of cucumber: Insect pest infestation in cucurbits causes heavy losses through reduction in yield, lowering quality of produce and by increasing cost of production. The extent of losses can be up to 100%, depending on the cucurbit species and the season. Therefore, eight modules were evaluated for eco-friendly management of major biotic stresses in cucumber (variety: Malini) during *kharif* season under field condition. Among the bio-pesticide modules tested, combination of neem oil, fruit fly trap and *Trichoderma* based module was effective in reducing biotic stresses in cucumber. Module I: Neem oil spray + fruit fly trap + *Trichoderma* (seed treatment + foliar spray + soil drenching) showed effectiveness against red pumpkin beetle (0.64 beetle/plant) and fruit flies (14.24% fruit damage) in cucumber, whereas in control (1.8 beetles/plant) and fruit flies (36.5% fruit damage). Module I also recorded 39.03% increase in yield over control plots. Therefore, neem oil + fruit fly trap based module may be considered as an important component for eco-friendly management of insect pests in cucumber for promoting organic production of cucumber in Meghalaya.

Damaged fruits by fruit fly

Leaf damaged by red pumpkin beetle

Package and practices of dragon fruit cultivation under Mizoram condition: Dragon fruit cultivation has a huge potential in Mizoram as the climatic condition is highly suitable for better yield and quality with a high market demand fetching a market price of ₹ 200–250/kg. The fruits start bearing after 15–20 months of planting and can continuously take yield up to 25–30 years with proper orchard management. Dragon fruit has huge neutraceutical properties and many health benefits and can control many diseases. It can therefore be considered as a super fruit, fruit of the future and super food for heart patient. The experiment was conducted to develop standard package to benefit farmers and other allied sectors in Mizoram.

An experiment was conducted to standardize the package and practices in ICAR-RC-NEH Region, Mizoram Centre, Kolasib with different combination of inorganic and organic nutrient managements revealed that application of NPK @ 25-75-75 g/plant along with FYM (@ 2 kg/plant and vermicompost (@ 1 kg/plant) produced more than 3-folds higher yield than control (21.0 t/ha). The INM practice of incorporating NPK, FYM and vermicompost for producing 66.6 t/ha yield of dragon fruit was recommended.

Technologies to detect food-borne pathogens in meat and meat products: Meat and meat products of pig origin often become contaminated with a number of food borne pathogens during and after slaughter. Salmonella spp., *Staphylococcus aureus* and *Clostridium perfringens* are among the top pathogens causing food-borne illnesses and deaths in consumers.

ICAR Research Complex for NEH Region, Umiam, Meghalaya developed three simple, rapid polymerase spiral reaction (PSR) assays to detect *Salmonella* spp., *S. aureus* and *C. perfringens* in pork and its products. This PSR assay to detect *Salmonella* was 10-fold more sensitive than conventional end-point PCR, however comparable to real-time PCR. The limit of detection (LoD) of the developed assay was 4×10^3 CFU/g of pork without enrichment and 4 CFU/g after 6 h enrichment. The detection of 4 CFU/g of pork was achieved within 8 h. The sensitivity of PSR assay to detect S. *aureus* was 100-fold more than real-time PCR. The detection limit of 19.9 CFU/g of pork was attained within 8 h. The assay developed to detect *C.*

perfringens was 100-fold more sensitive than conventional end-point PCR with an analytical sensitivity of 80 fg. The LoD of the PSR and PCR assay was 980 CFU/g and 9.8×10^4 CFU/g of pork, respectively. The detection of 980 CFU/g of pork was attained within 90 min.

Developed novel PSR assays for detection of three important food-borne pathogens in pork and pork products were compliant with the ASSURED (affordable, sensitive, specific, user-friendly, robust and rapid, equipment-free, and deliverable) concept proposed by World Health Organization for the development of diagnostics. Since these assays have multiple advantages over many food-borne pathogen detection assays currently employed; the extensive use of newly developed assays for routine detection of pathogens in small or resource-limited food testing laboratories is expected.

Isothermal RNA Amplification Technology (iRAT) reagents and detection method for Classical swine fever virus (CSFV)/any RNA virus: According to the World Organisation of Animal Health (OIE), Classical swine fever virus (CSFV) is one of the notifiable viruses of swine worldwide. A novel isothermal RNA amplification technology (iRAT) was developed to detect the CSFV genome in the infected tissue samples of pigs. The developed iRAT based CSFV detection method is specific, sensitive, easy to operate and cost effective. The reaction time as well as the detection time was reduced down to just 60 min in comparison to the conventional RT-PCR method which usually takes 150 to 180 min. In addition, the assay is advantageous in terms of enhanced accuracy (detect 5.3 µg/µl of viral RNA as compared with RT-PCR) and cost (₹ 86/ sample against ₹ 905 by conventional RT-PCR).

Island and Coastal Region

Genetic resources

Shweta Kapila: Shweta Kapila, a cattle breed from Goa (submitted by ICAR-CCARI, Old Goa) was registered with ICAR-National Bureau of Animal Genetic Resources, Karnal, Haryana. The accession number of breed is INDIA_CATTLE_3500_SHWETAKAPILA_03048. The breed is found in North Goa and South Goa districts of Goa. It has ccomplete white coloured cattle extending from muzzle to tail switch including eyelashes and muzzle (whitish brown). It has short to medium statured animal with straight face, straight and small horns directed upwards and outwards, and small to medium hump. The udder is bowl shaped and small to medium in size with cylindrical teats having rounded tips. Daily milk yield ranges from 1.8 to 3.4 kg with an average of 2.8 kg and lactation milk yield from 250 to 650 kg. The height ranges from 97 to 137 cm. The population size is approximately 22,000. The Institute is undertaking systematic research on the cattle breed for its suitability in the events of the climate change in the coastal region of the country.

Crop improvement

CCARI Bio 3– Value-added formulation of PGPB (*Bacillus methylotrophicus* STC-4) for vegetables: The population of the bacterium in the value-added formulation is $>10^9$ CFU/g with the shelf life of at least 18 months. There is no difference in the population between standard talc formulation and the value-added formulations. Agro byproduct could be added up to 10% (w/w) to the formulation and the other nutrient supplements could add value to the formulation.

Brinjal seedlings in CCARI Bio 3 treated soil (15 DAS); Control (15 DAS)

Brinjal seedlings in CCARI Bio 3 treated soil (30 DAS); Control (30 DAS)

The value-added formulation was evaluated for its growth promoting efficiency in brinjal and chilli by applying in the soil @ 50 g/m^2. Growth parameters (shoot length, root length, shoot weight and root weight) are higher in the value-added formulation compared to untreated control. No adverse effect was noticed in the value-added formulation applied treatments. Various nursery studies showed that the new formulation improved plant growth in brinjal and chilli.

CCARI Bio 4– Value added formulation of PGPB (*Bacillus methyllotrophicus* RCh6-2b) for vegetables: The population of the bacterium in the value-added formulation is $>10^9$ CFU/g with the shelf life of at least 18 months. There is no difference in the population

Chilli seedlings in CCARI Bio-4 treated soil (15 DAS)

(30 DAS)

between standard talc formulation and the value-added formulations. Agro by-product could be added up to 10% (w/w) to the formulation and the other nutrient supplements could add value to the formulation.

The value-added formulation was evaluated for its growth promoting efficiency in brinjal and chilli by applying in the soil @ 50 g/m^2. Growth parameters (shoot length, root length, shoot weight and root weight) are higher in the value-added formulation compared to untreated control. No adverse effect was noticed in the value added formulation applied treatments. Various nursery studies showed that the new formulation improved plant growth in brinjal and chilli.

Toxicological data of mother culture was generated as per the regulatory guidelines. The bacterium is non-toxic and can be used in agriculture for plant health management.

Activities carried out amid COVID-19: A team of scientists and technical officer of ICAR-Central Coastal Agricultural Research Institute, Old Goa has prepared a 'hand sanitizer' as per the guidelines for 'local production of WHO recommended hand rub formulation' at the Institute laboratory. As per the guidelines, hand sanitizer is prepared using the chemical ingredients-ethyl alcohol or isopropyl alcohol, hydrogen peroxide and glycerol in a prescribed proportion.

As a preventive measure, awareness about COVID-19 through distribution of mask and hand sanitizer prepared by Institute was also undertaken from time to time.

❑

Improving livelihood of the tribal/scheduled caste farmers through upscaling the technologies

Under STC and SCSP program farm and process machinery, technologies developed by ICAR-CCARI like seeds of newly released varieties of paddy, planting material of newly released varieties of cashew, bio-control agents, organic and fertilizer nutrients with soil health cards, pest and disease control agro-chemicals, vegetable seeds, farm tools, pheromone traps and lure traps for pests, fishing gear, artificial fish habitats, arecanut dehusking machines, electric cabinet dryer, sealing machine, mini rotary tiller, power sprayer, brush cutter, coconut tree climbers, bypass fat, milking machines, etc. have been distributed. Training and awareness required was also carried out for capacity building of the farmers. The activity was undertaken for livelihood improvement of the tribal and schedule caste farmers across the Goa and coastal districts of Maharashtra and Karnataka.

"A farmer is a magician who produces money from the mud."

— Narendra Modi

16. Organization and Management

Department of Agricultural Research and Education

The Department of Agricultural Research and Education (DARE) was established in the Ministry of Agriculture, Government of India in December 1973 to coordinate and promote agricultural research and education in the country. DARE provides necessary government linkages for the Indian Council of Agricultural Research (ICAR), the premier research organization for coordinating, guiding and managing research in areas including crop science, horticulture science, natural resource management, agricultural engineering, animal science, fisheries science, agricultural education and agricultural extension in the entire country. With 112 ICAR institutions and 74 agricultural universities spread across the country, this is one of the largest national agricultural research systems in the world. Apart from ICAR the Department of Agricultural Research and Education has other autonomous bodies, viz. Agricultural Scientists Recruitment Board, the Central Agricultural Universities (CAUs) at Imphal (Manipur), Jhansi (Uttar Pradesh), and Pusa (Bihar); Agrlnnovate India Limited, Delhi, under its administrative control. The Agrlnnovate India Limited (incorporated on 19 October 2011) aims to work on the strengths of DARE and ICAR and promotes, and spreads its research and development outcomes. The Agrlnnovate India Limited is an extended independent commercial outfit, which is expected to capitalize on the vast network of the ICAR institutes where the researchers are engaged in their mission to innovate and harness science to provide citizens access to food, nutrition, livelihood and income security.

Indian Council of Agricultural Research

The Indian Council of Agricultural Research is an autonomous organization under the Department of Agricultural Research and Education, Ministry of Agriculture and Farmers Welfare, Government of India. Formerly known as the Imperial Council of Agricultural Research, it was established on 16 July 1929 as a registered society under the Societies Registration Act, 1860 on the recommendations of the Royal Commission of Agriculture. It was reorganized in 1965 and again in 1973, with its Headquarters located in Krishi Bhawan, New Delhi, with support facilities in Krishi Anusandhan Bhawan 1 and 2 and NASC Complex, Pusa, New Delhi. The Union Minister of Agriculture and Farmers Welfare is the President of ICAR. The Principal Executive Officer of the ICAR is the Director General, who also functions as Secretary, Department of Agricultural Research and Education, Government of India. The General Body of the ICAR Society, headed by the Union Minister of Agriculture and Farmers Welfare is the supreme authority of the ICAR. Its members include, Ministers for Agriculture, Animal Husbandry and Fisheries, and the senior officers of the various state governments, Members of Parliaments and the representatives from industry, research institutes, scientific organizations and farming community (Appendix 2). The Governing Body (Appendix 3) headed by the community Director General, who is also the Secretary, DARE is the chief executive and decision making authority of the ICAR. The Governing Body consists of eminent agricultural scientists, educationist, public representatives and representatives of the farmers. It is assisted by the Accreditation Board, Regional Committees, Policy and Planning Committee, several Scientific Panels and Publications Committee. In scientific matters, the Director General is assisted by 8 Deputy Directors General, one each in (i) Crop Science, (ii) Horticulture Science, (iii) Natural Resource Management, (iv) Animal Science, (v) Agricultural Engineering, (vi) Fisheries Science, (vii) Agricultural Education, and (viii) Agricultural Extension, who are also assisted by Assistant Directors General, and are the Heads of their Subject Matter Division (SMDs) for the entire country. SMDs are responsible for extending all technical and financial guidance and support to the research Institutes, National Research Centres and the Project Directorates within their respective Divisions. In addition, Assistant Directors General of National Agricultural Science Fund (NASF), Coordination, Plan Implementation and Monitoring, Intellectual Relations and Human Resource Management also assist the Director General in their respective job roles. The Senior Officers at the ICAR (headquarters) are listed in Appendix 4. The research set up of the ICAR include 112: 72 Research Institutes (Appendix 5), 6 National Bureaux (Appendix 6), 22 Project Directorates and Agricultural Technology Application Research Institutes (Appendix 7), 12 National Research Centres (Appendix 8), and 82 All India Coordinated Research Projects and Network Research Projects (Appendix 9). The Directorate of Knowledge Management in Agriculture (DKMA) functions as communication arm of the ICAR responsible for delivery of information/knowledge generated by the network of the ICAR and its institutions; and addresses mandate of ICAR through publications, information, ICT, Public Relations Unit and CeRA. The ICAR promotes research, education and frontline extension activities in 74 Agricultural Universities, which include 63 State Agricultural Universities, 4 Deemed Universities, 3 Central Agricultural Universities, and 4 Central Universities with agricultural faculty by giving financial assistance in different forms (Appendix 10).

ADMINISTRATION

Filling up of vacant posts: During the year, the following posts were filled up under the promotion quota: five Director/Joint Director cum Registrar, one Director (F)/Comptroller, one Deputy Director (F)/ Chief Finance and Accounts Officer, three Deputy Secretary and three Chief Administrative Officer, eleven Senior Finance and Accounts Officer, three Under-Secretaries, five Senior Administrative Officer, three Deputy Director (OL), one Principal Private Secretary, ten Administrative Officer, nine Finance and Accounts Officer, three Section Officers and two Private Secretary.

Financial upgradation granted under MACP Scheme: During the year, 69 eligible officers and staff of ICAR (Hqrs) and Institutes were granted the benefits of financial up-gradation under the Modified Assured Career Progression scheme in accordance with the Government of India (Department of Personnel and Trainings) instructions in this regard.

FINANCE

The Revised Estimates in respect of DARE/ICAR for 2019–20 was ₹ 7,846.17 crore. An internal resources of ₹ 368.37 crore (including interest on Loans and Advances, income from Revolving Fund Schemes and interest on Short-term Deposits) was generated during the year 2019–20. The total allocation budget estimates for 2020–21 is ₹ 8,362.58 crore.

INTELLECTUAL PROPERTY AND TECHNOLOGY MANAGEMENT

National Agricultural Innovation Fund (NAIF)
Intellectual Property Protection

Patents: During the period under report, 53 new Patent Applications were filed in different subject domains of agricultural sciences at Indian Patent Office (IPO). The cumulative figure of patent applications at ICAR has now risen to 1,172 applications. IPO granted the 59 patent applications in the area of Chemicals (12); Biotechnology (9); Food (7); Mechanical Engineering (7); Pharmaceuticals (6); Agricultural Engineering (3); Agrochemicals (3); Electrical (2); Microbiology (2); and one in each of Bio-Chemistry; Bio-Medical Engineering; Civil; Physics, Polymer Technology; Textile; Traditional Knowledge in Biotechnology, which made ICAR's cumulative number of granted patents to 356. In this process 35 ICAR institutes were involved to protect their innovations.

To protect the plant varieties, 45 varieties (24 extant and 21 new varieties) were filed at Plant Varieties and Farmers' Rights Authority (PPV&FRA). For applications filed earlier, 54 varieties (43 extant and 11 new) were granted registration certificates during this period; which raised the cumulative figure of registered varieties to 900. The cumulative total for plant variety protection applications rose to 1,302.

Copyrights: During the period under report 36 applications were filed by 12 ICAR institutes. A total of 242 filed copyrights were thus recorded from different ICAR institutes.

Designs: 22 applications were filed by five ICAR institutes, which risen the cumulative figure with 53.

Trademarks: 37 trademark applications were filed by eight ICAR institutes for different products and processes. Till date a total of 168 trademark applications have been filed.

Capacity building activities: To create awareness in the subject area of innovation management and technology transfer, different ICAR institutes organized various capacity building programmes at institute/zonal/ national level. In this process, 43 ICAR institutes organized 59 awareness generation programs/interface/ product-specific meets/workshops/seminars, wherein 3,252 scientists/researchers/business professionals/ farmers/social workers benefitted. In order to expose the scientific and technical staff to specific nuances of intellectual property and technology management issues 69 personnel were deputed to attend capacity building programmes organized by different public and private organizations, viz. BIRAC; DBT-NBM-STEM, Hyderabad; FICCI; Kerala Agricultural University; National Biodiversity Authority; NRDC, New Delhi; PPVFRA, New Delhi; RGNIIPM, Nagpur; TIFAC, New Delhi, etc.

Outreach activities: Virtual Workshop-cum Training-Programme on Intellectual Property Rights in Agricultural Research and Education in India, during 12–28 September 2020 was jointly organized by IP&TM Unit of ICAR and NAHEP. The participation was through nomination and more than 100 faculties of SAUs and about 150 scientists from ICAR institutes including PIs/ In charges of ITMUs/ZTMCs/ABIs registered for the programme. The workshop was aimed to provide a complete overview and knowledge regarding protection and management of IPR in agriculture. The programme was designed with 14 technical sessions of one hour duration on each day.

Virtual workshop and review meeting of National Agriculture Innovation Fund (NAIF) was conducted on 9–10 October 2020, to review and monitor in detail the performance of individual ZTMCs/ITMUs/ABIs; to deliberate and derive achievable future targets; to identify where improvements/changes could be made in the Scheme for achieving the overall objectives more effectively and efficiently. In this meeting the participants were members of the Steering Committee of NAIF, the PIs/In charges of ZTMCs (2)/ITMUs (23)/ABIs (14) under Crop Science Division and personnel from IP&TM Unit, ICAR.

Technology transfer/commercialization: The period also witnessed increasing involvement of ICAR institutes in agribusiness activities with public and private sector organizations for partnerships in research and technology commercialization.

Technology licensing: This year, 297 such partnership agreements were developed with 208 public and private organizations and 25 farmers/entrepreneurs. In this process 41 ICAR institutes were involved from different Subject Matter Divisions, and transferred 227 technologies in different disciplines include; Animal Production Technologies (18); Crop Production Technologies (12); Farm Machinery and Tools (25); Fish Farming and Processes (19); Food Processing Technologies (59); Plant Protection Technologies (23); Seed and Planting Material (63); Textile Process (4); and four technologies from allied sectors. The highest number of technologies were developed by the ICAR-IIHR, Bengaluru (33); followed by ICAR-CPCRI, Kasargod (27); ICAR-CIRCOT, Mumbai (20); and 17 each by ICAR-CARI, Izatnagar; ICAR-CIFT, Cochin; and ICAR-IIVR, Varanasi.

Of 297 partnerships, 90 were IP protected technology (i.e. protection under Design/Patents/Trademark/ Copyright/PPV&FR registry) partnerships.

Professional service: This year, 325 such partnership agreements were formed for Consultancy/Contract Research and Service with 174 public and private organizations. In this process 24 ICAR institutes were involved from different Subject Matter Divisions, by providing 301 professional services.

Incubation fund

To enhance the agri-business environment at Council 50 Agri-Business Incubation (ABIs) Centers were supported at various institutes for facilitating the entrepreneurs/innovators/scholars/start-ups. During the reporting period, these centers had facilitated 235 such stakeholders for their business incubation activities. These efforts, motivated 214 entrepreneurs/startups to initiate their own business. To provide awareness and training on agri-business enterprises 94 Entrepreneur Development Programme (EDPs) were organized by these centers, wherein different stakeholders were benefitted. To boost-up the partnerships with public and private organizations, 563 meetings/negotiations/ technology discussions were organized. These centers were also visited by 2,347 technology seekers/inventors/ business people/VIP/VVIP/ foreigners.

ICAR-NAARM conducted a Virtual Orientation Workshop and Training Program in collaboration with IP&TM Unit for 50 ABI Centres of ICAR during 17–19 August 2020 on Micro Soft (MS) team's platform where 58 Principal Investigators (PIs) and Co-PIs of these centers participated. The pedagogy of the porgramme was sharing the experiences of 25 old ABIs, with recently opened 25 new ones through lectures and group discussions. The basics of incubation system and critical success factors; design thinking and operational guidelines for ABIs; entrepreneur's selection and services; IP issues; and grass root innovations were the core areas for discussion. The top officials of ICAR shared their views and observations with the way forward for better agri-business environment.

Progressive use of Hindi

Joint Hindi Advisory Committee of Agriculture, Co-operative and Farmers Welfare Department and Department of Agricultural Research and Education (Indian Council of Agricultural Research) was re-constituted under the Chairmanship of Minister for Agriculture and Farmers Welfare and its meeting is scheduled to be conducted shortly. During the period under report, 4 ICAR Institutes/Centres were notified in the Gazette under Official Language Rule 10(4). Till date 141 ICAR institutes/centres have been notified. During the period under report, 4 meetings of Official Language Implementation Committee were organized. Three meeting of the Joint Official Language Implementation Committee of DARE and ICAR were held under the chairmanship of Special Secretary, DARE and Secretary, Indian Council of Agricultural Research/ senior officer nominated by him. One meeting was held under the chairmanship of Secretary, DARE and Director General, ICAR.

In most of the ICAR Institutes/Centres, Official Language Implementation Committees were constituted and their meetings are being conducted regularly. Proceedings of these Committee meetings received at the headquarters were reviewed regularly and appropriate suggestions were given to the concerned institutes for taking remedial measures. The quarterly progress report is sent online to the Regional Implementation Office of Rajbhasha Department situated at Delhi. The quarterly progress reports received from various institutes are reviewed and suggestions are given to them for effective implementation. ICAR is participating regularly in TOLIC's meetings. The employees are nominated regularly for Hindi language, Hindi typing and shorthand

training. At headquarters, training in Hindi typing on Unicode is also being imparted by the Hindi Anubhag. During the period from 1.10.2019 to 30.09.2020, 3 Hindi Workshops were conducted. First such workshop was conducted on 27.11.2019 for officers of Technical Category on Work Efficiency and Stress Management and 18 officers participated in this workshop. Second workshop was conducted on 26.06.2020 through video conferencing mode for Section Officers on Stress free and Efficient Management of Official Work, in which 22 officers participated. Third workshop was conducted for Under Secretaries on 28.09.2020 on Crash Translation for Executive Official Work in Simple Hindi as per Official Language Policy and Rules and 15 officers participated in this workshop.

As usual, during this year also, Rajbhasha week/ fortnight/month was organized at Council's Headquarters and its institutes. At Council headquarters, various Rajbhasha Competitions were conducted. Rajbhasha Ullas Pakhwara was organized at Council's Headquarters from 14 September 2020 to 29 September 2020. On the occasion, the inspiring messages of Union and State Ministers for Agriculture and Farmers Welfare were issued. The Director General also issued an online video appeal thereby urging all officers/employees to do their maximum official work in Hindi. Under the Cash Award Scheme of Official Language being run at Council Headquarters, 10 personnel were given cash awards for doing their maximum work in Hindi during the year 2019-20. Two more award schemes are being implemented by the council at its own level which are as follows.

Rajarshi Tandon Rajbhasha Puraskar Yojana: Under this scheme, Institutes falling under 'A', 'B' and 'C' linguistic region awarded region-wise in different categories for excellent implementation of official language. During the year 2018-19 the following Institutes were awarded for doing their maximum work in Hindi:

	Largest Institutes	Award
I.	1. Indian Agricultural Research Institute, New Delhi	First Prize
	2. Central Potato Research Institute, Shimla	Second Prize
II.	**Awards to other Institutes/Centres of 'A' and 'B' Region**	
	1. National Fisheries Genetic Resources Bureau, Lucknow	First Prize
	2. Directorate of Mushroom Research, Solan	Second Prize
III.	**Institutes/Centres of 'C' Region**	
	1. Central Fisheries Technology Institute, Cochin	First Prize
	2. Sugarcane Breeding Institute, Coimbatore	Second Prize

Ganesh Shankar Vidyarthi Hindi Patrika Puruskar Yojana: This scheme is applicable for the Official Language Magazines being published by various Institutes. Under this scheme, awards are given away in two categories, one is for A, and B regions institutes combined and other is for institutes located in 'C' region for the best magazine. During the year 2018–19, the magazine of the following Institutes were awarded. Details are as under:

Name of selected magazine	Name of the Institute	Award
For A and B region Institutes		
Maru Baagvani	Central Institute for Arid Horticulture, Bikaner	First
Dugdh Ganda	National Diary Research Institute, Karnal	Second
Prasanskaran Pragati	Central Institute of Post-Harvest Engineering and Technology, Ludhiana	Third
Institutes of C Region		
Neelitima	Central Institute of Freshwater Aquaculture, Bhubaneshwar	First
Dhaan	National Rice Research Institute, Cuttak	Second
Baagvani	Indian Institute of Horticultural Research, Bengaluru	Third

In accordance with the instructions/orders of Official Language Department, Ministry of Home Affairs, a total of 11 Institutes were inspected for assessing the progress of Hindi during the period under report and suggestions were given to rectify the shortcomings observed during the inspection. This also includes inspections of Parliamentary Committee on Official Language. House journal of ICAR Headquarters '*Rajbhasha Alok*' depicting the Hindi activities of different institutes is being published regularly and the edition of the magazine for the year 2019 was released through video conferencing by Union Minister of Agriculture and Farmers Welfare on 16 July 2020 on the occasion of the foundation day of the Council. Keeping in view of the guidelines issued by Finance Ministry, decision was taken to release all the publications in audio-form. Various training programmes of public interest and useful for the farmers are being organized in Hindi and regional languages by various ICAR institutes. There has been a significant progress in the use of Hindi and other regional languages in respect of all the agricultural extension activities being undertaken by the KVKs situated in Hindi speaking regions and the Council. Besides, all materials to be presented in the Parliament, works related to annual action report, review of grants-in demand, governing body, Standing finance committee, Parliamentary Committee of Ministers of Agriculture, including annual general body meetings of ICAR Society, all proceedings of these various meetings were prepared bilingually in Hindi and English. The Agriculture Minister and other Senior

Officers delivered their addresses in Hindi. Their speeches were originally drafted in Hindi in the Council.

TECHNICAL COORDINATION

Two meetings of Directors of ICAR institutes and ATARIs were held under the Chairmanship of Secretary, DARE and DG, ICAR through Video Conferencing (VC). All the 114 Directors of ICAR institutes and ATARIs besides, Secretary, ICAR, Financial Advisor DARE/ ICAR, DDGs, ADG and senior officers from the ICAR Headquarters attended the meeting from their respective locations. First one was held on 19 March 2020 before the lockdown decision, wherein all Directors and senior officers from SMDs were asked to provide all possible assistance/ advisories to farmers and government in this critical situation of COVID-19 which should help not only sustain their farm activities but also to take care of their health and welfare. Second meeting through Video Conferencing was held on 10 April 2020 wherein it was emphasized to strictly follow lockdown guidelines, maintain hygiene, use of mask and social distancing in any circumstances. Besides these, various action points regarding the research protocols to be developed and observed were decided. It was emphasised to ensure the technology and input delivery among the farmers and other stakeholders using ICT and all other possible means were decided to minimise the impact of the COVID-19 on farmers agricultural sector. It was also decided to assess the losses in various agricultural commodities due to the pandemic along with the strategies for its mitigation. Need to create a bank of breeder's seed to mitigate emergency situations and to study the plant pathogens including viruses along with the host resistance along with the host-pathogen interaction to improve the preparedness to address such issues in future were emphasised. Use of plant genetic resources to identify resistance genes especially for viral diseases was identified as the top priority area of agricultural research.

Meetings of ICAR Regional Committees No. I and II were held on 30 June 2020 and 8 October 2020 through Video Conferencing from ICAR, New Delhi. The meeting of RC-I was inaugurated by Shri Narendra Singh Tomer, Agriculture Minister. Shri Parsottam Rupala and Shri Kailash Choudhary, Ministers of State for Agriculture and Farmers Welfare participated as the guests of Honour. The meeting of RC-II was inaugurated by Shri Parsottam Rupala, Minister of State for Agriculture and Farmers Welfare. Shri Kailash Choudhary, Minister of State for Agriculture and Farmers Welfare participated as the

Success stories of entrepreneurs/start-ups

Shri Mohammed Fawas T C, a 21 years old highly ambitious young man ventured to start the entrepreneurship in seafood sector with the Ready-to-Eat (RTE) Mussel products. The mussels are considered as one of the most nutritive foods, which stimulates the brain functions, improves heart health, promotes cellular functions, facilitates blood circulation, reduces arthritis and prevents anaemia and asthma. Shri Fawas and his partners consulted the ICAR-Central Institute of Fisheries Technology (CIFT), Cochin to get the technical support for improved packaging of RTE Mussel Produces, where institute had suggested the technique of thermal processing or high temperature processing for product storage without adding any chemical preservatives to enhance the products' shelf life at room temperature. Shri Fawas got registered as an Incubatee at the Agri-business Incubation Centre of ICAR-CIFT during the month of November, 2018.

The ICAR-CIFT-ABI provided him with the necessary technical supports for processing the Classic Malabar Snack "Stuffed Green Mussel" from the inception stage itself. It involved procurement of fresh Green Mussels, stuffed with traditionally blended rice and other ingredients, then packed carefully in food grade retort pouch at high temperature, sufficient to kill pathogens of public health significance and, thus, increasing the product's shelf life. After the successful test marketing, Shri Fawas registered a company during April-2019 by the name of M/s Foo Foods Pvt Ltd at Chaliyam, Kozhikode to create a marketing brand "FOO FOODS" for the product. The technology was transferred by ICAR-CIFT through the signing of a Memorandum of Understanding with the party. Later, Dr Trilochan Mohapatra, Secretary (DARE) and DG (ICAR) launched the product christened as *Kallummakkaya Nirachath* on 25 May 2019.

The RTE stuffed Mussel product "Kallummakkaya Nirachath" was highly appreciated by the consumers and retailers in respect of its quality, taste and cost. The product is now available in the Hypermarkets and Supermarkets in Kozhikode and Malabar regions throughout the year with a market price of only ₹ 140/pack (125 g) containing five stuffed Mussels. The cost of production was estimated to be ₹ 740/kg of mussels with average monthly production of 375 kg of RTE stuffed Mussel products. The net profit of the company after meeting all the expenditures is around ₹ 142,500/month with BCR 1.51.

guests of Honour. The Regional Committee Meetings held once every two years, provides an ideal platform for reviewing the status of agricultural research, education and extension in the mandated states and union territories. The Committee provides a forum for liaison and coordination among the institutes of the Indian Council of Agricultural Research (ICAR), State Agricultural Universities (SAUs) and State Departments of Agriculture, Horticulture, Animal Husbandry and Fisheries. Ministers of Agriculture/ Horticulture/ Animal Husbandry/Fisheries and the Secretaries of various agriculture and allied departments of State Departments, Members of ICAR Governing Body, Senior Officials from ICAR Headquarters and State Departments, Vice-Chancellors of SAUs, Directors and Scientists of ICAR Institutes in the region participated in the meeting, which is chaired by Secretary DARE and DG, ICAR. The problems being faced by the states in the areas of agriculture and allied fields and the technology options/ potential solutions available to be developed by the National Agricultural Research System (NARS) were discussed threadbare and actionable points were identified and assigned to the respective ICAR Research Institutes/ Agricultural Universities/KVKs to be resolved in a targeted time frame. The action taken on the issues raised in the previous Regional Committee Meetings were also reviewed.

During the period October, 2019–2020 to the Council provided financial support to 56 societies for the publication of Scientific Journals. In addition, Societies/ associations/universities were supported for holding National Seminars/ Symposia/Conferences (72 Nos) and International Seminars/Symposia/Conferences (33 Nos).

Annual Report of DARE/ICAR for the year 2019–2020 along with review statement was laid on the table of Lok Sabha (17.03.2020) and Rajya Sabha (19.03.2020). The Annual Account and Audit Report of ICAR for the year 2018–2019 along with review and delay statement was laid on the table of Lok Sabha and Rajya Sabha on 17.03.2020 and 12.03.2020, respectively.

The Umbrella Memorandum of Understanding (UMoU) are being signed between the ICAR and host Institutions, i.e. Central/States Agricultural Universities and other Departments to co-operate in conducting research through All India Coordinated Research Projects (AICRPs) / Revolving Fund Scheme / and any other such schemes funded/ sanctioned by the Council under various schemes to the Host Institution from time to time at specified location(s) under the specified Supervisor/ Principal Investigator/Leader of the Host Institution. Total 44 such UMoUs were signed with the Central/State Universities. Besides these, 14 Memorandum of Understanding (MoUs) were signed with other organizations to collaborate research activities of national interest.

92nd Foundation Day of ICAR and Award Ceremony

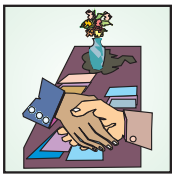
Incentivizing individual employees and teams for their outstanding performance, across organizations, makes them more efficient, responsive and productive apart from improving their level of job satisfaction. The awards, besides recognizing merit and accomplishments, generate healthy competition among individuals, groups and institutions to strive and attain still higher levels of excellence in their respective areas of work. The Indian Council of Agricultural Research has been recognizing and rewarding the institutions, scientists, teachers, farmers and agricultural journalists every year. To commemorate 92nd Foundation day of ICAR, the Award ceremony was organized at Krishi Bhawan, New Delhi through video conferencing on 16 July 2020. Various Awards were presented to the winners on the occasion. The awards were given in 20 different categories to 161 awardees, these comprise 94 scientists, 10 administrative personnel (including 2 women), 6 journalists and 31 farmers (including 5 women farmers). It is heartening to note that among 94 scientists, 12 were women. Two Institutes,1 university, two AICRPs, 14 KVKs were also awarded.

❑

Coconut chips positioned to become the NewGen coconut product

Over the years, the novel coconut product developed by the ICAR-CPCRI has become a consumer product across India. It is a ready to eat, non-fried crispy snack prepared from 8 to 9 months old coconut. The fresh kernel is cut into thin slices and subjected to osmotic dehydration and electric drying thereafter. It is an emerging, globally high demand micro food enterprise. The Institute has transferred the technology know-how of coconut chips to 38 licensees till now. Out of these, 20 firms are producing coconut chips regularly. These firms realize an output of 6 to 45 tonnes a year. The retail price of coconut chips varies

from ₹ 800 to ₹ 1,500/kg. The entrepreneurs are adding further value addition to chips in terms of flavours and packaging types. Some of the firms have started exporting of coconut chips to Canada, USA and Gulf countries. One of the attractions of this technology is its low investment requirement. One can start a moderate unit with an investment of ₹ 5 lakh. Such a unit will employ three persons regularly. The efforts of ICAR-CPCRI to promote marketing of coconut chips, especially under NAIP on value chain in Coconut had also contributed substantially for creating consumer awareness.



17. Partnership and Linkages

DARE

International collaboration

Consultative Group on International Agricultural Research (CGIAR) is a global partnership that unites international organizations engaged in research for a food-secured future. CGIAR research is dedicated to reducing rural poverty, increasing food security, improving human health and nutrition, and ensuring sustainable management of natural resources.

India is a donor member country to CGIAR from decades and also a voting member in CGIAR system. The Council, represents South Asia Constituency along with two alternate partner countries, viz. Bangladesh and Sri Lanka. India has assumed important role in CGIAR system as a permanent voting member. This responsibility requires reciprocation from India also. Accordingly, it contributes to CGIAR system through budget provisions of DARE/ICAR.

CGIAR research is carried out by 15 CGIAR centers in close collaboration with hundreds of partners, including national and regional research institutes, civil society organizations, academia, development organizations and the private sector. Out of the 15 Centres, ICAR/DARE has strong collaboration in the field of agricultural research, education and capacity building.

Work plans

- A Work Plan for the period 2020–2021 was signed on 04.12.2019 between Indian Council of Agricultural Research (ICAR), New Delhi, India an autonomous body under the aegis of DARE and The International Fertilizer Development center (IFDC), Alabama, USA. This Work Plan was signed under the provision of Memorandum of Understanding (MoU) for Cooperation in Agricultural Research and Education signed on 16 May 1994 between ICAR, New Delhi, India and IFDC, Alabama, USA.
- A Work Plan for the period 2020–2021 was signed on 13.02.2020 between ICAR, New Delhi, India, an autonomous body under the aegis of DARE and The Agricultural Research Council, Pretoria, South Africa. This Work Plan was signed under the MoU for Cooperation in Agricultural Research and Education signed on 26 July 2018 between ICAR, New Delhi, India and The Agricultural Research Council, Pretoria, South Africa.
- A Work Plan for the period 2017–2019 signed on 3 October, 2017 between ICAR, New Delhi, India, an autonomous body under the aegis of DARE and The Sri Lanka Council for Agricultural Research Policy (SLCARP), Sri Lanka was extended up to December, 2020. This Work Plan was signed under the MoU between ICAR, New Delhi, India and Sri Lanka Council of Agricultural Research Policy (SLCARP), Sri Lanka for scientific and technical cooperation concluded on 2 July 1998.
- Work Plan for the period 2020–25 between ICAR and International Food Policy Research Institute was signed on 1 May 2020. Work-plan (2020–25) was developed in accordance with the MoU signed between ICAR and IFPRI in 1988 and for keeping with their desire to promote and accelerate the collaborative efforts for research and training in food and agricultural policy.
- An MoU was signed on 23 October 2020 between ICAR, New Delhi, India and Asia-Pacific Association of Agricultural Research Institutions (APAARI), Bangkok, Thailand for cooperation in agricultural research and education.

Collaborative research projects

Following projects are under different stages of progress.

- "Exploitation of Inter-specific Diversity for Durum Wheat Improvement" in collaboration with University of Nottingham, International Center for Agricultural Research in the Dry Areas (ICARDA) and International Wheat and Maize Research Centre (CIMMYT) and ICAR-Indian Institute of Wheat and Barley Research (IIWBR), Karnal for the year 2015–2018 and extended for the year 2019.
- Deployment of high-yielding stress tolerant and top industrial quality durum wheat elites to targeted growing regions of India, in collaboration with Indian Agricultural Research Institute (IARI), New Delhi and International Centre for Agricultural Research in the Dry Areas (ICARDA).
- Management and mitigation of the spread of Tropical Race 4 of *Fusarium* wilt on Banana—Mapping of the TR 4 affected area of Banana in India, in collaboration with ICAR-National Research Centre for Banana (NRCB), Trichy and Bioversity International (BI), Rome, Italy.
- Evaluation of Sunflower pre-bred lines for stress resistance and associated trade-offs with yield.
- Impact of emerging nanomaterials and environmental contaminants on human and livestock reproductive health and identification of biomarkers.
- The mechanism behind formation of coocable milk gels (GELCOOK).

- Transfer of mitigation technologies for heat stress in farm animals.
- Assessing the productive and adaptive of two different goat breeds to heat stress based on differences in the phenotype and genotype traits.
- Dialogues in Gender and Coastal Aquaculture Gender and the seaweed farming value chain.
- Global Challenges Research Fund (GCRF) south Asian Nitrogen Hub.

Germplasm exchange

The cases of export of germplasm are processed in IC- Division as per the provisions/guidelines of the Biological Diversity Act, 2002 and the Biological Diversity Rules, 2004 also subject to guidelines/ notifications issued by Ministry of Environment and Forests, from time to time.

The six Bureaus/Institutes under ICAR system were designated by Ministry of Environment and Forests to act as repositories under the BD Act, 2002 for different categories of biological resources. Approvals of competent authority in respect of 2 cases were conveyed.

Annual Membership Contribution

Annual Contribution to Centre for Sustainable Agricultural Mechanization, CSAM (Regional Institution of UN ESCAP) Beijing, China amounting to US$ 15,000 was released for the year 2019–2020 on 07.01.2020 and for the year 2020–2021 on 15.09.2020. India's Annual Contribution was paid to Network of Aquaculture Centres in Asia-Pacific (NACA), Bangkok, Thailand for the years 2019–20 in March 2020. Annual contribution payable to NACA is US $ 60,000/annum.

Indo-ASEAN Research Collaboration

The 5th ASEAN India Ministerial Meeting on Agriculture and forestry (AIMMAF) was held during 16–17 October, 2019 at Brunei Darussalam. The Ministerial Meeting reaffirmed the commitment to contribute towards the vision and priorities of the ASEAN-India Partnership for Peace, Progress and Shared Prosperity (2016–2020), post-2015 Sustainable Development Goals and related goals of the UN Zero Hunger Challenge.

Indo-BIMSTEC Collaboration

International Seminar on Climate Smart Farming Systems for BIMSTEC member states was held during 11–13 December, 2019 in New Delhi wherein 13 delegates from BIMSTEC countries and BIMSTEC Secretariat attended the Seminar.

BIMSTEC delegates visited IARI and expressed their interest to take IARI model to their country.

The delegates visited the ICAR-Indian Indian Institute of Farming Systems Research (IIFSR), Modipuram and visited the farmers' field and different IFS models developed and interacted with different stakeholders. They were exposed to parallel production system of Integrated Organic Farming system and towards Organic Agriculture promoted by the institute at village Sardhana of Meerut district. The delegates were also given first hand/practical information on preparation of liquid/solid manures for organic farming besides interaction with participants of Certified Farm Advisor on Organic Farming. BIMSTEC delegates have also visited ICAR-Central Potato Research Institute campus (CPRI), Modipuram and ICAR-Central Institute for Research on Cattle (CIRC), Meerut and interacted with the scientists about climate resilient technologies and food systems.

Over all, the International Seminar on Climate Smart Farming Systems brought new insights and enriched the very process of the cooperation amongst BIMSTEC countries.

Indo-Afghanistan Research Collaboration

IARI is playing important role in developing trained human resource for agricultural research in Afghanistan and in establishing Afghan National Agricultural Sciences and Technology University (ANASTU) at Kandahar in Afghanistan, with the support of the Ministry of External Affairs (MEA), Government of India under the bilateral cooperation programme between Afghanistan and India. IARI conducted various activities during the year.

Indo-SAARC Collaboration

India is collaborating in promoting Agricultural Sectoral Research and Developmental activities in the SAARC Region. Several training proposals were received from SAARC Secretariat/SAARC Agriculture Centre (SAC) and the same were conducted successfully by obtaining necessary clearances and coordinating between SAARC Sectt., ICAR Institutes and other organizations. Institutional charges were waived off for the SAARC Programmes held at ICAR Institutes.

Foreign visits/deputations

- Secretary (DARE) & Director General, ICAR who is also the Vice-Chair of the Executive Committee of APAARI has participated in Online Executive Committee Meeting (ECM) of Asia-Pacific Association of Agricultural Research Institutions (APAARI) held from July 8–10, 2020 through digital video conferencing.

- Dr Ganesh Vasudeo Chaudhari, Scientist, VPKAS, Almora attended 38th International Vegetable Training Course (Vegetable Breeding for the Tropics) organized by World Vegetable Center, East and Southeast Asia, Bangkok at Thailand during 18/11/2019 to 29/11/2019.
- Dr J K Saha, Head of Division/Regional Station ICAR-Indian Institute of Soil Sciences departed for training "Exchange Training and Learning on Innovations and Options for Soil Protection and Rehabilitation" in Benin from 04/11/2020 to 09/11/2020.
- Mr Mohammed Koya K, Scientist, ICAR-Central Marine Fisheries Research Institute, Kochi attended Leadership Training Course on Fisheries Resources Management (LTCFRM) 2019 organised by Overseas Fishery Cooperation Foundation of Japan, Tokyo during 06/11/2019 to 09/12/2019.
- Dr Anil Rai, ADG (ICT), ICAR Hqrs., New Delhi attended the Chief Information Officer e-Governance Leadership Programme at Victoria University Wellington, New Zealand from 11/11/2019 to 15/11/2019.
- Dr Vartika Srivastava, Scientist, ICAR-NBPGR, New Delhi attended Cryopreservation of Tropical Crop Species organized by Laboratory of Tropical Crop Improvement, Katholieke Universiteit (KU), Belgium from 25/11/2019 to 23/12/2019.
- Dr R A K Aggarwal, Principal Scientist, ICAR-NBAGR, Karnal attended training on "Using Genebank Material for Livestock Populations, case studies and Optimisation using MoBPS Software organized by Agro Paris Tech & Image Consortium at Paris Tech., France from 20/11/2019 to 22/11/2019.
- Dr Kanchan Kumar Singh, Assistant Director General (FE), ICAR attended 15th Session of the governing council of the Centre for Sustainable Agricultural Mechanization on Asia and Pacific from 27/11/2019 to 29/11/2019 organized by UNESCAP-Centre for Sustainable Agricultural Mechanisation (CSAM), Jeonju, Republic of Korea.
- Dr Shaik N Meena, Principal Scientist, ICAR-IIRI participateed in the stakeholders workshop on "Digital Extension" organized by International Fund for Agricultural Development (IFAD) at United Nation Body for 4 days from 06/12/2019 to 09/12/2019 in Egypt.
- Dr Pawan Kumar, Scientist, ICAR-IVRI, Izatnagar attended Long Term CMR-DHR International fellowship of Indian Council of Medical Research for young bio-medical Scientist at Wake Forest School of Medicine, Winston-salem, North Carolina from 01/02/2020 to 31/01/2021.
- Dr Soumen Naskar, Senior Scientist, ICAR-IIAB, Ranchi for INSA fellowship under Bilateral Exchange Programme organized by National Animal Science Research Institute, Nepal Agricultural Research Council, Khumaltar, Lalitpur, Nepal from 17/12/2019 to 03/01/2020.
- Dr S K Mangrauthia, Senior Scientist, ICAR-IIRR, Hyderabad for 2019 Borlaug International Agricultural Science and Technology Fellowship Programme Borloug Fellowship at The Louisiana State University in Baton Rouge, USA from 13/12/2019 to 08/03/2020.
- Ms Usha Rani Pedireddi, Scientist, ICAR-IARI, New Delhi for pursuing PhD under ICAR International fellowship Texas A&M University, USA for period of 3 years from 16/12/2019 to 16/12/2022.
- Dr Ajay Kumar, Scientist, ICAR-IVRI, Izatnagar for availing Long Term ICMR-DHR (Indian Council of Medical Research Department of Health Research, New Delhi) International Fellowship for young-Bio-medical Scientists 2019–20 at Auburn University, USA from 15/01/2020 to 14/01/2021.
- Dr K Lakshmi, Senior Scientist, ICAR-SBI, Coimbatore attended Indo-US visiting fellowship organized by University of Florida, Department of Microbiology and Cell Science, Florida, USA from 26/1/2020 to 26/08/2020.
- Dr Veeresh Kumar, Scientist, ICAR-NBAIR, Bengaluru attended Full Bright Nehru Fellowship at North Carolina State University, Raleigh, USA for a period of 24 months from 01/03/2020 to 28/02/2022.
- Dr Balvinder Kumar, Principal Scientist, ICAR-

NRCE, Hisar attended International Veterinary Vaccinology Network Laboratory Exchange Award, Roslin Institute, University of Edinburgh at Animal Health Trust, New Market, UK from 01/03/2020 to 30/04/2020.

- Mr Pushpendra Koli, Scientist, ICAR-Indian Grassland and Fodder Research Institute (IGFRI), Jhansi for attending ICAR International Fellowship at Murdoch University, Australia for a period of three years from 16/03/2020 to 15/03/2023.
- Dr Bappa Das, Scientist, ICAR-Central Coastal Agricultural Research Institute, Goa for attending Agriculture Research Organization, Israel Postdoctoral Fellowship 2020–21 at Institute of Soils, Water and Environmental Sciences, Israel from 01/04/2020 to 31/03/2021.
- Dr Shaik N Meera, Principal Scientist, ICAR-IIRR, Hyderabad attended Technical Session on "Realizing the Potential of Digital Extension Strategies" in the International Forum on Innovation in Agriculture and Food Systems for achieving SDGs at Riyadh, Saudi Arabia from 15/03/2020 to 17/03/2020.
- Dr Shashank P R, Scientist, ICAR-IARI, New Delhi attended visit and training on Sphingidae Museum management sample's DNA analyses and collection treatments organized by Ekologicke Centrum Orlov-Sphingidae Museum, Czech Republic from 15/03/2020 to 21/03/2020.
- Mr T Lakshmi Pathy, Scientist, ICAR-SBI, Coimbatore for pursuing PhD Under ICAR International Fellowship at Commonwealth Scientific and Industrial Research Organization (CSIRO) in collaboration with University of Queensland, Brisbane, Australia for 3 years from 01/04/2020 to 31/03/2023.
- Ms Divya Parisa, Scientist, ICAR-ATARI, Zone-VII, Umiam for attending ICAR International Fellowship organized by University of Kiel, Germany for 3 years from 01/05/2020 to 30/04/2023.
- Mr Hemant Balasaheb Kardile, Scientist, ICAR-Central Potato Research Institute, Shimla for pursuing PhD under Graduate School Oregon State University Heckart Lodge 2900 SW Jefferson Way Corvallis, Oregon 97331 USA from 14/12/2020 to 13/12/2023.
- Dr Kuldeep Kumar Lal, Director, National Bureau of Fish Genetic Resources (NBFGR), Lucknow visited Bangkok, Thailand from 5 to 7 November 2019 and attended the regional consultative workshop on Strengthening Governance of aquaculture for sustainable development in Asia and related country review studies and demographic change in Fishing communities in Asia organized by NACA and FAO-RAP.
- A delegation led by Dr Joy Krushna Jena, DDG (Fy. Sci), ICAR and Dr J P Mishra, ADG (PIM) being one of the members from ICAR visited Hanoi, Vietnam for attending India-Vietnam Joint Working Group on Agriculture meeting held from 18 November to 21 November 2019.

CENTRAL AGRICULTURAL UNIVERSITIES

Central Agricultural University (CAU), Imphal (Manipur)

Central Agricultural University (CAU), Imphal was established in the year 1993 under the Central Agricultural University Act, 1992 of the Parliament (Act No. 40 of 1992). The university is a fully residential university having 13 constituent colleges covering 7 North-East Hill states under its jurisdiction except Assam.

Academic activities

The University offered 9 Undergraduate, 38 Masters and 21 PhD Degree Programmes in different subjects/disciplines through its 13 constituent colleges. On the recommendations of the ICAR Peer Review Team, the National Agricultural Education Accreditation Board, ICAR, New Delhi granted accreditation for various academic programmes (UG/PG/PhD's) to the Central Agricultural University, Imphal (Manipur) and its constituent colleges from 28 March 2016 to 27 March 2021.

A total of 506, 183 and 38 students including 13 foreign students were admitted in various Under-graduates, Masters and PhD programmes, respectively during the academic year 2020–21. A total of 328 UG and 140 PG students completed their degrees and 21 students were also awarded PhDs during this period.

Till date, 73% of the passed out students from this University are already employed/absorbed in government departments. During the period under report, 10 students have qualified Agricultural Research Service (ARS), 14 students Junior Research Fellowship (JRF) examination and 4 students ICAR SRF examination. Two students, viz. Keisham Geenita and D Bernice Ekhe topped in the ICAR AIEEA JRF examination in the streams of Fisheries Science and Community Science respectively.

Research activities

At present, the university has 75 ongoing internally funded research projects and 112 externally funded projects including 35 All India Coordinated Research Projects (AICRPs) and 4 All India Network Research Projects (AINRPs). Farmer friendly technologies (86) and location specific recommendations (380) in the field of agriculture and allied disciplines were developed for adoption by the farmers and agri-preneurs of NEH Region. Three varieties of rice, viz. CAU-R2 (Tomthinphou), CAU-R3 (Mangalphou) and CAU-R4 (Enotphou) were released and notified in the Gazette. One patent on Multi-Column Sand Filter a Method Thereof was also granted during the reporting year.

Faculties of constituent colleges of the university have published 825 research literatures comprising 342 full length research and 45 digital object identifier articles, 76 seminar proceedings, 138 papers presented in seminars, symposia, 76 popular articles, 15 books, 32 book chapters and 101 manuals/pamphlets etc.

Extension activities

The programmes implemented during the year include trainings, demonstration, field days, kisan melas, farmer congress, exhibitions, radio talks, TV telecast, film shows, workshop, etc. Transfer of technology activities were planned and coordinated in different districts of the seven states through its 13 constituent colleges, six Krishi Vigyan Kendras and six Multi Technology Testing and Vocational Training Centres.

Capacity building training programmes (46) for 861 extension functionaries of the line departments, KVKs, ATMAs and NGOs; 13 Vocational Training Programmes; and 531 need based hands on training programmes were organized in the field of agriculture and allied activities. Altogether, 228 unemployed youth and 23,393 farmers/farm women/rural youth were benefitted. Technologies (66) were tested on the farmers field by involving 360 farmers of Arunachal Pradesh, Manipur, Meghalaya, Mizoram and Tripura. Besides 136 front line demonstration were conducted covering 721.65 ha and benefitting 2,087 farmers.

Externally funded extension research/adaptive research projects (30) were implemented by the Directorate of Extension Education with total financial outlay of ₹ 15.58 crores. University has started ICT based extension services through m4agri project in Mizoram and Tripura. A total 6,365 farmers registered and 5,901 advisories were issued to farmers on agri and allied sectors. During the period, 50 Success Stories of Farmers were compiled and published with ISBN. KVK-Imphal East, CAU, Imphal was awarded Pandit Deen Dayal Upadhyay Krishi Vigyan Protshahan Puraskar 2019 under Zone VII for their outstanding activities in the last five years.

Dr Rajendra Prasad Central Agricultural University (DRPCAU), Pusa, Samastipur, Bihar

Dr Rajendra Prasad Central Agricultural University came into existence on 7 October 2016 after conversion of Rajendra Agricultural University into a Central University.

Following were some of the major achievements of financial year 2020:

The University had the honour to find a place under top 10 best among Government University of the country by India Today- MDRA survey, 2020. Hence RPCAU became first Agricultural University in India ranked under top 10 till date. Further, survey indicated that first University/Agricultural University in Bihar under top 10 in a national ranking survey. The university also got fifth spot in best student-teacher ratio.

Proud moment

The honorable Prime Minister of India Sri Narendra Modi ji has inaugurated the new building of School of Agribusiness and Rural Management and also laid the foundation stone of new facilities—hostels, International Guest house etc. on 10 September 2020.

Educational and academic achievements

During the year 2020–21, the university started new PG programme in Clothing and textile, Seed science and technology; and PhD programme in Food and nutrition, Farm machinery and power engineering, Processing and food engineering. Thus the University has total intake capacity of 319 students in 6 disciplines of UG Programme, 286 students in 26 disciplines of PG Programme and 38 students in 13-disciplines of PhD programme.

The automation of university activities started and the anti-plagiarism was introduced during the year 2020 to ensure ethics in research and thesis. The academic programme of the University was shifted to online mode from the last week of March 2020 to cope up with pandemic of COVID-19. The study materials related to ongoing courses were uploaded on the university website for access by the students. The classes were conducted online using digital platform. The quiz, midterm and final examination of winter semester were conducted online and results were declared. Out of total 1,197 students, 887 ongoing students were admitted to the Monsoon semester, 2020 and their classes were started online. To enhance the visibility of the University, the provision was made for admission of In-service students, overseas students and Industry sponsored students; and the application has already been invited for their admission in new session (2020–21) in PG and PhD programme.

Initiative taken for re-skilling of migrant returnee during COVID-19 pandemic

The university came forward to shoulder the responsibility of re-skilling the Migrant returnee (labourers) through technologies developed by the university to help them in their rehabilitation. Following were special trainings were started at the University headquarters and various KVKs in the University:

- Household waste-management and other wastes for organic manures

- Rearing of fast-growing Boar breed of goat
- Mushroom cultivation, production and processing.
- Culturing of fish wherever good water depth is available
- Use of University's developed solar cart for hygienic sale and keeping the product for longer using solar energy
- Re-circulating aquaculture in lesser space
- Wealth from waste like produce from banana, bamboo, pigeon pea stems, etc.
- Skill development, technical know-how and maintenance work training
- Empowering women in small know-how like Herbal Gulal making, Energy food preparation, value-addition like mushroom processing by making samosa, ladoo, snacks pickles, ornamental fish culture and honey production.

Rani Lakshmi Bai Central Agricultural University (RLBCAU), Jhansi (UP)

The Rani Lakshmi Bai Central Agricultural University, Jhansi made sustained strides towards achieving its mandated objectives and goals in the field of agricultural education, research and extension as an institution of national importance.

Academics

New PG programme in Soil Science, Entomology, Vegetable Science, Fruit Science and Silvi culture and Agro-forestry, were initiated in postgraduate from the current academic session. The University Internal Quality Assessment Cell was made fully functional with the defined goals and functions. In the wake of COVID-19 global pandemic, best possible efforts were made to train both the teachers and the students to continue planned educational activities on digital platform.

Research

The University released its first ever variety RLB Chana Kabuli-1 (RLBGK 1). The main features of the variety include mean weighted seed yield of 1,549 kg/ha, besides resistant/moderately resistant to *Fusarium* wilt, dry-root rot, collar rot and stunt.

Research work under various ICAR-AICRPs, viz. on Chickpea, and Rapeseed–mustard, aside from voluntary trials in the purview of AICRP-Maize, Barley, Pearl millet, MULLaRP and Sesame and Niger were undertaken towards enhancing productivity and production of these crops through development of high-yielding, multiple disease-resistant varieties for central India. Water absorption capacity of Desi and Kabuli chickpea cultivars showed wide variations among the respective groups. The mean per cent water absorption capacity of Desi and kabuli chickpea cultivars was 90.6 and 92.7, respectively. Seedling vigour showed wide variations from 0.46–4.34 cm in Desi group and 0.48–2.95 cm in Kabuli group, with a mean of 1.64 cm and 1.60 cm, respectively.

Infrastructure development

Shri Narendra Modi, Prime Minister of India dedicated the newly constructed Academic and Administrative buildings virtually to the nation on 29 August 2020. After the inauguration, the Prime Minister interacted with university students and asked about ways to address certain challenges like reducing import of edible oils and increasing food processing, especially in fruits and vegetables. During the interaction, the Prime Minister stressed on promoting recycling of water and rainwater harvesting through innovative and less costly technology in the region.

Sri Narendra Singh Tomar, Minister of Agriculture and Farmers Welfare, Government of India laid the foundation of College of Veterinary and Animal Science and College of Fisheries at Datia campus of Rani Lakshmi Bai Central Agricultural University, Jhansi on 27 September 2020.

A set of 82 indigenous wheat germplasm lines, released varieties, and genetic stocks was also evaluated for different agro-morphological characters and biotic stresses. A coordinated germplasm nursery of wheat (Elite International Germplasm Nursery, EIGN) with 91 germplasm lines, was evaluated. Fifteen promising wheat genotypes were identified from EIGN based on yield and chlorophyll content. The sowing techniques for green gram were standardized to promote line sowing for increasing crop productivity and input-use efficiency. Time taken by different sowing machines was the lowest for zero-till ferti-seed drill, i.e. 4 h/ha, whereas it was maximum under farmer's practice (6.5 h/ha). Similarly, seed yield obtained under the

conventional method was 22.4–33.3% lower (542 kg/ha) as compared to other techniques.

A study on diversity of various insect pollinators on mustard during blooming period showed that insect species belonged to orders Diptera, Hymenoptera and Coleoptera. Among these the syrphids (order Diptera) were most dominating.

Performance of different cultivars of pomegranate, viz. Bhagwa, Super Bhagwa, Ganesh, G-137, Ruby, Mridula, Arkata and Jalore seedless was evaluated. Maximum plant spread north to south × east to west was recorded in Ruby followed by G-137 and Arkata. Based on the study, cultivar Ruby and Super Bhagwa were found suitable for cultivation in Bundelkhand region. Twelve spray type cultivars of chrysanthemum were evaluated for different growth and flowering parameters. White Star and Karnal Pink were found promising for the region.

Extension

Front Line Demonstrations (329) were organized at farmer's field on rapeseed–mustard (45), chickpea (10), groundnut (150), maize (80), rice (17), sesame (21), mung-bean (4) and pigeon pea (2) in Jhansi, Datia, Tikamgarh and Niwari districts. The results of FLDs in rapeseed-mustard convincingly proved that by adopting the improved production practices, farmers could get an average 26% increase in productivity (1,467 kg/ha) over indigenous practices (1,166 kg/ha) with an average net monetary benefit of ₹ 12,069/ha. Improved technology provided farmers an alternative and better response in getting higher yield in chickpea. There was 20% of seed saving, optimum plant population and 27.3–40% higher yield advantage over farmer practices by using chickpea RVG-202. The net return (₹/ha) using improved practices was ₹ 42,978/ha in comparison to ₹ 28,528/ha by using farmer practices. Besides FLDs, several on-farm/off-farm demonstrations, field diagnostic surveys, field days and training programs were conducted for farmers to popularise scientific cultivation of various crops including pulses, oilseeds, fruits, vegetables and medicinal plants. To facilitate reach of the farm advisory at the farmer's door step, a dedicated *Farmer's Corner* was incorporated in the University website (http://www.rlbcau.ac.in/Farmers_corner.php).

Agrinnovate India Limited

Agrinnovate India Limited (AgIn), a Government of India enterprise, is steadily moving towards meeting its objective of stimulating and fostering innovations in agriculture and building 'A world of Innovative Partnerships'. As an effective interface between Indian Council of Agricultural Research (ICAR—an autonomous organization under DARE) on one side and the Stakeholders of agricultural sector (Farmers; Public and Private Sector firms; R&D organizations) on the other, AgIn strives to secure and promote sustainable technologies from NARE for the overall development of agribusiness sector.

The Company initiated effective partnerships with ICAR institutes and private companies. The company's revenue from operations touched ₹ 15,376,950 for the first time in nearly a decade, as against ₹ 3,057,630 during the previous Financial Year (2018–19). Accordingly, the company's net profit stood at ₹ 28,089,362 as against ₹ 23,663,549 since the last Financial Year 2018–19.

Business development activities

Nearly 340 technologies were added for the list of technologies ready for commercialization through Agrinnovate.

During the year 2019–20, AgIn helped transfer 52 technologies earning a gross revenue of ₹ 1.54 crore. Sectors of crop sciences (39%), dairy and veterinary sciences (32%), horticulture (23%) and fisheries (6%) contributed significantly in this endeavour of AgIn.

Promotional activities

Significant among these include:

- Revamping AgIn's website (www.agrinnovate.com);
- Participation and presentation at VAIGA 2020-Sustainable Development through Agriprenuership, Cochin, Kerala (January 2020)
- Participated and presented on the activities and role of AgIn at the seminar organized by Atal Innovation Mission, at AIM Institute Chattarpur, New Delhi (Nov 2019)
- Presented the activities of AgIn at CII's Northern Region's Conference on Innovations and Entrepreneurship in Agriculture, New Delhi (6 March 2020).

International collaborations and linkages

Agrinnovate India Limited facilitated the tech transfer and establishing an International linkage with Ms. Accrued Gains Pvt. Ltd., Republic of Botswana, by licensing—'Banana Pseudostem sap for use as biofertiliser for crop productivity enhancement. The technology developed by Navsari Agricultural University (NAU), Gujarat was transferred through a commercial non-exclusive license for a period of five years (December 2019).

Agrinnovate India Limited (AgIn) collaborated with BIRAC in licensing out the *Brucella Vaccine Technology* (*Brucella abortus* S19$#Äper) for the control of bovine brucellosis developed by ICAR-IVRI, Bareilly, to Hester Biosciences Limited, Gujarat for a global market access for 15 years (September 2020) ❑

"मैं इन कृषि विज्ञान केंद्रों को आधुनिक कृषि के नए **Lighthouse** के तौर पर देखता हूं । इन केंद्रों से निकला प्रकाश, देश के कृषि जगत को प्रकाशवान बनाएगा । विशेषकर कृषि विज्ञान केंद्र का सबसे महत्वपूर्ण काम है- किसान तक नई तकनीक, नई जानकारी को पहुंचाना"

— नरेन्द्र मोदी

18. Supporting Basic and Strategic Research

The 'National Agricultural Science Fund' supports basic and strategic research in agriculture with an outlay of ₹ 164.5 crores during the period 2017–18 to 2019–20. The main objective of the scheme has been to build capacity for basic, strategic and cutting edge application research in agriculture and address issues which can be solved by intensive basic and strategic research jointly by team of organizations/institutions. Underlying this objective are the following aims: (*i*) Foster research and a research culture that will use and advance the frontiers of scientific knowledge to effectively meet the present, anticipated and unanticipated problems of agriculture through various modes and critical investments in research projects; (*ii*) Build the capability of the National Agricultural Research System through development of wide partnerships in science through projects; (*iii*) Build a storehouse of advancement of knowledge in science related to agriculture and awareness of the national importance of basic and strategic research in agriculture; (*iv*) To provide policy support to the decision makers for use of basic and strategic research in agriculture and; (*v*) Organization of workshop, seminars, conferences, etc. to create awareness, prioritization, scientific popularization and related issues. The scheme has already funded 205 projects, mostly in consortium mode. At present 66 projects are in operation, out of which 62 are multi-institutional in nature. During last one year, NASF has taken many new initiatives like inclusion of allele mining, metabolomics, precision agriculture, application of sensors, nanotechnology and policy in agriculture as new strategic areas; and one mega project on Captive Breeding of *Hilsa*, *Tenualosa ilisha*: Phase II.

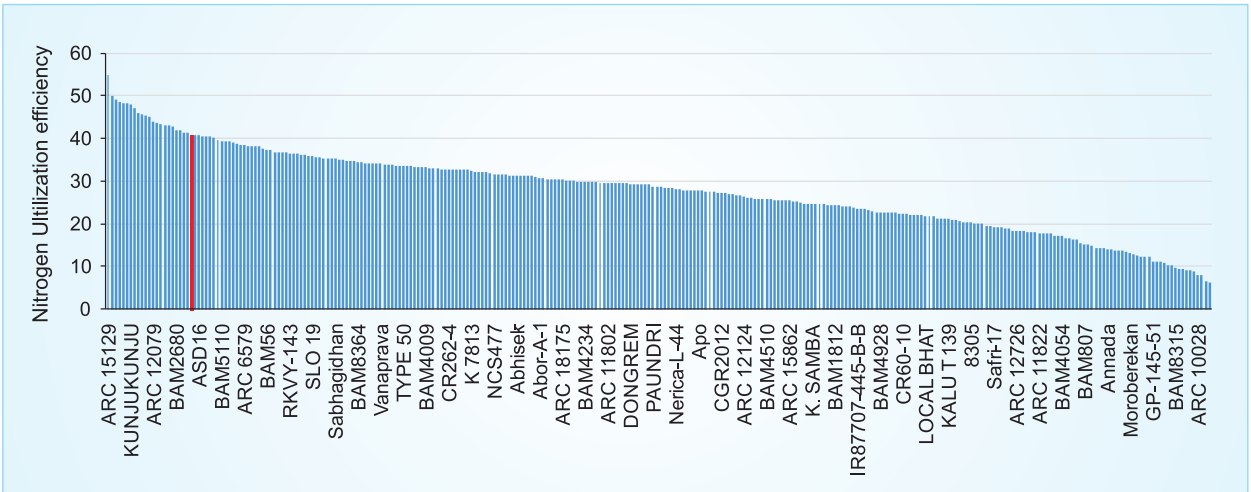
Besides supporting, reviewing, monitoring and evaluation of the ongoing projects during the year 2019–20, NASF evaluated 66 new full project proposals received under different themes of Call VIII by the respective expert committee. A total of 27 new projects were approved during the period. NASF also invited the pre proposals for new research projects under seven strategic areas for Call IX and received 1,345 pre-proposals, which are under the process of evaluation. NASF was also engaged in creating awareness for the need and nature of the basic research for agriculture among institutions within and outside the traditional NARS for prioritization of research. During the last year, four meetings of the Empowered Committee were organized for approval/ratification of new project proposals, review of the ongoing projects and to review/decide the administrative and financial issues of the NASF. Besides one meeting of the Empowered Committee was also held on 4th March, 2020 for finalization of strategic areas of NASF for invitation of new pre proposals under Call IX, wherein members of Expert Committees, all senior officers of ICAR, Directors of neighboring ICAR institutes and other specialized experts were also invited. In this meeting, the seven strategic areas were finalized as (*i*) Biotechnology, genomics and allele mining in plants, animals and fisheries; (*ii*) Abiotic and biotic stresses and, quality traits in plants, animals and fisheries; (*iii*) Precision agriculture and management of natural resources and application of sensors in crops, animals and Fisheries; (*iv*) Nanotechnology in agriculture, (*v*) Metabolomics in agriculture; (*vi*) Farm Mechanization and energy and (*vii*) Social Sciences and policy in agriculture.

Monitoring of ongoing projects: The on-going projects are being monitored at three levels, i.e. the projects are being reviewed by the 'Expert Committees' and the 'Empowered Committee. Besides, to mentor, monitor and review the projects each project also has an 'Advisory Committee'. Six Annual Review meetings were held in the months from December, 2019 to February, 2020 and August, 2020 to review the 59 ongoing projects. More than 10 advisory committee meetings were held during 2019–20 to mentor, monitor and evaluate the projects. Besides, the Empowered Committee also reviewed the progress of three mega projects, viz. 'Genetic improvement of rice for yield, NUE, WUE, abiotic and biotic stress tolerance through RNA Guided Genome Editing (CRISPR-Cas9/Cpf1)', 'Development of sustainable management tools for the invasive pest, Fall Armyworm *Spodoptera frugiperda* (J.E. Smith) in maize' and 'Production of multiple copies of elite buffalo bulls using animal cloning technology in September, 2020. In addition to the results in terms of high impact publications, patents and technologies, a strong and sustainable platform for developing scientific capacity and culture that encompasses the extended NARS is being established. This will ensure continuous flow of knowledge, ideas and working together among different stakeholders in the basic, strategic and frontier application research for solving problems in agriculture and also forming science policy in agriculture.

Salient achievements

During 2019–20, besides having more than 70 research publications in reputed journal, NASF had seven patents and 10 technologies. The research highlights of some selected projects are as follows:

Phenomics of water use efficiency and nitrogen use efficiency in rice: RIL population (170) of



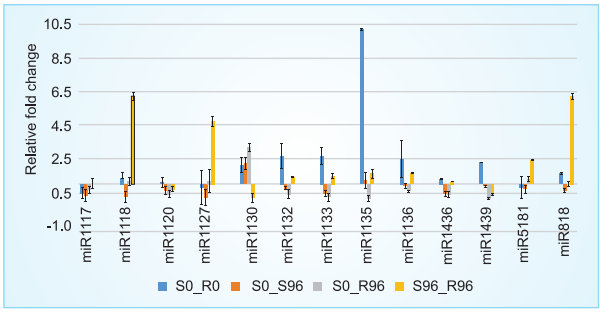
Variation in NUE among rice germplasm under N-deficit

BVD109 (drought tolerant) × IR 20 (drought susceptible) was phenotyped for diurnal and nocturnal water use towards identification of donors for component traits of water use. RILs C-822-103, C-822-105, C-822-123, C-822-130, C-822-99, C-822-124 and C-822-129 showed high transpiration efficiency as compared with both the parents BVD109 and IR20. The parents and RIL population were genotyped with 50 K SNP chip for QTL mapping. QTLs for nocturnal and diurnal transpiration and WUE were mapped. Similarly, for identification of germplasm lines with high NUE, 300 rice germplasm lines were phenotyped under nitrogen sufficient and deficient conditions. NUE varied from 3.6 to 32 g grain/g N uptake by plant at normal recommended dose of nitrogen application, while it varied from 6.3 to 49.6 g grain/g N uptake by plant under nitrogen deficient conditions. Genome-wide association study (GWAS) led to the identification of QTLs associated with NUE in rice.

Genetic improvement of rice for yield, NUE, WUE, abiotic and biotic stress tolerance: Four genes were selected for genome editing for improving yield of elite rice varieties. *Teosinte Branched1* (*TB1*) gene, a negative regulator tillering, was edited to crease a loss of function mutant of *TB1* gene with 13 bp deletion in rice cv. MTU1010. The transgene free *tb1* mutant produced about 35 tillers as compared with 15 tillers in WT MTU1010 plants and yielded 66–70% higher grain yield per plant.

Dense and Erect Panicle 1 (*DEP1*) codes for G protein γ subunit, involved in the regulation of number of grains per panicle. By using CRISPR-Cas9, a single base pair insertion mutant of *dep1* was created in MTU1010. The *dep1* mutant produced 52–54% and 21–15% higher grains/plant and grain yield per plant, respectively as compared with WT MTU1010. The OsCKX2 (Cytokinin oxidase/ dehydrogenase2) gene catalyzes the degradation of active cytokinin and thus, reduces the grain number. Hence, this gene function was knocked out by using CRISPR-Cas9 in rice cv. in MTU1010. The *ckx2* mutant in MTU1010 produced about 53–64% increase in the grains per panicle as compared with WT plants. The miR156 binding site in the coding sequence of *Ideal Plant Architecture 1* (*SPL14*/*IPA1*) gene was edited in Swarna. Putative mutants were developed by using CRISPR-Cas9 in Swarna with increase in grain number per panicle and about 20% high grain weight per plants were obtained. For enhancing abiotic stress tolerance, *Drought and Salt Tolerance* (*DST*) gene was edited by using CRISPR-Cas9 in MTU1010 led to the generation of different 19 mutants for the two guide RNAs of *DST* gene. A homozygous deletion mutant (deletion of 549–914 nucleotides) with loss of function was identified. Physiological analysis showed that this mutation conferred enhanced leaf width, reduction in stomatal conductance and enhanced salt and osmotic stress tolerance at seedling stage. For introducing tungro virus resistance, *eIF4G* gene was edited in rice cv. ASD16.

Epigenetic regulation of host-pathogen genetics in leaf rust resistance of wheat: A total of 50 miRNAs and 1178 lncRNAs were identified through in silico analysis of RNA-seq data; of these, 16 miRNAs and 22 lncRNAs were differentially expressed (DE). Expression of 8 miRNAs was induced in resistant NIL which targeted several important genes including disease responsive genes. As many as 49 lncRNAs were found to be the targets for miRNAs; the results were also validated using qRT-PCR analyses. Role of histone modification (H3K4me3 for activation and H3K27me3 for repression) was examined using ChIP-Seq; several differentially binding sites (DBSs) and the associated genes for modified H3 were identified. The role of DNA methylation is being examined using bisulfite sequencing and context specific (CG, CHG and CHH) differential methylation is observed during compatible and incompatible interactions. A number of disease response genes undergoing differential methylation have been identified including the cross interactions involving histone modifications, gene



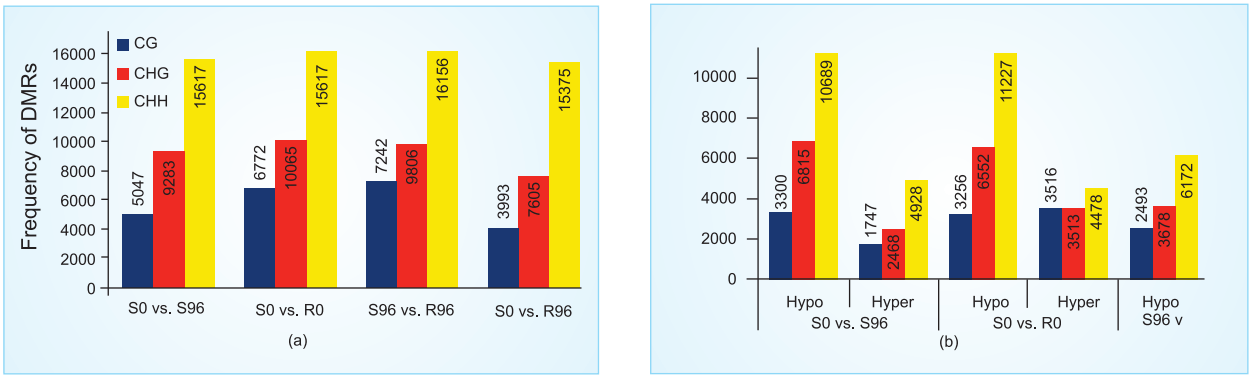
Relative fold change of miRNAs in mock (S0_R0), susceptible (S0_S96), resistant (R0_R96) and susceptible vs resistant treatment 96 h after pathogen inoculation (S96_R96)

expression and DNA methylation. The results are being validated using qRT-PCR and Chop-PCR. The computational prediction of non-coding(nc) RNAs and effectors was carried out in the available *P. triticina* genome sequences; some of these ncRNAs/effectors were validated using qRT-PCR.

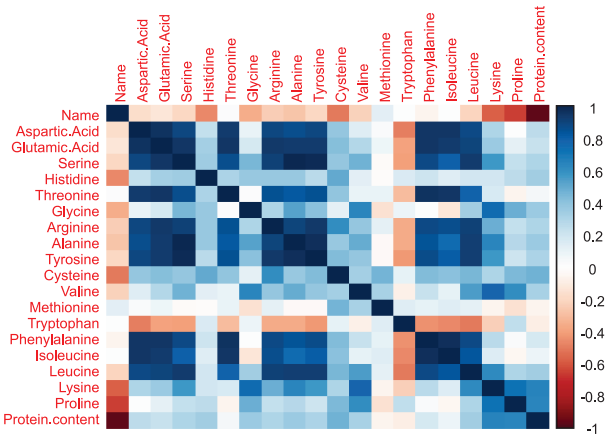
Genome editing for importing PRSV resistance: A host gene eIF4E (involved in virus translation) and a virus gene, Genome-linked viral protein (Vpg) (interacts with eIF4E) are being targeted to inhibit the host-virus interaction through genome editing approach. Cloning, sequencing and identification of eIF4E from the papaya indicated the presence of two isoforms, eIF4E and eIF(iso)4E. The eIF4E is 711 base pairs coding for 236 amino acids, while, eIF(iso)4E is slightly shorter at 207 amino acids. Amino acid change at 168_T/G was conspicuous and was present in most of the apparently healthy lines. Bioinformatics analysis was carried out to understand the interacting region between eIF4E gene sequence from papaya and VPG gene from the virus. The amino acid residues involved in ligand binding fall in to 3 domains: 61–54, 96–100 and 155–169. Based on the analysis, multiple PAM sites were selected for editing. Apart from these, the off target effects were assessed employing similarity to other host genes. Three gRNA sequences were synthesized and cloned in suitable vector having Cas9 gene. PRSV culture was established and checked with different virus identification techniques and Vpg gene from the PRSV genome was amplified, cloned and sequenced. Using suitable bioinformatics tool, gRNA sequence was predicted and is in the process of cloning.

Potential gene mining from salt tolerant grasses for improvement of salt tolerance in crops: Thirty-four differentially expressed genes (DEGs) from grass halophytes, *Urochondra setulosa* and *Dichanthium annulatum* showing high level of expression during salt stress were compared with DEGs in salt tolerant rice, CSR10 for salinity stress during reproductive stage @12 and 18 ds/m. The analysis showed two genes involved in trehalose metabolism (*Trehalose 6-P synthase, Trehalose 6-P Phosphatase*) were co-expressed both in *Urochondra* and *Dicanthium* at salt stress >18 dS/m. However, co-expression pattern was not identified in CSR 10 @ 18 dS/m and in contrast *trehalase* gene was differentially expressed in salt stress. Therefore, differential co-expression of trehalose biosynthesis genes could be one of the major mechanisms for salinity tolerance in *Urochondra* and *Dicanthium*. *Dehydrin* gene from *Urochondra* was cloned in pCAMBIA1304 binary vector and transformed in CSR 10.

Characterization, mapping and transcriptome analysis of chickpea: Four hundred and four chickpea germplasm were characterized for total seed protein content at 3 locations (ICAR-IARI New Delhi, PAU Ludhiana and ICAR-IIPR Kanpur) and for Fe, Zn and β-carotene at two locations ((ICAR-IARI, New Delhi and PAU, Ludhiana). GNG 1581, GNG 2144, Pusa 3022, HK 4, JG 14, Pusa 128 and Phule G 95311 are the recently released chickpea varieties having the best combination of grain yield, grain protein, Fe, Zn, and β-carotene. High yielding cultivars were found to contain higher amounts of seed, Zn and Fe. There was negative correlation of phytic acid with Zn and Fe. GNG 2171, KWR 108, Pusa 128, JAKI 9218, GBM 2 and Phule G 95311 are the HYVs containing high Fe and Zn with low phytic acid (4–5 mg/g). High protein genotypes had higher amounts of essential amino acids. Sulphur amino acids showed negative correlation with protein content. The expression analysis of more than 125 genes (across all the traits) was validated using quantitative real time PCR analysis in mature seeds. Several miRNAs/target genes were



Distribution of (a) context-wise DMRs and (b) hypo/hypermethylated DMRs in four pairs of comparisons. Hypo, hypomethylated; Hyper, hypermethylated



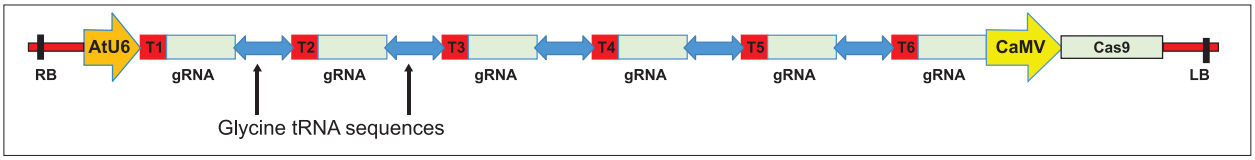
Pearson correlation coefficient among amino acids and protein content of chickpea genotypes.

identified and 10 of them have been validated. Genome wide association study, on panel comprising of 189 genotypes, led to identification of 31,956 SNPs. Twenty three genomic loci exhibiting significant association with seed protein have been identified. Five QTLs were identified for grain protein in a biparental mapping population involving JAKI 9218 (Low GPC) × T 39-1 (High GPC) (n=200, $F_{3:4}$). These were mapped to LG3, LG4, LG6 and LG8.

Molecular mapping and identification of candidate genes for anthracnose fruit rot disease resistance in chilli: A total of 357 F_2 segregating populations along with contrast parents were genotyped and based on GBS analysis, aligned with *Capsicum baccatum*_CM008444.1 and *Capsicum baccatum*_PBC81 whole genome sequence data, 8644 SNP markers were identified and consensus linkage map developed. The distribution of SNPs was observed across the 12 chromosomes. The SNPs located on Chr2 and 6 were validated in F_2 and $F_{2:3}$ phenotyped populations using the SSR primers designed specific to the regions where SNPs are present. The candidate genes (2 each located on Chr 2 and 6) linked to anthracnose fruit rot resistance have been identified. Genome-Wide Association Studies (GWAS), could identify two major genomic regions located on chr2 and chr6 as candidate resistance loci associated with anthracnose fruit rot in chilli. A total of 19 SNPs (QTNs; Quantitative Trait Nucleotides) significantly associated with fruit rot resistance (at –log10 (p) value >2.82 for % lesion area), of which five SNPs located on chr2 (physically positioned at 12666827 bp to 141379584 bp) and seven SNPs located on chr6 (physically positioned at 247161384 bp to 252255814) were found highly associated. Resistance related genes within the candidate genomic regions on chr2 (major locus) were searched on pepper pan genome and Cluster of Nucleotide Binding Site-Leucine Rich Repeat (NBS-LRR) domain was found to be involved in disease resistance in plants. The identified SNPs associated with candidate resistance loci are validated in the segregating populations and can be further used in Anthracnose Fruit Rot Resistance (AFRR) breeding program.

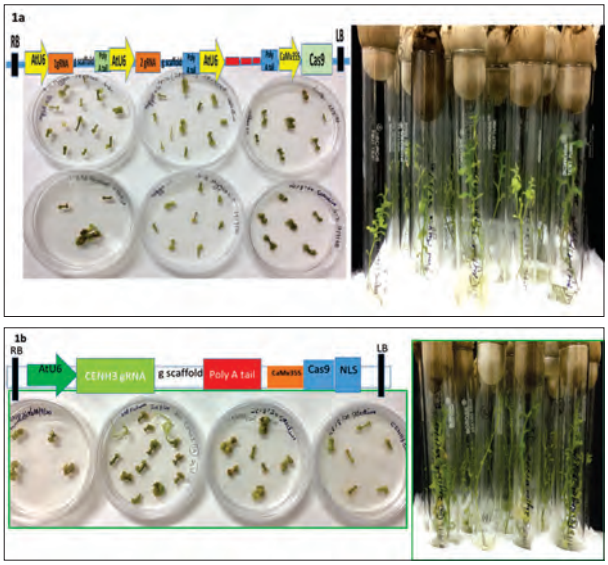
Utilization and refinement of haploid/doubled haploid induction systems: Three hundred ninety six DHs in rice and more than 800 DHs in maize were evaluated and promising lines were identified for further advancement and use in breeding programme. In case of wheat, 560 DH lines carry rust resistant genes *Yr15, Yr5, Yr36* and *Lr34, Lr57* in different combinations. Besides, about 150 high tryprophan+high provitamin A maize DH lines were generated and evaluated and promising lines were identified for use in development of biofortified maize hybrids. In rice, significant achievements were made in establishment of *in vitro* androgenic method in *indica* rice where callus induction frequency was observed to be 30.4–52% and green shoot regeneration ranged from 61.00 to 85.99%, cumulatively. No haploids were observed among the regenerants, which signifies 100% spontaneous doubling without the treatment of antimitotic agents. Subsequently, application of 5 mg/l of proline to MS media supplemented with NAA (0.1–1.0 mg/l) + Kn (0.5–2.0 mg/l) + BAP (1.0–2.0 mg/l) could enhance the green shoot regeneration by 3.42 times in IR20 x Mahulata followed by 2.44 times in TCN,1.76 times in Arize 6453 and 1.47 times in Arize 8433DT as compared to media devoid of proline; not a single albino was observed in the regenerants. In wheat, application of colchicine for 12 h after pollination (HAP) was found to produce higher doubling percentage as well as a greater number of seed per plant compared to colchicine application for 24 HAP. The frequency of full plant doubling was also high in 12 HAP of colchicine application. Among colchicine alternatives, APM (10 µM) + Trifluralin (350 µM) was confirmed as the best treatment compared with Amiprophos-methyl (APM) (10 µM) and Trifluralin (350 µM) when applied individually 24 h after pollination. Further, use of Phloroglucinol in embryo rescue media showed positive effect on plant regeneration. In case of maize, based on preliminary observations, three treatments - APM 20 ppm + Pronamide 2 ppm + Trifluralin 1 ppm for 12 h, APM 20 ppm + Trifluralin 1 ppm for 8 h and APM 20 ppm + Pronamide 1 ppm for 12 h were found promising. Pigmentation on dorsal basal portion of seed identifed as a putative trait for haploid classification in the hybrid CMVL 55, which is expected to help in haploid classification in source populations with anthocyanin inhibitor genes. For capacity building of various NARS partners in DH prouduction, one day online lecture was delivered to participants on DH in wheat. Two scientists from public and private sectors and one student from SAU were imparted training on androgenesis for DH production.

Targeted editing of potato genome to develop variety specific True Potato Seeds (TPS): The potato homologues of three MiMe and CENH3 genes namely StOSD1, StRec8, StSPO11 and StCENH3 were identified using NCBI BLAST from AtOSD1, AtRec8,



Representative multicistronic construct of MiMe genes

AtSPO11 and AtCENH3 genes sequences. Two gRNA targets were also identified in each gene and were assembled into pHSE401 CRISPR/Cas9 vector independently for MiMe and CENH3 and were confirmed by digestion. Multicistronic construct with all the three MiMe genes was prepared using gtRNA after each target gRNA sequence and assembled in pHSE401. Further the construct was used for genetic transformation of potato variety Kufri Jyoti using inter nodal stem cuttings for editing all the 3 MiMe genes simultaneously and CENH3 gene construct independently. Around 80 calli and 60 calli were generated using 5 mg/ml hygromycin selective media for MiMe and CENH3 construct, respectively.



Agrobacterium mediated transformation of KJ potato cultivar with multicistronic MiMe (*1a*) and CENH3 gRNA cassette (*1b*). The details of vectors and selection markers are as follows: Vector: pHSE404, *Agrobacterium* Strain: GV3103, gRNA: SPO11-1, OSD1, RAD21 specific 6 gRNA (2 gRNA/gene) and CENH3 gRNA, Explant: Hygromycin 5 mg/ml, Variety: Kufri Jyoti

Identification of superior donors and alleles in rice: To identify the rice donors having a higher ability to withstand the challenges posed by high temperatures, 435 *indica* rice accessions have been imported from the 3,000 sequenced accessions, with an aim to phenotype them under high temperature stress for spikelet fertility and grain chalkiness. Genetic relationship between some (281) of these accessions were analysed by constructing a neighbour joining dendrogram and Bayesian analysis of population structure and principal coordinate analysis was performed for finding out the natural diversity in the panel. On the basis of phenotypic evaluations for quantifying the spikelet fertility and grain chalkiness, accessions that have high spikelet fertility under high temperature were identified. Availability of the genotypic dataset (SNPs) based on Rice SNP-Seek database (further filtered using several parameters to remove false and low quality bases) and the phenotypic data gave a very good opportunity to understand how the allelic variation contributes to the phenotypic variations. The above processes aided in materialising our primary objective to perform the association analysis between the SNP markers and phenotypic data using the mixed linear model (MLM) for the identification of superior donors as well as candidate genes/alleles contributing to spikelet fertility and grain chalkiness under high temperature stress in rice.

Production of multiple clones of a superior buffalo breeding bull: Seven clones were produced from a single superior bull, named 'M-29', and birth of a re-cloned calf of a cloned bull, named 'Hisar-Gaurav' was successfully achieved. The genotype of cloned calves was confirmed by microsatellite analysis (parentage verification). The produced clones have normal physiological parameters such as blood hematological indices, respiration rate, body temperature, and heart rate. Besides, the institute has also produced 11,000 frozen semen doses and 25

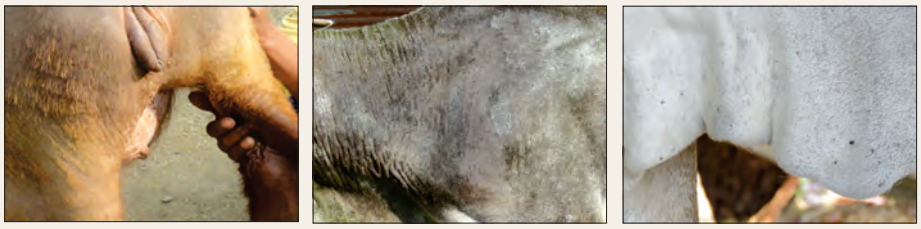
Seven clones (*left* to *right*) of a superior breeding bull (M-29) of Murrah breed and a re-cloned calf (*rightmost*) of cloned bull (Hisar-Gaurav)

Cloned bull Hisar-Gaurav (*right*) was produced in 2015, and his re-cloned calf was born in January 2020

Chemical, structural and functional characterization of identified anti-tick lead phytochemicals

The safe, stable and characterized flowable (F10) and natural cream formulations were developed to tackle the resistant tick problem. Identification and quantification of five active compounds in the formulation were validated by a reversed phase HPLC-PDA method. Both the formulations were 80–90% effective under *in vitro* model and 60–90% efficacious against ivermectin resistant ticks. Both the formulations were evaluated against experimental challenge infestations and 70–90% efficacy was recorded within 7 days of application. Fragility of mid gut with ingested blood spillage after 12 h and complete structural disorganization of mid gut after 48 h of treatment was recorded. The efficacy of anti-tick natural formulations (F10 and cream) was validated on more than 100 animals at different locations of Parbhani district of Maharashtra and reported more than 80% efficacy. Field trial of the formulation was also done in Uttarakhand and initial data revalidated the results obtained in Maharashtra. The first generation anti-tick technology has been transferred to Ajay Bio-tech India Ltd, Pune.

Tick infestation before application



Efficacy after 4–5 days

Efficacy of the formulations obtained in field trial in Maharashtra

progenies of 'Hisar Gaurav'. The Assamese cloned bull, which was produced in 2017, has been trained to produce semen, and to date, 1,200 semen doses have been produced. It has also been demonstrated that the cloned bulls have similar fertility as the donors and other non-cloned breeding bulls. So far, 10 cloned buffalo bulls have been produced, which can produce 10–15 lakh semen doses that can inseminate 5–7 lakh buffaloes for improving their genetic potentials.

Synthesis, characterization and effect of graded levels of nano selenium on performance of broiler chicken: Nano selenium was synthesized by chemical method by taking inorganic sodium selenite as selenium source, GSH as reducing agent and Bovine Serum Albumin (BSA) as stabilizer. The size of the nano Se particle was 40–80 nm and shape was spherical with the concentration of 3,200 ppm. Supplementation of 0.15 ppm of nano selenium improves the body weight gain, higher anti-oxidant enzyme status like GPx and SOD activity, both cellular and humoral immunity of the commercial birds. Nano Se concentration in liver, breast muscle, gizzard, kidney and brain is an indicator of Se bioavailability. Se levels in liver, breast muscle, gizzard, kidney and brain in all the Se treated groups were significantly higher but no effect on the organ weight was noticed. At higher level of supplementation, i.e. 0.60 and 1.20 ppm levels vacuolar degeneration in liver and degenerative tubular epithelial lining in kidney tissues were observed.

Pelleted Feed prepared with nano selenium; Experimental; birds fed nano selenium

Elucidating the mechanism and assessing amelioration potential of *Ocimum* and *Lucas* in zebrafish: The organic carbon, microbial biomass carbon and phosphorous availability in soil regulate S-adenosyl-L- methionine (SAM) and Ursolic acid (UA) and exceptionally high concentration of SAM was detected in *Ocimum* and *Lucas*. The exposure to hypoxia, acidic pH stress, density and excess fat (HFD) impair metabolic homeostasis through down regulation of energy sensors (SIRT1, pAMPK and PGC1α) and disruption of mitochondrial ATP production in muscle tissue. Interestingly, HPLC-purified SAM could suppress Fetuin A (FetA) and ameliorate impaired energy homeostasis. Additionally, abiotic stress in the

form of polluting organic ambience (Bisphenol A, 4-Nonylphenol), at environmentally relevant doses, severely impacted fish health. While elevated follicular death (atresia) and reduced maturational competence lead to reduced fecundity and reproductive fitness in BPA-treated females, 4-NP could alter redox balance (oxidative stress), inflammatory response, lipid accumulation (steatosis) and apoptotic index in zebrafish liver. Low dose of SAM, isolated from plant source (*Ocimum* spp), has the potential to induce oocyte maturation and formation of fertilizable female gamete.

A mouse model for PPRV and a novel vaccine vector for animals: Goat plague disease is caused by a virus named *peste-des-petits*-ruminants or *PPR* virus. The immunological responses during virus infection would not only help to devise better vaccines but also in applying appropriate disease curing measures. The genetically defective mice, developed for interferon response serve as an excellent *in-vivo* animal model for investigating PPRV pathogenesis. Replicating virus and its antigens were detected in most of the critical organs of infected mice. Innate immune cells such as neutrophils and macrophages likely transported the replicating virus to the central nervous system to cause encephalitis. This established and employed a laboratory animal model for investigating PPRV pathogenesis and protective role of $CD8^+$ T cells of immune system. A viral vector system based on the Indian vaccine strain (Sungri/96) of *peste-des-petits*-ruminants virus (PPRV), specifically for the development of next generation live attenuated dual/combined vaccines for other viral/bacterial/parasitic diseases of livestock in addition to PPR was also developed.

Identification of biomarkers for early diagnosis of *Mycobacterium avium* subspecies *paratuberculosis* (MAP): MAP 2191c or mammalian cell entry protein and *Mod*D Secretome protein in the form of peptide was targeted for the development of DIVA ELISA. Early detection of MAP infection even before the onset of clinical signs could aid in effective control of the disease transmission. The inflammatory biomarker IL18 was consistently up-regulated in MAP infected animals as early as 30 days post inoculation of MAP in experimental animals. While, IL1β and IFNγ genes were transcriptionally elevated in chronic cases as well as vaccinated animals beyond >90 dpt timeline. Besides, the calcium signaling and MAPK pathways were identified as key mechanisms which help in the survival of MAP inside the macrophages of host and successful chronic infection, that could be exploited in the nation-wide control programmes on JD.

Resveratrol and catechin-loaded niosomes and nanoparticles for fortification of milk and milk products: The process conditions of catechins-loaded niosomes were optimized, and the niosomes were characterized for fortification of milk, dahi and yoghurt. SEM, TEM and AFM analysis revealed that the catechins-loaded niosomes were monodispersed with spherical morphology and size ≤60 nm. FTIR spectra confirmed formation of niosomes and the encapsulation of catechins into them. HPLC analysis before and after encapsulation confirmed that catechins were completely recovered in the niosomes. Aqueous solubility of catechin improved after their nanoencapsulation. Free catechins were highly photosensitive to artificial UV light, whereas nanoencapsulated forms exhibited good photo stability. The catechins-loaded niosomes exhibited a sustained release under simulated GI conditions. Antioxidant activity of catechins was retained in the niosomes. The niosomes were stable up to 30 and 90 days at 30°C and 5°C, respectively. In the second approach, resveratrol and catechins were converted into the dry proniosomes using GRAS encapsulants. The morphological, ultrastructural, entrapment and release properties of resveratrol and catechins-loaded proniosomes were evaluated for fortification in milk. Maltodextrin produced proniosomes with hydrodynamic diameter below 200 nm and entrapment efficiency above 90%. Also, catechins were converted into electrospun nanofibres. The surface morphology and topography of the nanofibres and the antioxidant activity and release characteristics of catechins were determined. The nanofibres had cylindrical and non-porous ultrastructure with continuous three-dimensional network, and mean fibre diameter and encapsulation efficiency less than 100 nm and 92%, respectively.

Role of dietary trace minerals in animals: Feeding rats higher (300 to 450 ppb) than recommended (150 ppb) level of Se in the purified diet and exposed to heat stress conditions for 6 h daily for two weeks resulted in restoration of blood hemoglobin and hepatic function, maintenance of higher serum T_3 and insulin hormones levels and reduced heat stress induced oxidative stress by decreasing serum MDA levels besides increasing serum GSH, catalase and SOD enzyme activity. However, serum GPx activity of the heat stressed rats increased only with 450 ppb Se level. Selenium at 300 and 450 ppb concentration in the diet significantly reduced serum pro-inflammatory cytokine IL-1 and 450 ppb Se significantly improved anti-inflammatory cytokine IL-10, however, 300 ppb Se in the diet improved humoral immunity of rats reared under stress conditions. Hence, Selenium at 450 ppb level ameliorated heat stress induced harmful effects by improving antioxidant status, regulating thyroid and insulin hormone, reducing inflammatory cytokines and improving humoral immunity indicating higher requirement of dietary selenium under heat stress conditions. On assessing the effects of higher dietary levels of trace element zinc it was found that higher zinc at 24 and 36 ppm level lowered oxidative stress biomarker in rats. Feeding 36 ppm zinc in the diet reduced hepatic Metallothionein-1 (MT-1) gene expression irrespective of stress condition, however, endotoxin exposure up-regulated intestinal zinc transporter genes (ZIP-1 and ZnT-1) expression in rats feed diet containing 12 ppm zinc, but higher zinc

at 24 and 36 ppm concentration resulted in down-regulation of zinc transporter genes under healthy as well as endotoxin stress conditions.

Production of protein isolates/concentrates from de-oiled cakes/meals: A novel process to produce protein isolates/concentrates from oilseed cakes/meals (example soy meal, groundnut cake) has been developed without addition of strong or diluted acid. The developed process is unique as it is added acid free and also provides about 5% higher yield of protein as compared to the existing chemical process. The protein produced by this method is superior in terms of solubility, wettability, water absorption capacity and degree of hydrolysis. The yield so obtained is about 35–36% of the total weight of soymeal and 25% of total weight of groundnut cake used, whereas, in the existing process, maximum 30% protein yield from soymeal can be obtained. The developed method comprises novel bacterial strains isolated from a food sample for producing protein from de-oiled meal/flour. The

Soy protein isolated through novel method

Groundnut protein isolated through novel method

resultant supernatant after precipitation of protein from a particular batch may be used for precipitation of another batch and so on. The protein produced through developed process may find demand at national as well as international level to boost immunity. The plant protein is used in protein supplements, texturized vegetable proteins, imitation dairy products, sea food products, beverage industry, infant food formulations, weaning food formulations, bakery products, meat analogues for various purposes.

Electronic nose for the optimum harvesting time and fruit quality in apple and papaya: A portable and low cost sensor technology for non-invasive detection of ripening stages and selected nutritional

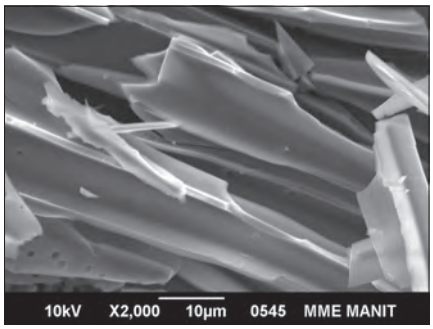
Fruit-nose sensor prototype to measure apple ripeness

Field testing of sensor at apple orchards

profile of apple and papaya has been developed. The E-nose sensor can work independently with its own display or can be integrated with any android mobile phone using SMART-Nose app. In addition to ripening stage, this E-nose sensor can also predict sugar, protein and polyphenol contents non-invasively under post-harvest storage conditions. Comprehensive metabolomics profile of the changes in the volatile organic compounds (VOC) and nutritional properties of apple (cv. Red Delicious, Golden Delicious) and papaya (cv Red Lady) during post-harvest storage conditions were completed. The validation of the sensor at apple orchards of ICAR-CITH, JK is under process.

Thermal degradation of crop residues: The hemi cellulosic and cellulosic bio-polymeric DTG segment gradually vanished as the process temperature increased whereas the lignin dominance was enhanced. However, the presence of all three bio-polymers cellulose, hemicellulose and lignin was remarkably noticed in torrefied biomaterial. During slow pyrolysis, hemicellulosic and cellulosic bio-polymers almost vanished and lignin bio-polymer dominated the processed bio-product. At high temperature after pyrolysis, only lignin was noticed. Torrefaction and

slow pyrolysis increased the total carbon (48% to 80%; at 200 to 450°C). The thermal degradation process was found to impart the changes in the surface morphology of the processed biomaterial and SEM image highlights the formation of micro-channel and micro-cavities on surface of thermally degraded biomaterial. The iso-conversional FWO model was found better than other models for measuring activation energy for complete range of conversion (from 0.1 to 0.9). Thermal degradation processes were found to reduce, on an average, the activation energy levels of the lignin segment as the process temperature increases.



Formation of micro channel and cavities in thermally degraded bio-material

Lactic acid bacteria based biorefineries for converting agro and food based biomass: Lactic acid bacteria based bio refineries for converting agro and food based biomass into PLA and high value-added products, an enzymatic process for the production of polylactides was developed. Purified lactic acid (LA) was used for the synthesis of poly-lactic acid (PLA), a biodegradable and biocompatible plastic by enzymatic method. PLA is a high value-added product synthesized from LA. PLA was characterized by NMR, FTIR, TGA, XRD, SEM, and diffraction scanning calorimetry. Furthermore, foods with improved organoleptic and nutraceutical properties were prepared by using co-products polyols, GABA, and EPS. Encapsulation of GABA and LAB using exopolysaccharides as a coating agent was carried out and its stability study under different process conditions was evaluated. Shelf-stable microcapsules of LAB and GABA containing inulin and dextran as wall materials were prepared using spray drying technology. Spray drying produced a highly stable microcapsule of desirable flowability with higher encapsulation efficiency (99.6%).

Production and processing of microalgal biomass for biodiesel: Among different microalgal species *Chlorella minutissima* was a good lipid accumulator. *Anabaena variabilis* is rich in carbohydrate content, whereas *Oscillatoria formosa*, *Calothrix* sp. and *Spirulina subsalsa* are rich in protein + carbohydrate contents. While, *Aulosira fertilissima, Calothrix* sp., and *O. formosa* are poor lipid accumulators. High lipid accumulator, *C. minutissima,* grown in open and closed raceway ponds reported the average areal productivity of biomass and lipid at 30 cm culture depth to be 11.38 and 1.29 g/m^2/day for open raceway, and 11.75 and 1.37 g/m^2/day for closed raceway ponds, respectively. In the hydrothermal liquefaction (HTL) study, the maximum bio-crude yield (36%) of *C. minutissima* was obtained at 300°C under 200 bar pressure at 60 min retention time without catalyst use. The effect of various acid catalysts, viz. CH_3COOH, HCOOH, HCl, H_2SO_4 and H_3BO_3 were studied, and CH_3COOH was found to stimulate the bio-crude yield up to 45%. A protocol was standardized for maximum extraction of microalgal protein from *C. minutissima* biomass that can be substituted in the diets of freshwater fishes as a protein supplement. The selected protocol produced maximum extraction of protein up to 0.4 g/g.

Biological filter for safe waste water irrigation: The sorption of cadmium and chromium as well as degradation of paracetamol by novel strains *Pseudomonas aeruginosa* IIWM-DW-02E (E), *Bacillus cereus* IIWM-DW-01O (O) and *Acinetobacter baumannii* IIWM-DW-03H (H) encapsulated in alginate beads was analyzed. Based on Langmuir equation the adsorption of Cd and Cr by the microbial isolates were in the order E > O > H. Isolate E had the maximum potential of degrading paracetamol. Three more novel bacterial isolates having potential of absorbing heavy metals and degrading paracetamol were identified and their RNA sequences were submitted in NCBI: *Bacillus megaterium* IIWM-DW-09I, *Enterobacter asburiae* IIWM-JS-07L and *Bacillus cereus* IIWM-OMS-06N. Synthetic municipal wastewater (COD=259.24±100.12 mg/l and Sulphate=180.17±31.65 mg/l) spiked with metals: Fe (5 ppm), Mn (2 ppm), Cu (2 ppm), Zn (2 ppm), Ni (2 ppm), Cr (5 ppm), and Pb (2 ppm) was treated for a period of 37 weeks at two differing flow rates of 50±2 and 26±3 ml/h for testing the performance of Graphite, Gravel and FRP biofilters for metal removal. The COD and sulphate removal were up to 100% and 70%, respectively with highest in graphite. Fe, Zn, Ni, Cr, Pb concentrations in effluent were 0.1–0.15 ppm, attributed to biosorption and bio-chemical precipitation. Manganese removal, generally problematic as requires elevated pH (>8), differed considerably in graphite (40–72%), FRP (32–62%) and gravel (60–80%), respectively. This was also due to composition of material. SiO_2 shows good adsorption for Mn and so gravel filter is effective for it.

Microbial consortia for improving soil health: The liquid formulation of microbial consortia was developed for rapid development of compost from bio-wastes. Compost quality standard has been assessed and it was found that compost is ready for field application after 20 days from kitchen and vegetable waste followed by horticultural waste compost (30 days) and farm waste (45 days). The developed bio filters using selective fungi were effective for elicitation of Zn (~30%) and Ni (>30), Pb (>40%), Cd (>20%) and therefore improve the quality of compost. The manurial value of compost was enriched by using 0.5% Urea-N, 2.5% P_2O_5 through rock phosphate, 5% Pyrites

Ekcel-ShrdR and CompostR for rapid decomposition of biowaste using Accel-Microbial Consortia

(W/W on materials dry weight basis). The total content of N and P increased from 1.12 to 1.8% and 3.2 to 4.12%, respectively in these materials. The maize and soybean crop grew better under enriched compost plots as compared to un-inoculated control. There was no plant pathogenic nematode observed in these enriched compost. Further, it was observed that *E. coli* and *Salmonella* species were not found in this enriched compost under aerobic decomposition.

Conservation agriculture in maize systems: The zero tilled (ZT) maize systems left markedly higher SOC as compared to conventionally tilled (CT) in sandy loam soil of Indo-Gangetic plains. Similarly, the portion of the recalcitrant carbon pool was found higher under ZT over CT, which underlines the importance of the conservation agriculture based crop management in improving carbon quality and its sequestration potential in the soil. Earthworm population was significantly higher in ZT system irrespective of the tillage. There was positive correlation between earthworm cast and its population count. Better enzymatic activities including urease, alkaline phophatsae, florescein diacetate and glucosidase was also observed in earthworm cast than normal soil which shows its importance in improving soil biological activities at large. The improvement in carbon quality and earthworm activities in ZT could be the important factor for explaining higher yields and resource use efficiency under this production system.

Effect of climate, nutrient management and soil type in soybean-based cropping system: Significant changes in the vertical distribution of soil organic carbon (SOC), total nitrogen and nitrogen cycling enzyme activity were recorded in soybean-based cropping systems in different agro-climatic regions. The SOC and total nitrogen in the top 30 cm (relative to the total top 90 cm) was found to the tune of 65, 71, 60 and 80%; and 76, 68, 68 and 71% for vertisols of Bhopal, Jabalpur, Indore and Alfisol of Ranchi, respectively across soil nutrient management. The profile distribution of SOC and total nitrogen content decreased with increase in temperature and precipitation and a significant negative correlation was found between SOC and maximum temperature. Soil pH, clay, soil microbial activity and soil nutrient management are the essential factors influencing the SOC spatial distributions. Soil nutrient management significantly influenced the distribution of SOC and total nitrogen content till 60 cm depth across site. The order of SOC sequestration is soybean–wheat > soybean–chickpea > soybean-fallow cropping system. Integrated use of nutrients (100% NPK+ FYM) increased SOC storage and enzyme activities over NPK fertilization at all sites. Across site, reduced tillage together with 30% residue retention and application of 100% NPK + FYM @ 6 t/ha had the highest SOC sequestration (344 kg/ha/yr) for 0–15 cm soil depth.

Smart Shrimp Aquaculture Mobile Application (SAM-APP): An android based Smart Shrimp Aquaculture Mobile Application (SAM-APP) was developed by ICAR-CIBA. In the first part of the app, after the initial registration, the end-users need to enter information about their personal profile and their farm/pond specific information, based on that the app would advise the farmer on the scale with which he can operate his farm. After seed stocking in the ponds, the end-user has to enter certain optional and mandatory information like water quality parameters, feeding protocols and animal health on daily basis in the SAM-APP. The app processes the data and displays recommendations to the farmer pond wise, facilitating them to optimise the inputs and managing the farm efficiently. The SAM-APP was trial-tested in two shrimp farming clusters one each in Andhra Pradesh and Tamil Nadu for its computability and adoptability.

❑

"Happiness in the lives of farmers increases happiness in all of us."

— Narendra Modi

19. Training and Capacity Building

Training is a systematic learning event to methodically impart required knowledge, skills and behaviour to the employees. ICAR is perusing training and capacity building of employees of all categories. The highlights of Training and Capacity Building of ICAR employees of all categories undertaken during 2019–20 are enumerated here.

New initiatives

Online submission of Annual Training Plan (***ATP***): As per ICAR HRM Policy, Training and Capacity Building, it is utmost important for all the Institutes/ HQs to develop Annual Training Plan (ATP) based on Training Need Assessment (TNA) for all categories of employees and submit to Training Manager, ICAR in the beginning of the year.

Trainers development programme: To support ICAR-NAARM, Hyderabad and other ICAR-Institutes for organizing various training programmes for Administrative and Finance staff, a specialized *Trainers Development Programme for Developing Masters' Trainers in ICAR*, was designed, developed and organized by ICAR-NAARM, Hyderabad in coordination with Administration Section and HRM Unit, ICAR HQs during 4 to 9 December 2019 for the first time. In this training programme, 22 Administrative and Finance staff participated, all of them attended such type of training first time after joining ICAR service.

Training programme for staff dealing with security or security officer: For the first time, a *Capacity Building Programme for a Secure and Resilient Workplace*, was designed, developed and organized by ICAR-CPRI, Shimla, in coordination with HRM Unit, ICAR HQs from 25–27 November 2019 in which 33 Technical and Administrative staff of 26 ICAR-Institutes dealing with Security or Security Officers participated.

Training programme for administrative staff dealing with court cases: For the first time, a training programme on *Improving Skills of Administrative Staff of ICAR dealing with Court Cases,* was designed, developed and organized by ICAR-CAZRI, Jodhpur in coordination with Legal Cell and HRM Unit, ICAR

Trainers Development Programme at ICAR-NAARM, Hyderabad


Training of administrative staff dealing with Court Cases at ICAR-CAZRI, Jodhpur


Training of staff dealing with Security or Security Officer at ICAR-CPRI, Shimla

Training of staff associated with Works/Estate/Building Maintenance at ICAR-CIAE, Bhopal

HQs from 25–27 November 2019 in which 18 Administrative staff dealing with court cases participated.

Training programme for staff associated with works/estate/building maintenance: For the first time, a training programme on *Repair and Maintenance of Office, Residential Building including Guest Houses,* was designed, developed and organized by ICAR-CIAE, Bhopal in coordination with Works/Engineering Cell and HRM Unit, ICAR HQs from 21–23 January 2020 in which 29 Administrative/Technical staff associated with Works/Estate/Building Maintenance participated.

Training programme on assets management: Suitable training programme for Administrative including Finance staff dealing with Assets Management in ICAR was lacking in the system. Therefore, for the first time, a new training programme on *Assets Management,* was designed, developed and organized by ICAR-IARI, New Delhi in coordination with Finance Division and HRM Unit, ICAR from 4–8 November 2019 in which 28 administrative including finance category of staff participated.

Training of administrative staff dealing with Assets Management at ICAR-IARI, New Delhi

Capacity building programme for CJSC Members: For the first time, a Capacity Building Programme for CJSC members was designed, developed and organized by ICAR-NAARM, Hyderabad from 27–31 January 2020 in which 89 CJSC Members of ICAR Institutes/HQs participated. All the CJSC member participated for the first time in such kind of training programme after being elected as CJSC member.

Implementation of training management information system (TMIS): The Training Management Information System (TMIS) has been effectively implemented in ICAR w.e.f. 1 April 2019. It is mandatory for all ICAR-Institutes/Headquarters/PC Units with ICAR employees to submit the Annual Training Plan (ATP) and applications for attending Training Programme in ICAR/Non-ICAR Institutes through TMIS to make all the HRD related activities paperless. Most of the Institutes including HQs submitted ATP for 2019–20 and applications online through TMIS.

Effectiveness of trainings conducted/attended: The effectiveness of trainings conducted/attended during 2017–18 in ICAR was studied and statistically analysed. The assessment study was based on response of 1,782 staff belonging to all four categories who attended the training as well as their Reporting Officers from 106 ICAR-Institutes across 26 states/UTs. It was revealed that pooled perceived training effectiveness index (PTEI) was 3.86, referring to medium effectiveness of trainings. The mean PTEI score was the highest for SSS (3.94) followed by Administrative staff (3.90). Overall, most of the participants (58.83%) reported medium degree of effectiveness of the training programmes. Significant behavioural changes and changes in practices as a consequence of exposure to the trainings were observed. The study also revealed that the perceived training effectiveness was significantly associated with age, gender, experience of the trainees and duration of training programmes. The PTEI was positively and significantly associated with age and gender while negatively and significantly associated with experience of trainee. Some observed constraints of the trainees were inadequate infrastructure at the Institute, particularly with regard to lodging and boarding; lack of practical exposure; and sometimes lesser relevance of few topics, etc. The major suggestions were inclusion of more practical sessions; follow up programmes for trainer-trainee meet, and increasing the duration of trainings in few cases.

The PTEI was strongly associated with Subject Matter Divisions (SMDs) and category of employees. Scientists of Agricultural Engineering Division had highest PTEI score (3.98) followed by Animal Science (3.87). In case of other than Scientist category (Technical, Administrative and Skilled Support Staff), the highest PTEI score was achieved by Fisheries Science Division (4.16) followed by Crop Science Division (4.04). It was concluded that the trainings organized by ICAR should continue for all staff to bring about desirable changes in competencies. About 65.3% participants from Agricultural Engineering Division attached medium level of effectiveness of training programmes followed by Crop Science Division (54.1%). About 42.9% participants from Horticulture Science Division attached high level of effectiveness of training programmes closely followed by Agricultural Education Division (42.1%).

Other initiatives

Executive development programmes for senior officers with international exposure: During the year, an Executive Development Programme (EDP) on *Developing Effective Organisational Leadership for Senior Officers of ICAR,* was organized by ASCI, Hyderabad in coordination with ICAR-NAARM, Hyderabad and HRM Unit, ICAR HQs. The programme was envisaged to enhance leadership capacities, competence, skills of senior research managers and officers to improve the organizational efficiency. Overall, 45 multidisciplinary Senior Scientific and Administrative staff together in 2 batches with both In-country (ASCI, Hyderabad; 2–4 August 2019 for Batch 1 and 9–11 August 2019 for Batch-2) and International components (Netherlands, Belgium,

Participants visiting University of Bonn, Germany (Batch-1; 2019–20)

Participants visiting Research Institute of Organic Agriculture, Frick, Switzerland (Batch-2; 2019–20)

Germany and Switzerland; 21–30 September 2019 for Batch 1 and 12–21 October 2019 for Batch-2) participated.

Scientific staff: ICAR-Institutes organized 272 training programmes for Scientific Staff (1,055) for enhancing their competency in various fields.

CAFT Training of Scientific staff at ICAR-CIAE, Bhopal

Training workshop for vigilance officers: Two days Training Workshop for Vigilance Officers of ICAR was organized by ICAR-NAARM, Hyderabad from 31 October to 1 November, 2019 as most of the Vigilance Officers of ICAR-Institutes are Scientists who do not have required competency to handle vigilance and disciplinary cases. In this workshop, 32 Vigilance Officers of 32 Institutes participated.

Management development programme for PME cell incharges: To acquaint the PME Cell Incharges with the techniques for Research Prioritization, Monitoring and Evaluation, a six-day MDP on *Priority Setting, Monitoring and Evaluation (PME) of Agricultural Research Projects*, was organized by ICAR-NAARM, Hyderabad from 18–23 July 2019. In the said MDP, 34 PME Cell Incharges of 34 Institutes participated.

Training programme for ITMU/ZTMU incharges: A training programme on *IP Valuation and Technology Management*, was organized by ICAR-NAARM, Hyderabad from 15–19 October 2019 in which 30 ITMU/ZTMU Incharges participated.

Technical Staff: During 2019–20, ICAR-Institutes organized 112 training programmes for Technical Staff (728).

Training of Technical staff at ICAR-CICR, Nagpur

Training programme for technical staff associated with farm/farm managers: In order to manage the research/livestock/fisheries farms more effectively and efficiently, a specially designed and developed training programme on *Farm Management* was successfully organized by ICAR-IIFSR, Modipuram from 17–23 September 2019. A total of 33 technical staff associated with Farm/Farm Manager (30 from ICAR + 3 Non-ICAR) participated.

Training programme for library staff: Technical staff associated with Library work in various ICAR Institutes/HQs were nominated by the Council for Training Programme organised by ICAR-NAARM, Hyderabad on *KOHA* during 20–25 February 2020. A total of 19 technical staff of such category participated.

Training programme for regular drivers: ICAR-CIAE, Bhopal organized a specialized training programme on *Automobile Maintenance, Road Safety and Behavioural Skills* in coordination with HRM Unit, ICAR HQs. In this programme, 92 Regular Drivers in Technical grade participated in 3 batches, out of which 90% got first time opportunity after joining ICAR service.

Administrative staff: ICAR-Institutes/HQs organized 45 training programmes for Administrative including Finance stafff or improving their competency and 1,321 administrative staff of ICAR of various grades participated.

Specialized training programme for caretakers/ guest house Incharges: A specialized training programme on *Hospitality Management*, in collaboration with Institute of Hotel Management,

SMD-wise number of employees undergone training

SMDs/HQs	No. of employees trained					% employees trained				
	Scientist	Tech.	Admin	SSS	Total	Scientist	Tech.	Admin	SSS	Total
Crop Sciences	274	260	343	94	971	16.2	18.7	40.6	7.1	82.6
Horticultural Sciences	155	108	181	86	530	21.2	15.7	46.9	15.2	99.0
NRM	151	125	159	34	469	19.0	12.6	38.0	5.7	75.3
Agricultural Education	30	22	63	23	138	20.8	23.4	59.4	39.7	143.3
Agricultural Engg.	39	21	82	18	160	19.9	8.0	59.9	15.1	102.9
Animal Sciences	203	102	185	48	538	26.9	13.5	37.9	4.0	82.4
Fisheries Sciences	166	76	165	37	444	27.5	15.2	55.4	9.4	107.6
Agricultural Extension	11	8	35	0	54	31.4	30.8	58.3	0.0	120.5
ICAR HQs	26	6	108	0	140	20.8	23.4	59.4	39.7	34.3
Total	1,055	728	1,321	340	3,444	21.0	15.2	43.1	7.9	20.1

Catering Technology and Applied Nutrition (IHMCT&AN), Hyderabad was organized by ICAR-NAARM, Hyderabad from 26 June to 2 July 2019. In the said training programme, 21 Caretakers/Incharges of Guest Houses of various ICAR-Institutes participated, out of which, about 91% attended first time such training programme after joining ICAR service.

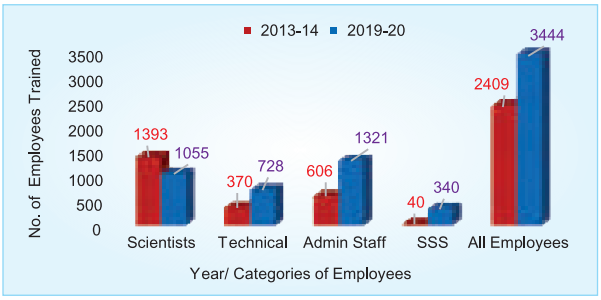
Training programme for stenographers: During the reporting period, ICAR-NAARM, Hyderabad organized a training programme on *Enhancing Efficiency and Behavioural Skills*, in coordination with HRM Unit, ICAR HQs in 2 batches at ICAR-CPRI, Shimla and ICAR-NAARM, Hyderabad. In this programme, 51 stenographers in various grades participated, out of which 100% stenographers got training first time after joining ICAR services.

Training programme for skilled support staff (SSS): Based on the identified training needs, ICAR-Institutes/HQs are organising trainings for skilled support staff after the creation of HRM Unit at ICAR HQs. During 2019–20, 27 training programmes were organized for skilled support staff by 27 ICAR-Institutes/HQs and 340 SSS were trained.

Field/exposure visit of SSS: It was realized that there should be a provision of field/exposure visit of Skilled Support Staff category (SSS) who have never visited other ICAR-Institutes even in the same state. Keeping this in view, 21 ICAR-Institutes had organized Field/Exposure visit of 288 SSS to nearby ICAR-Institutes during 2019–20.

Employees trained

Manpower trained (In terms of number): During the reporting period, 3,444 employees have undergone various types of training and capacity building programmes, out of which Scientists, Technical, Administrative including Finance, and Skilled Support Staff (SSS) were 1,055, 728, 1,321 and 340, respectively. Compared to 2013–14, there was considerable improvement in number of employees who have undergone trainings particularly in Technical, Administrative and Skilled Support Staff, where improvement was 96.8, 118 and 750%, respectively, along with overall improvement of 43% in all the categories of employees during 2019–20.



Improvement in capacity building of ICAR employees since creation of HRM Unit

During the reporting period, Crop Science Division deputed highest number of Scientists (274), Technical

Number of trainings organized by various SMDs during 2019–20

SMDs/HQs	Scientists	Technical staff	Administrative staff	SSS	All employees
Crop Sciences	45	47	5	6	103
Horticultural Sciences	19	9	4	5	37
NRM	34	9	1	1	45
Agricultural Education	72	8	11	1	92
Agricultural Engineering	26	4	2	1	33
Animal Sciences	43	19	3	5	70
Fisheries Sciences	22	13	9	8	52
Agricultural Extension	11	3	1	0	15
ICAR HQs	0	0	9	0	9
Total	**272**	**112**	**45**	**27**	**456**

staff (260), Administrative staff (343) and Skilled Support Staff (94) for various capacity building programmes. Thus, overall maximum number of employees were trained in Crop Science Division (971) followed by Horticultural Science Division (530), out of 3,444 employees trained in the ICAR system.

In terms of per cent employees trained under each category, Scientists (21.0%), Technical (15.2%), Administrative including Finance (43.1%) and Skilled Support Staff (7.9%) were trained in various aspects as per their training needs during 2019-20 with overall 20.1% employees across the categories who got opportunity for capacity building. This is evident that 7.9, 26.6 and 7.2% more Technical, Administrative including Finance and Skilled Support Staff, respectively got training opportunities during 2018–19 as compared to 2013–14 with overall improvement of 7.4% in capacity building of all the categories of employees.

The training programmes organised for scientists, technical, administrative including finance, and skilled support staff were 272, 112, 45 and 27, respectively. Compared to 2013-14, ICAR-Institutes/HQs organized 67.2 and 440.0% more training programmes for technical and skilled support staff, respectively with overall 4.1% higher training during 2019-20. It is also being emphasized to give more opportunities outside ICAR in other competent and relevant Institutes.

Agricultural Education Division organised maximum number of trainings for scientists (72) and administrative staff (11), Crop Science Division for technical staff (47) and Fisheries Science Division for skilled support staff (8). Moreover, maximum number of training programmes for all employees were organized by Crop Science Division (103) and was closely followed by Agriculatural Education Division (92).

❑

"कुपोषण रहित भारत के निर्माण के लिए किसानों का सशक्तिकरण जरुरी।"

— नरेन्द्र मोदी

APPENDIX I

ACTIVITY PROGRAMME CLASSIFICATION

Budget Estimates (BE) and Revised Estimates (RE) for the year 2019–20 and BE 2021–22 in r/o DARE Secretariat, Contribution, AP Cess, CAUs and NAAS and IAUA are given in Table 1.

Table 1. Budget Estimates and Revised Estimates of DARE

(Rupees in Lakh)

Items		Budget Estimates	Revised Estimates	Budget Estimates
		2019–20	2019–20	2020–21
		Unified Budget	Unified Budget	Unified Budget
Major Head	**'3451'**			
090	**Secretariat-Economic Services**	805.00	688.00	755.00
Major Head	**'2415'**			
80	**General**			
80.120	**Assistance to other institutions**			
01	**Grant-in-Aid Central Agricultural University Imphal**			
010031	Grants in Aid General	-	-	-
010035	Grants for creation of Capital Assets	-	-	-
010036	Grants in Aid Salaries	-	-	-
02	**Grant-in-Aid Central Agricultural University Bundelkhand**			
020031	Grants in Aid General	405.00	405.00	500.00
020035	Grants for creation of Capital Assets	6992.00	7671.00	10000.00
020036	Grants in Aid Salaries	500.00	425.00	500.00
03	**Grant-in-Aid Central Agricultural University Bihar**			
030031	Grants in Aid General	1010.00	955.00	1100.00
030035	Grants for creation of Capital Assets	10000.00	10000.00	6000.00
030036	Grants in Aid Salaries	8000.00	8000.00	7490.00
05	**Grants-in-Aids to National Academy of Agricultural Sciences and Indian Agricultural Universities Association**			
050031	Grants in Aid General	156.00	156.00	160.00
050035	Grants for creation of Capital Assets	-	-	-
050036	Grants in Aid Salaries	-	-	-
06	**Agricultural Scientists' Recruitment Board**			
060031	Grants in Aid General	1570.00	892.00	900.00
060035	Grants for creation of Capital Assets	1490.00	21.00	500.00
060036	Grants in Aid Salaries	900.00	571.00	658.00
80.798	**International Co-operation (Minor Head)**			
01	**India's Membership Contribution to Commonwealth Agricultural Bureau**			
010032	Contribution	25.35	25.35	25.35
02	**India's Membership Contribution to Consultative Group on International Agricultural Research**			
020032	Contribution	590.00	545.00	545.00
04	**Asia Pacific Association of Agricultural Research Institutions**			
040032	Contribution	9.00	9.00	9.00
05	**N.A.C.A.**			
050032	Contribution	46.00	46.00	46.00
07	**International Seed Testing Association, Zurich, Switzerland**			
070032	Contribtion	4.25	4.25	4.25
08	**International Society for Horticulture Science, Belgium**			
080032	Contribution	0.40	0.40	0.40
Major Head	**'2552' North Eastern Areas**			
259	**General (Agri. Res. & Edn. Schemes) (Minor Head)**			
01	**Grants-in-Aid-General to Central Agricultural University, Imphal**			
010031	Grants in Aid General	2393.00	2240.00	2400.00
010035	Grants for creation of Capital Assets	6700.00	6700.00	9000.00
010036	Grants in Aid Salaries	9500.00	9522.00	8990.00
	TOTAL	**51096.00**	**48876.00**	**49583.00**

Notes on Demands For Grants, 2020-2021

MINISTRY OF AGRICULTURE AND FARMERS" WELFARE

DEMAND NO. 2

Department of Agricultural Research and Education

A. The Budget allocations, net of recoveries, are given below: (Rupees in crore)

Schemes		Actual 2018–2019			Budget 2019–2020			Revised 2019–2020			Budget 2020–2021		
		Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
	Gross	*7943.58*	*...*	*7943.58*	*8078.76*	*...*	*8078.76*	*7846.17*	*...*	*7846.17*	*8362.58*	*...*	*8362.58*
	Recoveries	*-399.33*	*...*	*-399.33*	*...*	*...*	*...*	*...*	*...*	*...*	*...*	*...*	*...*
	Receipts	*...*	*...*	*...*	*...*	*...*	*...*	*...*	*...*	*...*	*...*	*...*	*...*
	Net	**7544.25**	**...**	**7544.25**	**8078.76**	**...**	**8078.76**	**7846.17**	**...**	**7846.17**	**8362.58**	**...**	**8362.58**
CENTRE'S EXPENDITURE													
I Establishment Expenditure of the Centre													
1. Secretariat	2415	6.25	...	6.25	6.85	...	6.85	6.40	...	6.40	6.30	...	6.30
	3451	6.64	...	6.64	7.95	...	7.95	6.78	...	6.78	7.55	...	7.55
Total-Secretariat		**12.89**	**...**	**12.89**	**14.80**	**...**	**14.80**	**13.18**	**...**	**13.18**	**13.85**	**...**	**13.85**
II Central Sector Schemes/Projects													
2. Agricultural Extension	2415	205.53	...	205.53	208.67	...	208.67	208.67	...	208.67	228.82	...	228.82
	2552	...	...	...	12.48	...	12.48	12.48	...	12.48	13.68	...	13.68
Total -Agricultural Extension		**205.53**	**...**	**205.53**	**221.15**	**...**	**221.15**	**221.15**	**...**	**221.15**	**242.50**	**...**	**242.50**
3. Agricultural Engineering	2415	59.50	...	59.50	62.30	...	62.30	62.23	...	62.23	67.05	...	67.05
	2552	...	...	...	1.72	...	1.72	1.79	...	1.79	2.95	...	2.95
Total -Agricultural Engineering		**59.50**	**...**	**59.50**	**64.02**	**...**	**64.02**	**64.02**	**...**	**64.02**	**70.00**	**...**	**70.00**
Management of Natural Resources													
4. Natural Resource Management Institutes including Agro Forestry Research	2415	148.51	...	148.51	132.32	...	132.32	129.02	...	129.02	141.52	...	141.52
	2552	...	...	...	27.16	...	27.16	29.81	...	29.81	32.48	...	32.48
Total-Natural Resource Management Institutes including Agro Forestry Research		**148.51**	**...**	**148.51**	**159.48**	**...**	**159.48**	**158.83**	**...**	**158.83**	**174.00**	**...**	**174.00**
5. Climate Resilient Agriculture Initiative	2415	44.21	...	44.21	40.52	...	40.52	41.40	...	41.40	46.80	...	46.80
	2552	...	...	...	7.04	...	7.04	4.60	...	4.60	5.20	...	5.20
Total-Climate Resilient Agriculture Initiative		**44.21**	**...**	**44.21**	**47.56**	**...**	**47.56**	**46.00**	**...**	**46.00**	**52.00**	**...**	**52.00**
Crop Sciences													
6. Crop Science	2415	651.99	...	651.99	652.94	...	652.94	602.00	...	602.00	680.38	...	680.38
	2552	...	...	...	48.59	...	48.59	33.00	...	33.00	35.12	...	35.12
Total-Crop Science		**651.99**	**...**	**651.99**	**701.53**	**...**	**701.53**	**635.00**	**...**	**635.00**	**715.50**	**...**	**715.50**
7. Horticultural Science	2415	165.75	...	165.75	173.47	...	173.47	156.43	...	156.43	174.60	...	174.60
	2552	...	...	...	4.87	...	4.87	17.18	...	17.18	19.40	...	19.40
Total -Horticultural Science		**165.75**	**...**	**165.75**	**178.34**	**...**	**178.34**	**173.61**	**...**	**173.61**	**194.00**	**...**	**194.00**

Contd...

Schemes		Actual 2018–2019			Budget 2019–2020			Revised 2019–2020			Budget 2020–2021		
		Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
8. National Agricultural Science Fund	2415	50.75	...	50.75	54.80	...	54.80	50.00	...	50.00	55.00	...	55.00
Animal Sciences													
9. Animal Science		288.98	...	288.98	300.55	...	300.55	299.57	...	299.57	297.00	...	297.00
	2552	...	...	...	10.43	...	10.43	10.43	...	10.43	33.00	...	33.00
Total -Animal Science		**288.98**	**...**	**288.98**	**310.98**	**...**	**310.98**	**310.00**	**...**	**310.00**	**330.00**	**...**	**330.00**
10. Fisheries Science	2415	132.34	...	132.34	141.38	...	141.38	141.38	...	141.38	152.40	...	152.40
	2552	...	...	...	1.01	...	1.01	1.01	...	1.01	3.60	...	3.60
Total-Fisheries Science		**132.34**	**...**	**132.34**	**142.39**	**...**	**142.39**	**142.39**	**...**	**142.39**	**156.00**	**...**	**156.00**
Agricultural Education													
11. Agricultural Universities and Institutions	2415	525.59	...	529.59	535.35	...	535.35	429.84	...	429.84	454.40	...	454.40
	2552	...	...	...	30.16	...	30.16	20.16	...	20.16	25.60	...	25.60
Total -Agricultural Universities and Institutions		**525.59**	**...**	**525.59**	**565.51**	**...**	**565.51**	**450.00**	**...**	**450.00**	**480.00**	**...**	**480.00**
12. Economic Statistics and Management	2415	27.66	...	27.66	29.76	...	29.76	29.76	...	29.76	30.00	...	30.00
13. National Agricultural Higher Education Project		155.28	...	155.28	...	...	...	...	...	...	...	...	...
14. National Agricultural Higher Education Project (EAP)		52.63	...	52.63	223.68	...	223.68	207.85	...	207.85	230.00	...	230.00
Total -Central Sector Schemes/Projects		**2508.72**	**...**	**2508.72**	**2699.00**	**...**	**2699.00**	**2488.61**	**...**	**2488.61**	**2729.00**	**...**	**2729.00**
III Other Central Sector Expenditure													
b Autonomous Bodies													
15. ICAR Headquarters		5056.09	...	5056.09	4711.75	...	4711.75	4721.23	...	4721.23	4977.75	...	4977.75
	2552	...	...	...	157.05	...	157.05	147.57	...	147.57	160.00	...	160.00
		5056.09	...	5056.09	4868.80	...	4868.80	4868.80	...	4868.80	5137.75	...	5137.75
16. Central Agricultural Universities	2415	363.92	...	363.92	269.07	...	269.07	274.56	...	274.56	255.90	...	255.90
	2552	...	...	...	185.93	...	185.93	184.62	...	184.62	203.90	...	203.90
		363.92	...	363.92	455.00	...	455.00	459.18	...	459.18	459.80	...	459.80
17. National Academy of Agricultural Sciences	2415	1.96	...	1.96	1.56	...	1.56	1.56	...	1.56	1.60	...	1.60
18. Agricultural Scientists Recruitment Board		...	...	...	39.60	...	39.60	14.84	...	14.84	20.58	...	20.58
Total -Autonomous Bodies		**5421.97**	**...**	**5421.97**	**5324.96**	**...**	**5324.96**	**5344.38**	**...**	**5344.38**	**5619.73**	**...**	**5619.73**
f Others													
19. Actual Recoveries		-399.33	...	-399.33	...	...	...	...	...	...	...	...	...
	3451	...	...	...	...	...	...	...	...	...	...	...	...
		-47.00	...	-47.00	...	...	...	...	...	...	...	...	...
Grand Total -		**7544.25**	**...**	**7544.25**	**8078.76**	**...**	**8078.76**	**7846.17**	**...**	**7846.17**	**8362.58**	**...**	**8362.58**
B. Developmental Heads													
Economic Services													
1. Agricultural Research and Education		7537.61	...	7537.61	7584.37	...	7584.37	7376.74	...	7376.74	7820.10	...	7820.10
2. Secretariat-Economic Services		6.64	...	6.64	7.95	...	7.95	6.78	...	6.78	7.55	...	7.55
Total -Economic Services		**7544.25**	**...**	**7544.25**	**7592.32**	**...**	**7592.32**	**7383.52**	**...**	**7383.52**	**7827.65**	**...**	**7827.65**
Others													
3. North Eastern Areas		...	...	...	486.44	...	486.44	462.65	...	462.65	534.93	...	534.93
Total -Others		**...**	**...**	**...**	**486.44**	**...**	**486.44**	**462.65**	**...**	**462.65**	**534.93**	**...**	**534.93**
Total -		**7544.25**	**...**	**7544.25**	**8078.76**	**...**	**8078.76**	**7846.17**	**...**	**7846.17**	**8362.58**	**...**	**8362.58**

1. **Secretariat—**The provision is for the expenditure on salary of DARE staff.
2. Agricultural Extension- The provision is for the activities to reach out to the farmers at grass root level through Krishi Vigyan Kendras to disseminate and refine frontline agricultural technologies. It includes training of farmers and extension personnel on local technologies, distribution of seed and planting materials and testing of soil and water samples.
3. **Agricultural Engineering—**The provision is for research, development and refinement of farm equipment, process and value addition protocols.
4. **Natural Resource Management Institutes including Agro-Forestry Research—**The provision is for research to address low farm productivity and profitability, land degradation, low water productivity, soil health deterioration and low nutrient use efficiency, deterioration in ecosystem services, abiotic stresses, etc. It is necessary to encounter deteriorating natural resource base for long term sustainability.
5. **Climate Resilient Agriculture Initiative—**The provision is to conduct strategic research and technology demonstration to enhance resilience of Indian agriculture to climate change and climate vulnerability. The research on adaptation and mitigation covers crops, livestock, fisheries and natural resource management.
6. **Crop Science—**Research provision is to develop trait-specific high yielding field crop varieties/hybrids having tolerance to pest and diseases, besides various abiotic stresses. The quality attributes are also given due importance with no yield penalty. The All India Coordinated Research Project (AICRPs)/Network Research Projects with active collaboration with State Agricultural Universities (SAUs) are engaged in the development of improved crop varieties/ hybrids, cost-effective production and environment-friendly protection technologies in different agro-climatic regions.
7. **Horticultural Science—**The provision is to address thrust areas of enrichment of horticultural genetic resources, development of new cultivation with resistance mechanism to biotic and abiotic stresses, appropriate production technology and health management system of horticultural and vegetable crops.
8. **National Agricultural Science Fund—**Supports basic and strategic research in agriculture to address the prioritized research problems.
9. **Animal Sciences—**The provision is to develop new technologies to support production enhancement, profitability, competitiveness and sustainability of livestock and poultry sector for food and nutritional security. It will facilitate need based priority research in livestock and poultry sector in on-going and new emerging areas to support productivity increase, thereby reducing the gap between potential and actual yield.
10. **Fisheries Science—**The provision is to implement research and academic programmes in fisheries and aquaculture. It also provides technical, training, analytical, advisory support and consultancy services in the field of resources assessment and management, standardization of aquaculture hatchery and grow-out culture technologies, responsible fishing system and species diversification and utilization of inland saline soils for aquaculture, fish health monitoring, etc.
11. **Agricultural Universities and institutions—**The provision will provide financial support to all the agricultural universities in the country comprising State Agricultural Universities (SAUs), Deemed universities (DUs), and Central Universities (CUs) with Agriculture Faculty. The scheme is also responsible for maintainance and improvement of standard of agricultural education through (*i*) accreditation of educational institutions, (*ii*) providing International/national fellowships both at post and undergraduate levels, (*iii*) organization of training and capacity building programmes for the scientists/faculty of National Agricultural Research System in cutting-edge areas.
12. **Economics, statistics and management—**The provision is for conducting research in the areas of agricultural economics and agricultural statistics to address the policy, management and database issues and accordingly provide need-based support to other schemes and agricultural stakeholders.
13. The provision is for National Agricultural Higher Education Project (NAHEP) which aims to develop resources and mechanism for supporting infrastructure, faculty and student advancement, and providing means for better governance and management of agricultural universities, so that a holistic model can be developed to raise the standard of current agricultural education system that provides more jobs and is entrepreneurship oriented and on par with the global agriculture education standards.
14. The provision is for the externally aided component of the National Agricultural Higher Education Project (NAHEP) which aims to develop resources and mechanism for supporting infrastructure, faculty and student advancement, and providing means for better governance and management of agricultural universities, so that a holistic model can be developed to raise the standard of current agricultural education system that provides more jobs and is entrepreneurship oriented and on par with global agricultural standards.
15. **ICAR Headquarter—**provision is primarily for the salaries, pensions and expenses on administrative and logistic support to different schemes under ICAR in order to implement them efficiently. The provision in RE 2018–19 goes up dramatically because of revision of pay scales and pension to Scientific personnel of ICAR due to implementation of 7th CPC.
16. **Central Agricultural Universities—**The provision is to strengthen the regional education, research and extension capabilities based on local agro-climatic situation.
17. **National Academy of Agricultural Sciences—**The provision is to provide a forum to Agricultural Scientists to deliberate on important issues of agricultural research, education and extension and present views of the scientific community as policy inputs to planners, decision/opinion makers at various levels.
18. **Agricultural Scientists Recruitment Board—**The provisions are for the creation of an separate autonomous body which would be responsible for the recruitment to posts in the Agricultural Research Service (ARS) of the ICAR and other group A posts in ICAR.

APPENDIX 2

INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

4(i) *Minister-in-charge of the portfolio of Agriculture in the Union Cabinet- President of the Society*

1. Shri Narendra Singh Tomar — Ex-officio
Minister of Agriculture & Farmers Welfare,
Rural Development and Panchayati Raj,
Government of India, Krishi Bhavan,
New Delhi 110 001

4(ii) *Minister of State in the Union Ministry of Agriculture & Farmers Welfare dealing with ICAR*

2. Shri Kailash Choudhary — Ex-officio
Minister of State for Agriculture & Farmers Welfare,
Government of India, Krishi Bhavan,
New Delhi 110 001

4(iii) *Union Ministers holding charge of Finance, Planning, Science & Technology, Education and Commerce* (*in case the Prime Minister is holding any of these portfolios, the Minister of State in the Ministry / Department concerned*)

3. Smt. Nirmala Sitharaman — Ex-officio
Minister of Finance and Corporate Affairs,
Government of India, North Block,
New Delhi 110 001

4. Shri Rao Inderjit Singh — Ex-officio
Minister of State for Planning
Government of India, Room No. 132,
NITI Aayog, New Delhi 110 001

5. Dr Harsh Vardhan — Ex-officio
Minister of Science & Technology and Earth Science,
Health and Family Welfare,
Government of India, CSIR Building,
2 Rafi Marg, New Delhi 110 001

6. Shri Ramesh Pokhriyal 'Nishank' — Ex-officio
Minister of Education, Government of India
Shastri Bhavan, New Delhi 110 001

7. Shri Piyush Goyal
Minister of Commerce & Industry
Government of India,
Udyog Bhavan, New Delhi 110 001

4(iv) *Other Ministers in the Union Ministry of Agriculture & Farmers Welfare*

8. Shri Parshottam Rupala — Ex-officio
Minister of State for Agriculture & Farmers Welfare,
Government of India,
Krishi Bhavan, New Delhi 110 001

4(v) *Ministers in the States in-charge of Agriculture/ Horticulture/Animal Husbandry/ Fisheries*

ANDHRA PRADESH

9. Shri Kurasula Kanna Babu — Ex-officio
Minister for Agriculture and Cooperation,
Government of Andhra Pradesh,
A.P. Secretariat, Valagapudi,
Hyderabad, Andhra Pradesh 500 022

10. Dr Seediri Appalaraju — Ex-officio
Minister for Animal Husbandry & Fisheries,
Government of Andhra Pradesh,
A.P. Secretariat, Valagapudi,
Hyderabad, Andhra Pradesh 500 022

ARUNACHAL PRADESH

11. Shri Tage Taki
Minister for Agriculture, Animal Husbandry, Horticulture & Fisheries,
Government of Arunachal Pradesh
CM Secretariat, Itanagar,
Arunachal Pradesh 791 111

ASSAM

12. Shri Atul Bora — Ex-officio
Minister for Agriculture & Horticulture & Animal Husbandry
Government of Assam, Assam (Civil) Secretariat,
Dispur, Guwahati, Assam 781 006

13. Shri Parimal Suklabaiya
Minister of Fisheries,
Government of Assam, Assam (Civil) Secretariat,
Dispur, Guwahati, Assam 781 006

BIHAR

14. Sh. Amrendra Singh — Ex-officio
Minister for Agriculture
Government of Bihar, Vikas Bhavan,
New Secretariat, Bailey Road,
Patna, Bihar 800 015

15. Sh. Mukesh Sahni — Ex-officio
Minister for Animal & Fisheries Resources,
Government of Bihar, Vikas Bhavan,
New Secretariat, Bailey Road,
Patna, Bihar 800 015

CHHATTISGARH

16. Shri Ravindra Choubey — Ex-officio
Minister of Agriculture, Animal Husbadry & Fisheries,
Government of Chhattisgarh,
Mahanadi Bhawan, Mantralaya Naya
Raipur, Chhattisgarh 492 002

DELHI

17. Shri Gopal Rai — Ex-officio
Minister for Development
Delhi Secretariat, I.P. Estate,
New Delhi 110 002

GOA

18. Shri Chandrakant Kavalekar — Ex-officio
Minister of Agriculture & Horticulture
Government of Goa, Secretariat,
Porvorim, Goa 403 521

19. Shri Mauvin Godinho — Ex-officio
Minister of Animal husbandry,
Government of Goa, Secretariat,
Porvorim, Goa 403 521

20. Shri Filipe Rodrigues — Ex-officio
Minister of Fisheries
Government of Goa, Secretariat,
Porvorim, Goa 403 521

GUJARAT

21. Shri Ranchhodbhai Chanabhai Faldu — Ex-officio
Minister for Agriculture & Horticulture,
Government of Gujarat,
Swarnim Sankul-I, New Sachivalaya,
Gandhinagar, Gujarat 382 010

22. Shri Kunvarjibhai Mohanbhai Bavaliya — Ex-officio
Minister of Animal Husbandry,
Government of Gujarat,
Swarnim Sankul-I, New Sachivalaya,
Gandhinagar, Gujarat 382 010

23. Shri Jawaharbhai P. Chavda — Ex-officio
Minister of Fisheries,
Government of Gujarat,
Swarnim Sankul-I, New Sachivalaya,
Gandhinagar, Gujarat-382 010

HARYANA

24. Shri Jai Prakash Dalal — Ex-officio
Minister for Agriculture and Farmer Welfare,
Fisheries & Animal Husbandary
Government of Haryana, Haryana Civil Secretariat,
Chandigarh, Haryana

HIMACHAL PRADESH

25. Shri Virender Kanwar — Ex-officio
Minister for Agriculture, Animal Husbandry & Fisheries,
Government of Himachal Pradesh, H.P. Secretariat,
Shimla, Himachal Pradesh 171 002

26. Shri Mahender Singh Thakur — Ex-officio
Minister for Horticulture,
Government of Himachal Pradesh, H.P. Secretariat,
Shimla, Himachal Pradesh 171 002

JHARKHAND

27. Shri Badal Patralekh — Ex-officio
Minister of Agriculture, Animal Husbandry,
Government of Jharkhand,
Project Building HEC, Dhurva,
Ranchi, Jharkhand 834 002

KARNATAKA

28. Shri B.C. Patil — Ex-officio
Minister for Agriculture & Horticulture,
Government of Karnataka, Vidhan Soudha,
Bengaluru, Karnataka 560 001

29. Sh. Narayana Gowda — Ex-officio
Minister for Horticulture,
Government of Karnataka, Vidhan Soudha,
Bengaluru, Karnataka 560 001

30. Shri Prabhu Chauhan — Ex-officio
Minister of Animal Husbandry
Government of Karnataka,
Vikasa Soudha, Vidhan Soudha,
Bengaluru, Karnataka 560 001

31. Shri Kota Srinivas Poojary — Ex-officio
Minister of Fisheries,
Government of Karnataka,
Vikasa Soudha, Vidhan Soudha,
Bengaluru, Karnataka 560 001

KERALA

32. Shri V. S. Sunil Kumar — Ex-officio
Minister for Agriculture & Horticulture,
Government of Kerala, Government Secretariat Annexe
Thiruvananthapuram, Kerala 695 001

33. Shri K. Raju — Ex-officio
Minister for Animal Husbandry
Government of Kerala
Government Secretariat Annexe
Thiruvananthapuram, Kerala 695 001

34. Smt. J. Mercykutty Amma — Ex-officio
Minister for Fisheries, Government of Kerala,
Government Secretariat Annexe
Thiruvananthapuram, Kerala 695 001

MADHYA PRADESH

35. Shri Kamal Patel — Ex-officio
Minister of Agriculture Development
Government of Madhya Pradesh, Vallabh Bhavan,
Bhopal, Madhya Pradesh 423 006

36. Shri Prem Singh Patel — Ex-officio
Minister of Animal Husbandry,
Government of Madhya Pradesh, Vallabh Bhavan,
Bhopal, Madhya Pradesh 423 006

37. Shri Bharat Singh Kushwaha — Ex-officio
(MoS independent charge)
Minister of State for Horticulture
Government of Madhya Pradesh, Vallabh Bhavan,
Bhopal, Madhya Pradesh 423 006

MAHARASHTRA

38. Shri Dadaji Bhuse — Ex-officio
Minister for Agriculture
Government of Maharashtra, Mantralaya,
Mumbai, Maharashtra 400 032

39. Sh. Sandipanrao Bhumre — Ex-officio
Minister for Horticulture,
Government of Maharashtra, Mantralaya,
Mumbai, Maharashtra 400 032

40. Shri Sunil chattrapal kedar — Ex-officio
Minister for Animal Husbandry
Government of Maharashtra, Mantralaya,
Mumbai, Maharashtra 400 032

41. Shri Aslam Shaikh — Ex-officio
Minister for Fisheries
Government of Maharashtra, Mantralaya,
Mumbai, Maharashtra 400 032

MANIPUR

42. Shri Oinam Lukhoi Singh — Ex-officio
Minister for Agriculture & Animal Husbandry,
Government of Manipur, Secretariat,
Imphal, Manipur 795 001

43. Shri Shorokhaibam Rajen — Ex-officio
Minister for Fisheries
Government of Manipur, Secretariat,
Imphal, Manipur 795 001

MEGHALAYA

44. Sh. Banteidor Lyngdoh — Ex-officio
Ministry of Agriculture & Horticulture
Government of Meghalaya,
Meghalaya Secretariat (C),
Shillong, Meghalaya 793 001

45. Shri Prestone Tynsong — Ex-officio
Minister for Animal Husbandry
Government of Meghalaya,
Meghalaya Secretariat (C),
Shillong, Meghalaya 793 001

46. Shri Dasakhiatbha Lamare — Ex-officio
Minister for Fisheries
Government of Meghalaya,
Meghalaya Secretariat (C),
Shillong, Meghalaya 793 001

MIZORAM

47. Shri Pu Zoramthanga — Ex-officio
Hon'ble Chief Minister & holding the charge of Ministry of Horticulture,
Government of Mizoram,
Aizwal, Mizoram 796 001

48. Sh. Pu Tawnluia — Ex-officio
Ministry for Animal Husbandry,
Government of Mizoram,
Aizwal, Mizoram 796 001

49. Shri Pu C. Lalrinsanga — Ex-officio
Minister for Agriculture,
Government of Mizoram,
Aizwal, Mizoram 796 001

50. Pu K. Lalrinliana — Ex-officio
Minister of State for Fisheries,
Government of Mizoram,
Aizwal, Mizoram 796 001

NAGALAND

51. Shri Neiphiu Rio — Ex-officio
Chief Minister holding the charge of Ministry of Horticulture, Animal husbandry & Fisheries,
Government of Nagaland, Civil Secretariat Complex
Kohima, Nagaland 797 004

52. Shri G. Kaito Aye — Ex-officio
Minister of Agriculture,
Government of Nagaland, Civil Secretariat Complex
Kohima, Nagaland 797 004

ODISHA

53. Shri Arun Kumar Sahoo — Ex-officio
Minister for Agriculture, Fisheries & Animal Resource Development,
Government of Odisha, Odisha Secretariat,
Bhubaneswar, Odisha 751 001

PUNJAB

54. Captain Amarinder Singh, — Ex-officio
Chief Minister holding the Charge of Ministry of Agriculture & Horticulture,
Government of Punjab, Punjab Civil Secretariat,
Chandigarh, Punjab

55. Shri Tript Rajinder singh Bajwa — Ex-officio
Ministry for Animal husbandry & Fisheries,
Government of Punjab, Punjab Civil Secretariat,
Chandigarh, Punjab

PUDUCHERRY

56. Shri R. Kamalakannan — Ex-officio
Minister for Agriculture
Government of Puducherry,
Puducherry 605 001

57. Shri A. Namassivayam — Ex-officio
Minister for Animal Husbandry
Government of Puducherry,
Puducherry 605 001

58. Shri Malladi Krishna Rao — Ex-officio
Minister for Fisheries
Government of Puducherry,
Puducherry 605 001

RAJASTHAN

59. Shri Lal Chand Kataria — Ex-officio
Minister for Agriculture, Animal Husbandry & Fisheries,
Government of Rajasthan,
Rajasthan Secretariat, Mantralaya Bhawan,
Jaipur, Rajasthan 302 005

SIKKIM

60. Shri Lok Nath Sharma — Ex-officio
Minister for Agriculture Development & Horticulture, Animal Husbandry, Fisheries,
Government of Sikkim,
New Secretariat, Development Area,
Gangtok, Sikkim 737 101

TAMIL NADU

61. Shri Thiru K.P. Anbalagan — Ex-officio
Minister for Agriculture & Horticulture
Government of Tamil Nadu,
Chennai, Tamil Nadu 600 009

62. Shri Thiru D. Jayakumar — Ex-officio
Minister for Fisheries,
Government of Tamil Nadu,
Chennai, Tamil Nadu 600 009

63. Shri K. Radhakrishnan — Ex-officio
Minister for Animal Husbandry,
Government of Tamil Nadu,
Chennai, Tamil Nadu 600 009

TELANGANA

64. Shri Singireddy Niranjan Reddy — Ex-officio
Minister of Agriculture
Room No.261, D-Block
Government of Telangana, Telangana Secretariat
Hyderabad, Telangana 500 022

65. Shri Talasani Srinivas Yadav — Ex-officio
Minister of Animal husbandry & Fisheries,
Room No.261, D-Block,
Government of Telangana, Telangana Secretariat,
Hyderabad Telangana 500 022

TRIPURA

66. Shri Pranajit Singha Roy — Ex-officio
Minister for Agriculture & Horticulture,
Government of Tripura, Civil Secretariat,
Agartala, Tripura 799 001

67. Shri Narendra Chandra Debbarma — Ex-officio
Minister for Fisheries
Government of Tripura, Civil Secretariat,
Agartala, Tripura 799 010

68. Smt. Santana Chakma — Ex-officio
Minister for Animal Resource Development,
Government of Tripura, Civil Secretariat,
Agartala, Tripura 799 001

UTTARAKHAND

69. Shri Subodh Uniyal — Ex-officio
Minister for Agriculture & Horticulture
Government of Uttarakhand,
Uttarakhand Vidhan Sabha Bhawan,
Dehradun, Uttarakhand

70. Smt. Rekha Arya — Ex-officio
Minister for Animal Husbandry & Fisheries,
Government of Uttarakhand,
Uttarakhand Vidhan Sabha Bhawan,
Dehradun, Uttarakhand

UTTAR PRADESH

71. Shri Surya Pratap Shahi — Ex-officio
Minister of Agriculture
Government of Uttar Pradesh, UP Civil Secretariat,
Lucknow, Uttar Pradesh

72. Shri Laxmi Narayan Chaudhary — Ex-officio
Minister of Animal Husbandry & Fisheries,
Government of Uttar Pradesh, UP Civil Secretariat,
Lucknow, Uttar Pradesh

73. Sh. Shriram Chauhan — Ex-officio
Minister of State for Horticulture (Independent Charge)
Government of Uttar Pradesh, UP Civil Secretariat,
Lucknow, Uttar Pradesh

WEST BENGAL

74. Dr Ashish Banerjee — Ex-officio
Minister for Agriculture,
Government of West Bengal,
"NABANNA", HRBC Building, 3rd Floor, 325,
Sarat Chatterjee Road, Howrah
Kolkata, West Bengal 711 102

75. Shri Swapan Debnath — Ex-officio
Minister of State for Animal Resources Development
(Independent Charge),
Government of West Bengal,
Prani Sampad Bhavan, LB-2, Sector-III,
Salt Lake, Kolkata, West Bengal 700 091

76. Sri Chandranath Sinha — Ex-officio
Minister for Fisheries Department,
Government of West Bengal,
BENFISH TOWER, 8th Floor, GN Block,
Salt Lake, Sector-V, Kolkata, West Bengal 700 091

77. Sri Janab Abdur Rezzak Mollah — Ex-officio
Minister for Horticulture
Government of West Bengal, Mayukh Bhavan,
2nd Floor, Sector-I,
Salt Lake, Kolkata, West Bengal 700 091

4(vi) *Member, NITI Ayog, In-charge of Agriculture*

78. Dr Ramesh Chand — Ex-officio
Member (Agriculture) NITI Ayog,
Niti Bhawan, New Delhi 110 001

4(vii) *Six members of Parliament—four elected by Lok Sabha and two elected by Rajya Sabha*

79. VACANT

80. VACANT

81. VACANT

82. VACANT

83. VACANT

84. VACANT

4(viii) *Director-General, Indian Council of Agricultural Research*

85. Dr T. Mohapatra — Ex-officio
Secretary, DARE & DG, ICAR,
Krishi Bhavan, New Delhi 110 001

4(ix) *All Secretaries in the Ministry of Agriculture & Farmers Welfare*

86. Shri Sanjay Agarwal — Ex-officio
Secretary, Deptt. of Agriculture, Cooperation
& Farmers Welfare
Ministry of Agriculture & Farmers Welfare,
Krishi Bhavan, New Delhi 110 001

4(x) *CEO, NITI Ayog*

87. Shri Amitabh Kant — Ex-officio
CEO, Niti Ayog,
Yojana Bhavan, Sansad Marg,
New Delhi 110 001

4(xi) *Secretary, Department of Bio-technology*

88. Dr Renu Swarup — Ex-officio
Secretary, Department of Biotechnology,
Block 2, 7th Floor, CGO Complex,
Lodhi Road, New Delhi 110 003

4(xii) *Director-General, Council of Scientific and Industrial Research*

89. Dr Shekhar C. Mande — Ex-officio
Director General, Council of Scientific and
Industrial Research,
Anusandhan Bhavan, 2-Rafi Ahmed Kidwai Marg,
New Delhi 110 001

4(xiii) *Chairman, University Grants Commission*

90. Dr D. P. Singh — Ex-officio
Chairman, University Grants Commission
Bahadur Shah Zafar Marg,
New Delhi 110 002

4(xiv) *Chairman, Atomic Energy Commission* (*or Director, Bhabha Atomic Research Centre, if nominated by the Chairman, Atomic Energy Commission*)

91. Shri Kamlesh Nilkanth Vyas — Ex-officio
Chairman, Atomic Energy Commission
Department of Atomic Energy, Anushakti Bhavan,
Chhatrapati Shivaji Maharaj Marg,
Mumbai 400 001

4(xv) *Member, Finance (Secretary/ Additional Secretary) in the Ministry of Finance, Government of India*

92. Sh. Rajeev Ranjan — Ex-officio
Additional Secretary (Expenditure)
Department of Expenditure
Ministry of Finance, North Block
New Delhi 110 001

93. **Alternative member for ministry of Finance - AS & FA (DARE/ICAR)**
Shri G. Srinivas — Ex-officio
AS & FA (Food and public dustrubution/ICAR)
Krishi Bhawan, New Delhi 110 001

4(xvi) *Five Vice-Chancellors of Agricultural Universities, nominated by the President*

94. Prof S. K. Rao, 17.05.2023/ VC Term-25/10/2022
Vice Chancellor,
Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya,
Race Course Road,
Gwalior, Madhya Pradesh 474 002

95. Dr Parvinder Kaushal 17.05.2023/VC Term
Vice Chancellor, -31/03/2022
Dr YS Parmar University of Horticulture & Forestry,
Solan, Nauni, Himachal Pradesh 173 230

96. Dr N. Kumar 17.05.2023/VC Term-15/11/2021
Vice Chancellor,
Tamil Nadu Agricultural University,
Coimbatore, Tamil Nadu 641 003

97. Prof. G.K. Singh 17.05.2023/ VC Term-01/03/2022
Vice Chancellor,
UP Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan,
Mathura, Uttar Pradesh 281 001

98. Dr Anupam Mishra 29.12.2023/VC Term. 01/03/2022
Vice Chancellor, Central Agricultural
University, Imphal, P.O. Box No. 23,
Imphal, Manipur 795 004

4(xvii) *Five Technical Representatives, namely Agricultural commissioner, Horticultural Commissioner, animal Husbandry Commissioner, fisheries Development commissioner, from the Union Ministry of Agriculture and Inspector-General of forests, government of India*

99. Dr S.K. Malhotra Ex-officio
Agriculture Commissioner,
Dept. of Agriculture & Cooperation,
Ministry of Agriculture & Farmers Welfare,
Krishi Bhavan, New Delhi 110 001

100. Dr B.N.S. Murthy Ex-officio
Horticulture Commissioner,
Dept. of Agriculture & Cooperation,
Ministry of Agriculture & Farmers Welfare,
Krishi Bhavan, New Delhi 110 001

101. Dr Praveen Malik Ex-officio
Animal Husbandry Commissioner,
Dept. of Animal Husbandry, Dairying,
Ministry of Animal Husbandry, Dairying and Fisheries,
Krishi Bhavan, New Delhi 110 001

102. Dr P. Paul Pandian Ex-officio
Fisheries Development Commissioner
Department of Fisheries,
Ministry of Animal Husbandry, Dairying and Fisheries,
Krishi Bhavan, New Delhi 110 001

103. Dr Pankaj Asthana Ex-officio
Inspector General of Forests (NAEB)
Ministry of Environment & Forests,
Paryavaran Bhawan, B-Block
CGO Complex, Lodi Road,
New Delhi 110 003

4(xviii) *Fifteen scientists from within and outside the Council including one representative from the Indian Council of Medical Research*

104. Dr N.C. Gautam 07-02.2021
Vice-Chancellor,
Mahatma Gandhi Chitrakoot Gramodaya
Vishwavidhyalaya
Chitrakoot, Satna, Madhya Pradesh 485 334

105. Dr Kamala Kanta Saharia 07-02.2021
Professor (Extension Education)
Department of Extension Education,
College of Veterinary Science, AAU,
Khanpara, Guwahati, Assam 781 022

106. Dr T.V.R.S. Sharma (Emeritus Scientist) 07-02.2021
Former Head, Field Crops,
ICAR-Central Agricultural Research Institute,
Garacharma, Port Blair,
Andman-Nicobar Island 744 101 India

107. Dr P.S. Rathore 07-02.2021
Former Vice Chancellor,
Tara Nagar C, Plot no. 60, Near Khirni Phatak,
Thothwara, Jaipur, Rajasthan 302 012

108. Dr Prakash Shastri, 07-02.2021
Professor (Plant Pathology),
College of Agriculture (RVSKVV),
Khandwa, Madhya Pradesh 450 001

109. Pro. Arun Kumar Das 07-02.2021
Agricultural university Bhubaneswar,
Odisha. Residence-159/3907,
Bhakt Madhunagar, Gundamunda, Khandagiri,
Bhubaneswar, Odisha 751 030

110. Dr M. Premjeet Singh 07-02.2021
Vice Chancellor,
Central Agricultural University,
Imphal, Manipur

111. Dr Jitendra kumar Chauhan 07-02.2021
Professor & Chairman,
School of Social Science,
College of Post Graduate Studies,
Barapani (Umiam), Shilong–Meghalaya 793 103

112. Dr K.P. Viswanatha 07-02.2021
Vice Chancellor,
Mahatma Phule Agricultural University,
Rahuri, Maharashtra

113. Dr C.J. Dangria 07-02.2021
Former VC (NAU),
501, Nakshatra Apartment,
B/S Crystal Mall, Chitrakut Society,
Jamnagar, Gujarat 361 006

114. Dr P. M. Salimath 07-02.2021
Former Vice Chancellor (UAS, Raichur),
405, Raya Residency, Savmati Nagar,
Dharwad, Karnataka 580 001

115. Dr K. P. Singh 07-02.2021
Vice Chancellor,
Chaudhary Charan Singh Agricultural University,
Hisar, Haryana 125 004

116. Dr M. S. Nataraju 07-02.2021
Director of Extension,
University of Agricultural Science, GKVK,
Hebbal, Bengaluru, Karnataka 560 065

117. Dr Bharat S. Sontakki 07-02.2021
Head, Extension Systems Management Division,
ICAR-National Academy of Agricultural Research Management (ICAR-NAARM),
Rajendranagar, Hyderabad 500 030
201, Soumya Homes, RKN Colony,
Behind Eeshwar Theatre, RKN Colony,
Hyderguda (Attapur) 500 048

Representative from the Indian Council of Medical Research

118. Dr Raman R. Gangakhedkar 30.09.2022
Scientist-G & Head,
Division of Epidemiology (ECD),
ICMR Hqrs., Ansari Nagar,
New Delhi 110 029

4(xix) *Three representatives of commerce and industry, nominated by the President*

119. Sh. Rajendra Prasad Gupta 07.03.2022
Harsidhi, East Champaran,
Bihar 845 422

120. Sh. Anil Rao 07.03.2022
967, Sector 14, Gurgaon, Haryana

121. VACANT

4(xx) *One farmer from each region of the country as mentioned in Rule 60(a) and four representatives of rural interests, nominated by the President.*

122. **(Representative of Region-I)**
Shri Nripendra Chaudhary 07.09.2023
Village- Seemli, Ward no. 2, P.O. -Luxere,
Distt.–Haridwar, Uttarakhand 247 663

123. **(Representative of Region-II)**
Shri Komirisetty Sambasiva Rao 17.05.2023
Pedapalakaluru (PO), Guntur Rural,
Gunture District,
Guntur, Andhra Pradesh 522 005

124. **(Representative of Region-III)**
Shri Khangembam Nabakumar Singh 17.05.2023
Kumbi Bazar, P.S.-Kumbi, P.O.-Moirang,
Bishnupur-District, Manipur 795 133

125. **(Representative of Region-IV)**
Sh. Sanjeev Kumar Yadav, 17.05.2023
State Vice-President,
Bharatiy Janta Party Kisan Morcha,
Guru Govind Singh Path Chowk,
Patna City, Patna, Bihar 800 008

126. **(Representative of Region-V)**
Shri Bikramjit Singh 17.05.2023
Cheema, Ward No. 9, Payal,
Ludhiana, Punjab 141 416

127. **(Representative of Region-VI)**
Sh. Jagdish Singh 07.09.2023
Village-Raidhana, Teh. Ladnun (Nagaur),
Rajasthan

128. **(Representative of Region-VII)**
Sh. Manoj Bhaikaji Vyavahare 17.05.2023
Ashti, Tal. Mohol,
Dist. Solapur, Maharashtra 413 303

129. **(Representative of Region- VIII)**
Sh. Virupaxi G. Revadigar 07.09.2023
Basava Medical Stores,
Basava Circle, Main Bazar,
Tq: Bilagi, Dist: Bagalkot,
Bilagi, Karnataka 587 116

4 *Representatives of Rural Interests*

130. Shri Pushp Jain 11.04.2021
Ex-member of Parliament,
53/54, Maa Kripa Housing Society,
Circuit House Road, Pali (Rajasthan)

131. Shri Suresh Chandel 11.04.2021
Ex-member of Parliament,
Village – Gandhi Ropa, Post Beri Ropa,
Distt.&Tehsil-Bilaspur 174 001, Himachal Pradesh
Shri Suresh Chandel
Ex-member of Parliament,
House No. 70/5, Roura, Sector-3,
Bilaspur, Himachal Pradesh 174 001

132. Shri Akhilesh Kumar 11.04.2021
Shyama Bhavan, Mathiya Zirat,
Motihari, East Champaran (Bihar)

133. VACANT

4(xxi) *Four Directors of the Indian Council of Agricultural Research Institutes, nominated by the President*

134. Dr Manmohan Singh Chauhan 17.05.2023/Term-
Director, 31.03.2021/31.01.2022
NDRI, Karnal (Haryana) 132 001

135. Dr Ravishankar C.N. 17.05.2023/Term-
Director, 19.08.2021/30.04.2025
Central Institute of Fisheries Technology (CIFT)
CIFT Junction, Willingdon Island
Matsyapuri P.O., Cochin, Kerala 682 029

136. Dr Narendra Pratap Singh, 17.05.2023/Term-
Director, 27.01.2021/31.01.2022
Indian Institute of Pulses Research (IIPR)
Kanpur, Uttar Pradesh 208 024

137. Dr Arun Kumar 07.12.2023/Term- 07.10.2025
Director, Central Sheep and Wool
Research Institute (CSWRI),
Avikanagar, Rajasthan 304 501

4(xxii) *Four representatives of State Governments to be nominated zone-wise on a rotational basis by Director General, ICAR*

138. Dr B. Janardhan Reddy 17.06.2023/Ex-officio
Agriculture Production Commissioner and Secretary,
Agriculture Cooperation Department,
Government of Telangana, Ground Floor,
D-block, Fathe Maidan, Near Nizam College,
Basheer Bagh, Hyderabad, Telangana 500 001

139. Dr Aboobacker Siddique P 17.06.2023/Ex-officio
Secretary,
Department of Agriculture, Animal Husbandry and Co-operatives,
Government of Jharkhand
Ground Floor, Nepal House, Doranda,
Ranchi, Jharkhand 834 002

140. Dr Rajesh Sharma 17.06.2023/Ex-officio
Secretary,
Department of Animal Husbandry, Fisheries & Gaupalan
Government of Rajasthan
Room No. 5008, Main Building,
Government Secretariat
Jaipur, Rajasthan 302 015

141. Dr K. Gopal 17.06.2023/Ex-officio
Principal Secretary,
Animal Husbandry, Dairying and Fishery,
Government of Tamil Nadu

4(xxiii) *One representative of Agro and Agro-Processing Industries nominated by President*

142. Mr. Kanwal Singh Chauhan 05.02.2022
Shimla Farm, Village – Aterna district
Sonipat, Hayana

4(xxiv) *One representative from a distinguished Non-Governmental Organization dealing with Agriculture/ Extension nominated by President*

143. Ms Sushma Singh 17.05.2023
MSA Flat No. 103, Tower-1, Butler palace,
Lucknow, Uttar Pradesh 226 001

4(xxv) *Secretary, Indian Council of Agricultural Research - Member Secretary*

144. Shri Sanjay Singh Ex-Officio
Addl. Secy., DARE & Secy., ICAR,
Krishi Bhavan
New Delhi 110 001

APPENDIX 3

MEMBERS OF THE GOVERNING BODY OF THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

Rule 35(i)
Chairman

1. Dr Trilochan Mohapatra
   Director-General,
   Indian Council of Agricultural Research,
   Krishi Bhawan, New Delhi 110 001

Rule 35(ii)
Member, Finance, Alternate member- Financial Adviser (DARE/ICAR)

2. Dr T.V. Somanathan
   Secretary (Expenditure)
   Department of Expenditure,
   Ministry of Finance, North Block,
   New Delhi 110 001

   Alternate member-Financial Adviser (DARE/ICAR)
   Shri G. Srinivas,
   Additional Secretary & Financial Advisor
   (Food and Public Distribution/ICAR),
   Krishi Bhavan, New Delhi 110 001.

Rule 35(iii)
Secretary, Niti Ayog

3. Shri Amitabh Kant,
   CEO, Niti Ayog,
   Yojana Bhavan, Sansad Marg,
   New Delhi 110 001

Rule 35(iv)
Secretary, Agriculture

4. Shri Sanjay Agarwal
   Secretary (Agriculture & Cooperation)
   Department of Agriculture & Cooperation,
   Ministry of Agriculture
   Krishi Bhavan, New Delhi 110 001

Rule 35(v)
Secretary, Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture

5. —

Rule35(vi)
Three Scientists (including one management expert who are not employees of ICAR-nominated by the President)

6. Dr N.C. Gautam
   Vice Chancellor,
   Mahatma Gandhi Chitrakaoot Gramodaya
   Vishwavidhyalaya,
   Chitrakoot, Satna, Madhya Pradesh 485 334

7. Dr Kamala Kanta Saharia
   Professor (Extension Education)
   Department of Extension Education,
   College of Veterinary Science,
   AAU, Khanpara,
   Guwahati, Assam 781 022

8. Dr Prakash Shastri
   Professor (Plant Pathology),
   College of Agriculture
   Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya
   (RVSKVV),
   Khandwa, Madhya Pradesh 450 001

Rule 35 (vii)
Five Vice-Chancellors of Agricultural Universities—nominated by the President

9. Dr Ramesh Chandra Srivastava
   Vice Chancellor,
   Dr Rajendra Prasad Central Agricultural University,
   Pusa, Samastipur, Bihar 848 125

10. Prof S. K. Rao
    Vice Chancellor
    Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya,
    Race Course Road,
    Gwalior, Madhya Pradesh 474 002

11. Dr Parvinder Kaushal
    Vice Chancellor,
    Dr YS Parmar University of Horticulture & Forestry,
    Solan, Nauni, Himachal Pradesh 173 230

12. Dr N. Kumar
    Vice Chancellor,
    Tamil Nadu Agricultural University,
    Coimbatore, Tamil Nadu 641 003

13. Prof. G.K. Singh
    Vice Chancellor,
    UP Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan
    Vishwavidyalaya Evam Go-Anusandhan Sansthan,
    Mathura, Uttar Pradesh 281 001

Rule 35(viii)
Three Members of Parliament nominated by the President—(Two from Lok Sabha and one from Rajya Sabha)

14. Vacant
15. Vacant
16. Vacant

Rule 35(ix)
Four Farmers/Representatives of Rural Areas nominated by the President

17. Vacant

18. Shri Pusp Jain
    Ex-MP,
    Pali (Rajasthan) 53/54,
    Maa Kripa Housing Society,
    Circuit House Road, Pali (Rajasthan)

19. Shri Suresh Chandel
Ex-Member of Parliament,
Village-Gandhi Ropa, P.O. Beri, Tehsil & District,
Bilaspur, Himachal Pradesh

Preferred Contact Address:
Shri Suresh Chandel,
Ex-Member of Parliament, House No. 70/5, Roura Sector-3, Bilaspur, Himachal Pradesh

20. Shri Akhilesh Kumar
Shyama Bhavan, Mathiya Zirat,
Motihari, East Champaran (Bihar)

Rule 35(x)
Three Directors of Research Institutes of the Council nominated by the President

21. VACANT

22. Dr Manmohan Singh Chauhan
Director
ICAR-National Dairy Research Institute,
Karnal, Haryana 132 001

23. Dr Ravishankar C.N.
Director,
ICAR-Central Institute of Fisheries Technology,
CIFT Junction Matsyapuri PO,
Cochin, Kerala 682 029

Rule 35(xi)
Four representatives of State Governments to be nominated zone-wise on a rotational basis by Director General, ICAR

24. Dr B. Janardhan Reddy
Agriculture Production Commissioner and Secretary,
Agriculture Cooperation Department,
Government of Telangana,
Ground Floor, D-Block, Fathe Maidan,
Near Nizam College,
Basheer Bagh,
Hyderabad, Telangana 500 001

25. Dr Aboobacker Siddique P
Secretary,
Department of Agriculture,
Animal Husbandry and Co-operatives,
Government of Jharkhand, Ground Floor, Nepal House,
Doranda, Ranchi, Jharkhand 834 002

26. Dr Rajesh Sharma
Secretary,
Department of Animal Husbandry, Fisheries & Gaupalan
Government of Rajasthan
Room No. 5008, Main Building, Government Secretariat,
Jaipur, Rajasthan 302 015

27. Dr K. Gopal
Principal Secretary,
Animal Husbandry, Dairying and Fishery,
Government of Tamil Nadu

Rule 35(xii)
One representative of Agro and Agro-Processing Industries to be nominated by President

28. Shri Kanwal Singh Chauhan
R/o Shimla Farm, Village-Aterna,
District Sonipat, Haryana 131 023

Rule 35(xiii)
One representative from a distinguished Non-Governmental Organization dealing with Agriculture/Extension nominated by President

29. Ms Sushma Singh
MSA Flat No. 103, Tower-1,
Butler palace,
Lucknow, Uttar Pradesh 226 001

Rule 35(xiv) Secretary, ICAR-Member Secretary

30. Shri Sanjay Singh
Additional Secretary,
DARE & Secretary, ICAR,
Krishi Bhawan, New Delhi 110 001

Changes upto 01.01.2021

APPENDIX 4

SENIOR OFFICERS AT THE HEADQUARTERS OF THE ICAR

1. **Dr Trilochan Mohapatra**
   Director General,
   ICAR and Secretary to the Government of India,
   Department of Agricultural Research and Education

2. **Shri Sanjay Singh**
   Secretary,
   ICAR and Additional Secretary to Government of India,
   Department of Agricultural Research and Education

Deputy Directors General

1. Dr K. Alagusundaram (Agricultural Engineering)
2. Dr A.K. Singh (Agricultural Extension)
3. Dr Joykrushna Jena (Fisheries Science)
4. Dr Anand Kumar Singh (Horticulture Science)
5. Dr S.K. Chaudhari (Natural Resource Management)
6. Dr B.N. Tripathi (Animal Sciences)
7. Dr Tilak Raj Sharma (Crop Sciences)
8. Dr R.C. Agarwal (Acting) (Agricultural Education)

Assistant Directors General

Crop Science

1. Dr R.K. Singh (CC)
2. Dr S K Jha (OP) (Acting)
3. Dr Y.P. Singh, FFC (Acting)
4. Dr D.K. Yadava (Seed) (Acting)

Horticultural Science

1. Dr Vikramaditya Pandey, Fruits & Plantation Crops (Acting)
2. Dr B.K. Pandey, Vegetable Spices & Medicinal Plant (Acting)

Natural Resource Management

1. Dr S. Bhaskar (AAF&CC)
2. Dr Adlul Islam (S&WM) (Acting)

Agricultural Engineering

1. Dr Kanchan Kumar Singh (FE)
2. Dr S.N. Jha (PE)

Animal Sciences

1. Dr Ashok Kumar (AH) (Acting)
2. Dr Amrish Kumar Tyagi (AN&P)
3. Dr Vishesh Kumar Saxena (AP&B)

Fisheries Science

1. Dr P. Pravin (MF)
2. Dr Bimal Prasanna Mohanty (IF)

Agricultural Extension

1. Dr V.P. Chahal (Acting)
2. Dr Randhir Singh

Agricultural Education

1. Dr G. Venkateshwarlu (EQA&R)
2. Dr M.K. Agnihotri, ADG (HRD) (Acting)
3. Dr P.S. Pandey (EP&HS) (Acting)

Others Units

1. Dr Sanjeev Saxena (IPTM&PME)
2. Dr Shiv Prasad Kimothi (Cdn.)
3. Dr A.K. Vyas (HRM)
4. Dr Atmakuri Ramakrishna Rao (PIM)
5. Dr J.P. Mishra (IR) (Acting) and OSD (PPP)
6. Dr Anil Rai (ICT) (Acting)

National Agricultural Science Fund (NASF)

1. Dr Sanjeev Saxena, ADG (Acting)

Principal Scientists

Crop Science

1. Dr S.K. Jha
2. Dr Y.P. Singh
3. Dr P.R. Chaudhary

Horticultural Science

1. Dr B.K. Pandey
2. Dr Manish Das
3. Dr Vikramaditya Pandey
4. Dr S.K. Malhotra (on deputation)

Natural Resource Management

1. Dr Adlul Islam
2. Dr Parveen Kumar

Agricultural Education

1. Dr M.K. Agnihotri
2. Dr (Mrs) Vanita Jain
3. Dr (Mrs) Nidhi Verma
4. Dr K.P. Tripathi
5. Dr Neeraj Rana
6. Dr S.K. Sankhyan

Fisheries Science

1. Dr Prem Kumar
2. Dr (Mrs) Yasmeen Basade

Agricultural Engineering

1. Dr Devinder Dhingra (on deputation)
2. Dr Panna Lal Singh

Animal Sciences

1. Dr Rajan Gupta
2. Dr Vineet Bhasin
3. Dr (Mrs) Jyoti Misri

Agri. Extension

1. Dr P. Adhiguru
2. Dr Keshava
3. Dr Naresh Girdhar

Others Units

1. Dr S.K. Malik, DG Office
2 Dr N.K. Jain (HRM)
3. Dr M. K. Tripathi (PIM)
4. Dr P.K. Katiha (PIM)
5. Dr A.S. Mishra (Tech. Cdn.)
6. Dr Sanjeev Panwar (Tech. Cdn.)
7. Dr Shiv Datt (IPTM)
8. Dr Ashok Kumar (NASF)
9. Dr S.K. Singh (DKMA)
10. Dr A.K. Mishra (IR)
11. Dr K.P. Singh (e-gov.)

National Agricultural Higher Education Project (NAHEP)

1. Dr P. Ramasundaram, PS & NC
2. Dr R.B. Sharma, PS & NC
3. Dr Prabhat Kumar, PS & NC
4. Dr (Mrs) Hema Tripathi, PS & NC

Agricultural Scientists' Recruitment Board

1. Prof. (Dr) A.K. Misra, Chairman
2. Prof. (Dr) A.K. Srivastava, Member
3. Dr P.K. Chakraborty, Member
4. Dr K.K. Singh, Member

Directorate of Knowledge Management in Agriculture

1. Dr S.K. Singh, Project Director (Acting)

APPENDIX 5

ICAR INSTITUTES AND THEIR DIRECTORS

National Institutes

1. Dr A.K. Singh
   Indian Agricultural Research Institute,
   New Delhi 110 012

2. Dr B.P. Mishra (Acting)
   Indian Veterinary Research Institute,
   Izatnagar 243 122, Uttar Pradesh

3. Dr Manmohan Singh Chauhan
   National Dairy Research Institute,
   Karnal 132 001, Haryana

4. Dr Gopal Krishna
   Central Institute of Fisheries Education,
   Jaiprakash Road, Seven Bungalow (Versova)
   Mumbai 400 061, Maharashtra

5. Dr Ch. Srinivasa Rao
   National Academy of Agricultural Research
   Management, Rajendranagar,
   Hyderabad 500030, Telangana

6. Dr Himanshu Pathak
   National Institute of Abiotic Stress Management,
   Malegaon, Baramati,
   Pune 413 115, Maharashtra

7. Dr Arunava Pattanayak
   Indian Institute of Agricultural Biotechnology,
   Ranchi, Jharkhand

8. Dr Probir Kumar Ghosh
   National Institute of Biotic Stress Management,
   Raipur, Chhattisgarh

9. Dr D. Maity
   OSD, IARI, Jharkhand

Agricultural Sciences

10. Dr B. Augustine Jerard (Acting)
    Central Island Agricultural Research Institute,
    Post Box No. 181
    Port Blair 744 101, Andaman and Nicobar Islands

11. Dr O.P. Yadav (Acting)
    Central Arid Zone Research Institute,
    Jodhpur 342 003, Rajasthan

12. Dr Champat Raj Mehta
    Central Institute of Agricultural Engineering,
    Nabi Bagh, Berasia Road,
    Bhopal 462 038, Madhya Pradesh

13. Dr P.L. Saroj
    Central Institute of Arid Horticulture,
    Bikaner 334 006, Rajasthan

14. Dr Y.G. Prasad
    Central Institute for Cotton Research
    Post Bag No. 2, Shankar Nagar P.O.
    Nagpur 440 010, Maharashtra

15. Dr Shailendra Rajan
    Central Institute for Sub-tropical Horticulture,
    Rehmankhera, PO Kakori,
    Lucknow 227 107, Uttar Pradesh

16. Dr Desh Beer Singh
    Central Institute of Temperate Horticulture,
    Old Air Field, Rangreth 190 007, Jammu and Kashmir

17. Dr Nachiket Kotwaliwale
    Central Institute of Post Harvest Engg. and Technology,
    P.O. PAU Campus, Ludhiana 141 004, Punjab

18. Dr P.G. Patil
    Central Institute for Research on Cotton Technology,
    Adenwala Road, Matunga,
    Mumbai 400 019, Maharashtra

19. Dr Anita Karun (Acting)
    Central Plantation Crops Research Institute
    Kasaragod 671 124, Kerala

20. Dr Manoj Kumar (Acting)
    Central Potato Research Institute
    Shimla 171 001, Himachal Pradesh

21. Dr Mohammed Osman (Acting)
    Central Research Institute for Dryland Agriculture,
    Santoshnagar, Saidabad P.O.,
    Hyderabad 500 059, Telangana

22. Dr Dinesh Babu Shakyawar
    National Institute of Natural Fibre Engineering and
    Technology
    12, Regent Park, Kolkata 700 040, West Bengal

23. Dr D. Maiti (Acting)
    National Rice Research Institute,
    Cuttack 753 006, Odisha

24. Dr Parbodh Chander
    Central Soil Salinity Research Institute,
    Zarifa Farm, Kachhwa Road,
    Karnal 132 001, Haryana

25. Dr R.S. Yadav (Acting)
    Indian Institute of Soil and Water Conservation,
    218, Kaulagarh Road,
    Dehradun 248 195, Uttarakhand

26. Dr D. Damodar Reddy
    Central Tobacco Research Institute,
    Rajahmundry 533 105, Andhra Pradesh

27. Dr V. Ravi (Acting)
    Central Tuber Crops Research Institute,
    Sreekariyam, Thiruvananthapuram 695 017, Kerala

28. Dr E.B. Chakurkar (Acting)
    Central Coastal Agricultural Research Institute,
    Ela, Old Goa, North Goa 403 402, Goa

29. Dr Ujjawal Kumar (Acting)
ICAR Research Complex for Eastern Region,
ICAR Parisar, P.O. Bihar Veterinary College,
Patna 800 014, Bihar

30. Dr Basant Kumar Kandpal (Acting)
ICAR Research Complex for NEH Region,
Umroi Road, Umiam, Ri-Bhoi 793 103, Meghalaya

31. Dr Rajendra Parsad
Indian Agricultural Statistics Research Institute,
Library Avenue, Pusa Campus, New Delhi 110 012

32. Dr Vijay Kumar Yadav (Acting)
Indian Grassland and Fodder Research Institute,
Pahuj Dam, Gwalior Road,
Jhansi 284 003, Uttar Pradesh

33. Dr M.R. Dinesh
Indian Institute of Horticultural Research
Hessaraghatta Lake Post,
Bengaluru 560 089, Karnataka

34. Dr Narendra Pratap Singh
Indian Institute of Pulses Research,
Kanpur 208 024, Uttar Pradesh

35. Dr Ashok Kumar Patra
Indian Institute of Soil Sciences
Nabi Bagh, Berasia Road,
Bhopal 462 038, Madhya Pradesh

36. Dr Santhosh J. Eapen
Indian Institute of Spices Research,
Marikunnu P.O.,
Kozhikode 673 012, Kerala

37. Dr A.D. Pathak
Indian Institute of Sugarcane Research,
Rai Bareilly Road, P.O. Dilkusha,
Lucknow 226 002, Uttar Pradesh

38. Dr K.K. Sharma
Indian Institute of Natural Resins and Gums,
Namkum, Ranchi 834 010, Jharkhand

39. Dr Jagdish Singh
Indian Institute of Vegetable Research,
PB No. 01, PO Jakhini, Shahanshapur
Varanasi 221 005, Uttar Pradesh

40. Dr Bakshi Ram
Sugarcane Breeding Institute,
Coimbatore 641 007, Tamil Nadu

41. Dr Lakshmi Kant (Acting)
Vivekanand Parvatiya Krishi Anusandhan Sansthan,
Almora 263 601, Uttarakhand

42. Dr Gouranga Kar
Central Research Institute for Jute and Allied Fibres,
Barrackpore, Kolkata 700120, West Bengal

43. Dr Azad Singh Panwar
Indian Institute of Farming System Research,
Modipuram, Meerut 250 110, Uttar Pradesh

44. Dr Sujoy Rakshit
Indian Institute of Maize Research,
PAU Campus,
Ludhiana 141004, Punjab

45. Dr Ravi Kumar Mathur (Acting)
Indian Institute of Oil Palm Research
Pedavegi, West Godavari 534 450, Andhra Pradesh

46. Dr (Mrs) Sujatha (Acting)
Indian Institute of Oilseeds Research,
Rajendranagar,
Hyderabad 500 030, Telangana

47. Dr Subramanyam (Acting)
Indian Institute of Rice Research,
Rajendranagar,
Hyderabad 500 030, Telangana

48. Dr G.P. Singh
Indian Institute for Wheat and Barley Research
P. Box No. 158, Agrasain Marg,
Karnal 132 001, Haryana

49. Dr Atma Ram Mishra (Acting)
Indian Institute of Water Management,
Opposite Rail Vihar, Chandersekharpur
Bhubaneshwar 751 023, Odisha

50. Dr S.K. Srivastava (Acting)
Central Institute for Women in Agriculture,
Plot No.50, Mauza-Jokalandi, P.O. Baramunda,
Bhubaneswar 751 003, Odisha

51. Dr Ayyandar Arunachalam
Central Agro-Forestry Research Institute,
Near Pahuj Dam,
Jhansi 284 003, Uttar Pradesh

52. Dr M.S. Ladaniya (Acting)
Central Citrus Research Institute,
P.B. No. 464, Shankar Nagar P.O.,
Amravati Road,
Nagpur 440 010, Maharashtra

53. Dr Suresh Pal
National Institute of Agricultural Economics and Policy Research,
P.B. No. 11305, DPS Marg,
Pusa, New Delhi 110 012

54. Dr Sanjay Kumar
Indian Institute of Seed Science
P.B. No. 11, Kusmaur, P.O. Kaithauli,
Mau Nath Bhanjan 275 101, Uttar Pradesh

55. Dr Vilas A. Tonapi
Indian Institute of Millets Research,
Rajendranagar, Hyderabad 500 030, Telangana

56. Dr Nita Khandekar (Acting)
Indian Institute of Soyabean Research,
Khandwa Road, Indore 452 017, Madhya Pradesh

57. Dr (Mrs) Sarvjeet Kaur
ICAR-NIPB (earlier NRCPB)
LBS Centre, Pusa Campus,
New Delhi 110012

58. Dr Subhash Chander
National Research Centre for Integrated Pest Management,
LBS Building, New Delhi 110012

59. Dr Anjani Kumar (Acting)
Mahatma Gandhi Integrated Farming Research Institute,
Piprakothi, Motihari, East Champaran,
Bihar ICAR RC for Eastern Region
ICAR Parisar, Patna 800 014, Bihar

Animal Sciences and Fisheries

60. Dr Sanjeev Kumar (Acting)
Central Avian Research Institute
Izatnagar, Bareilly 243 122, Uttar Pradesh

61. Dr S.S. Dahiya (Acting)
Central Institute for Research on Buffaloes,
Sirsa Road, Hisar 125 001, Haryana

62. Dr B. Rai (Acting)
Central Institute of Research on Goats,
Makhdoom,
Mathura 281 122, Uttar Pradesh

63. Dr Basant Kumar Das
Central Inland Fisheries Research Institute,
Barrackpore 700 120, West Bengal

64. Dr K.K. Vijayan
Central Institute of Brackishwater Aquaculture,
75, Santhome High Road, Raja Annamalai Puram,
Chennai 600 028, Tamil Nadu

65. Dr Ravishankar C.N.
Central Institute of Fisheries Technology,
Willingdon Island, Matsyapuri P.O.,
Kochi 682 029, Kerala

66. Dr Saroj Kumar Swain (Acting)
Central Institute of Freshwater Aquaculture,
Kausalyaganga, Bhubaneshwar,
Khurda 751 002, Odisha

67. Dr A. Gopalakrishnan (Acting)
Central Marine Fisheries Research Institute,
P.B. No. 1603, Ernakulam North P.O.,
Kochi 682 018, Kerala

68. Dr Arun Kumar
Central Sheep and Wool Research Institute,
Distt. Tonk, Avikanagar, 304 501, Rajasthan

69. Dr Raghevendra Bhatta,
National Institute of Animal Nutrition and Physiology,
Adugodi,
Bengaluru 560 030, Karnataka

70. Dr Vijendra Pal Singh (Acting),
National Institute of High Security Animal Diseases,
Anand Nagar, Bhopal 462 021, Madhya Pradesh

71. Dr Abhijit Mitra
Central Institute for Research on Cattle,
P.B. No. 17, Grass Farm Road,
Meerut Cantt. 250 001, Uttar Pradesh

72. Dr Bibek Ranjan Shome
National Institute of Veterinary
Epidemiology and Disease Informatics,
H.A. Farm Post, Hebbal,
Bengaluru 560 024, Karnataka

APPENDIX 6

NATIONAL BUREAUX AND THEIR DIRECTORS

Agricultural Sciences

1. Dr N. Bhaktavatsalam
   National Bureau of Agricultural Insect Resources,
   P.B. No. 2491, H.A. Farm Post,
   Bengaluru 560 024 Karnataka

2. Dr Anil Kumar Saxena
   National Bureau of Agriculturally Important Micro-organisms,
   P.B. No. 6, Kusmaur, Maunath
   Bhanjan 275 101 Uttar Pradesh

3. Dr Kuldeep Singh
   National Bureau of Plant Genetic Resources,
   Pusa Campus, New Delhi 110 012

4. Dr Brahma Swaroop Dwivedi
   National Bureau of Soil Survey and Land Use Planning,
   Shankar Nagar, P.O. Amravati Road,
   Nagpur 440 010, Maharashtra

Animal Sciences and Fisheries Sciences

5. Dr R.K. Vij (Acting)
   National Bureau of Animal Genetic Resources,
   P.B. No. 129, G.T. Road Bye Pass,
   Karnal 132 001, Haryana

6. Dr Kuldeep Kumar Lal
   National Bureau of Fish Genetic Resources,
   Canal Ring Road, P.O. Dilkusha,
   Lucknow 226 002, Uttar Pradesh

APPENDIX 7

PROJECT DIRECTORATES, AGRICULTURAL TECHNOLOGY APPLICATION RESEARCH INSTITUTES AND THEIR DIRECTORS

Agricultural Sciences

1. Dr Radhakrishnan T.
   Directorate of Groundnut Research,
   Post Box No. 5, Ivnagar Road,
   Junagadh 362 001, Gujarat

2. Dr P.K. Rai
   Directorate of Rapeseed-Mustard Research,
   Sewar, Bharatpur 321 303, Rajasthan

3. Dr Janki Sharan Mishra
   Directorate of Weed Research, Maharajpur, Adhartal,
   Jabalpur 482 004, Madhya Pradesh

4. Dr Anitha Karun (Acting)
   Directorate of Cashew Research,
   Darbe, P.O. Puttur,
   Dakshina Kannada 574 202, Karnataka

5. Dr K. V. Prasad (Acting)
   Directorate of Floriculture Research
   Pune

6. Dr Satyajit Roy (Acting)
   Directorate of Medicinal and Aromatic Plants Research,
   Boriavi, Anand 387 310, Gujarat

7. Dr Ved Prakash Sharma (Acting)
   Directorate of Mushroom Research,
   Chambaghat,
   Solan 173 213, Himachal Pradesh

8. Dr Major Singh
   Directorate on Onion and Garlic Research,
   Rajgurunagar,
   Pune 410 505, Maharashtra

Animal Sciences

9. Dr R.K. Singh (Acting)
   Directorate of Foot and Mouth Disease,
   IVRI Campus,
   Mukteshwar 263138, Uttarakhand

10. Dr R.N. Chatterjee (Acting)
    Directorate of Poultry Research,
    Rajendranagar,
    Hyderabad 500 030, Telangana

11. Dr D. Sarma (Acting)
    Directorate of Coldwater Fisheries Research,
    Anusandhan Bhawan, Industrial Area,
    Bhimtal 263 136, Uttarakhand

Agricultural Technology Application Research Institutes

12. Dr Rajbir Singh (Acting)
    Agricultural Technology Application Research Institute,
    Zone-I, PAU Campus,
    Ludhiana 141004, Punjab

13. Dr Subrata Kumar Roy (Acting)
    Agricultural Technology Application Research Institute,
    Zone-II, Bhumi Vihar, Block-GB, Sector-III,
    Salt Lake,
    Kolkata 700 097, West Bengal

14. Dr Anil Kumar Tripathi (Acting)
    Agricultural Technology Application Research Institute,
    Zone-III, TOP, Umroi Road,
    Barapani 793 103, Meghalaya

15. Dr Atar Singh (Acting)
    Agricultural Technology Application Research Institute,
    Zone-IV, G.T. Road, Rawatpura,
    Near Vikas Bhawan, Kanpur 208 002, Uttar Pradesh

16. Dr J.V. Prasad (Acting)
    Agricultural Technology Application Research Institute,
    Zone-V, CRIDA Complex, Santoshnagar,
    Hyderabad 500 059, Telangana

17. Dr S.K. Singh
    Agricultural Technology Application Research Institute,
    Zone-VI, CAZRI Campus,
    Jodhpur 342 003, Rajasthan

18. Dr Shyam Ranjan Kumar Singh (Acting)
    Agricultural Technology Application Research Institute,
    Zone-VII, JNKVV Campus,
    Jabalpur 484 002, Madhya Pradesh

19. Dr V. Venkatasubramanian
    Agricultural Technology Application Research Institute,
    Zone-VIII, ICAR Transfer of Technology Project,
    MRS HA Farm Post, Hebbal,
    Bengaluru 560 030, Karnataka

20. Dr Anjani Kumar
    Agricultural Technology Application Research Institute,
    Patna

21. Dr Lakhan Singh
    Agricultural Technology Application Research Institute,
    Pune

22. Dr Anil Kumar Tripathi
    Agricultural Technology Application Research Institute,
    Guwahati

APPENDIX 8

NATIONAL RESEARCH CENTRES AND THEIR DIRECTORS

Agricultural Sciences

1. Dr (Mrs) S. Uma
   National Research Centre for Banana,
   Thogamalai Road, Thayanur Post,
   Thiruchirapalli 620 102, Tamil Nadu

2. Dr R.G. Somkumar (Acting)
   National Research Centre for Grapes,
   P.B. No. 3, Manjri Farm Post, Solapur Road,
   Pune 412 307, Maharashtra

3. Dr Vishal Nath
   National Research Centre for Litchi
   Mushahari Farm, Mushahari,
   Muzaffarpur 842 002, Bihar

4. Dr Ram Pal (Acting)
   National Research Centre for Orchids,
   Pakyong, Gangtok 737 106, Sikkim

5. Dr Jyotsana Sharma (Acting)
   National Research Centre on Pomegranate,
   NH-9, Byepass Road, Shelgi
   Sholapur 413 006, Maharashtra

6. Dr Gopal Lal
   National Research Centre on Seed Spices,
   Tabiji, Ajmer 305 206, Rajasthan

Animal Sciences and Fisheries Sciences

7. Dr R.K. Sawal (Acting)
   National Research Centre on Camel
   Jorbeer, P.B. No. 07
   Bikaner 334 001, Rajasthan

8. Dr Yashpal (Acting)
   National Research Centre for Equines,
   Hisar 125 001, Haryana

9. Dr Sukhadeo Baliram Barbuddhe
   National Research Centre on Meat,
   Chengicherla, P.B. No. 19, Uppal PO,
   Hyderabad 500 039, Telangana

10. Dr Meraj Haider Khan (Acting)
    National Research Centre for Mithun,
    Jharnapani, P.O.
    Medziphema 797 106, Nagaland

11. Dr S. Rajkhowa (Acting)
    National Research Centre on Pig,
    Rani, Guwahati 781 131, Assam

12. Dr Prithviraj Chakravarty (Acting)
    National Research Centre on Yak,
    Dirang, West Kameng 790 101, Arunachal Pradesh

APPENDIX 9

ALL INDIA CO-ORDINATED RESEARCH PROJECTS AND NETWORK PROGRAMMES

AICRPs

1. AICRP on Micro and Secondary Nutrients & Pollutant Elements in Soils and Plants, Bhopal
2. AICRP on Soil Test Crop Response, Bhopal
3. AICRP on Long Term Fertilizer Experiments, Bhopal
4. AICRP on Salt Affected Soils and Use of Saline Water, Karnal
5. AICRP on Irrigation Water Management, Bhubaneshwar
6. AICRP Dryland Agriculture, Hyderabad
7. AICRP on Agrometeorology, Hyderabad
8. AICRP on Integrated Farming System, Modipuram
9. AICRP on Agroforestry, Jhansi
10. AICRP on Weed Management, Jabalpur
11. AICRP on Farm Implements and Machinery, Bhopal
12. AICRP on Ergonomics and Safety in Agriculture, Bhopal (ESA)
13. AICRP on Energy in Agriculture and Agro based Industries, Bhopal (EAAI)
14. AICRP on Animal Energy System, Bhopal (earlier UAE)
15. AICRP on Plasticulture Engineering and Technology, Ludhiana
16. AICRP on Post Harvest Engineering and Technology, Ludhiana
17. AICRP on Rice, Hyderabad
18. AICRP on Wheat and Barley, Karnal
19. AICRP on Maize, Ludhiana
20. AICRP Sorghum, Hyderabad
21. AICRP on Pearl Millets, Jodhpur
22. AICRP on Small Millets, Bangaluru
23. AICRP on Forage Crops and Utilization, Jhansi
24. AICRP on Chickpea, Kanpur
25. AICRP on MULLaRP, Kanpur
26. AICRP on Pigeon Pea, Kanpur
27. AICRP NSP (Crops), Mau
28. AICRP on Oilseed, Hyderabad
29. AICRP on Linseed, Kanpur
30. AICRP on Sesame and Niger, Jabalpur
31. AICRP on Groundnut, Junagarh
32. AICRP on Soybean, Indore
33. AICRP on Rapeseed and Mustard, Bharatpur
34. AICRP on Sugarcane, Lucknow
35. AICRP on Cotton, Coimbatore
36. AICRP on Nematodes in Cropping System, New Delhi
37. AICRP on Biocontrol of Crop Pests, Bengaluru
38. AICRP-Honeybees and Pollinators, New Delhi
39. AICRP Fruits (Tropical and Sub Tropical), Bengaluru
40. AICRP Potato, Shimla
41. AICRP Floriculture, Pune
42. AICRP Mushroom, Solan
43. AICRP Vegetables, Varanasi
44. AICRP Tuber Crops, Tiruvanthapuram
45. AICRP Palms, Kasargod
46. AICRP on Cashew, Puttur
47. AICRP Arid Zone Fruits, Bikaner
48. AICRP Spices, Calicut
49. AICRP on Medicianl& Aromatic Plants, Anand
50. AICRP on Cattle, Meerut
51. AICRP on Goat Improvement, Makhdoom
52. AICRP on Nutritional and Physiological Intervention for Enhancing Reproductive Performance in Animal
53. AICRP on ADMAS, Bengaluru
54. AICRP on Foot and Mouth Disease, Mukteshwar
55. AICRP on Poultry, Hyderabad
56. AICRP on Pig, Guwahati
57. AICRP Home Science

NETWORK PROJECTS

1. AINP on Soil Biodiversity - Biofertilizer, Bhopal
2. Network Programme on Organic Farming, Modipuram
3. Network project on Engineering Intervention in Micro irrigation system for Improving Water Productivity
4. Network project on Processing and Value Addition of Natural Resins and Gums, Ranchi
5. Network Project on Conservation of Lac Insect Genetic Resources, Ranchi
6. All India Network Project (AINP) on Potential Crops, New Delhi
7. Application of Micro-organisms in Agriculture and Allied Sectors (AMAAS)
8. Network Project on Functional Genomics and Genetic Modification in Crops, NIPB, New Delhi
9. AINP on Arid Legumes, Kanpur
10 AINP on Tobacco, Rajamundry
11. AINP on Jute and Allied Fibres, Barrackpore
12. AINP on Soil Arthropod Pests, Durgapura, Rajasthan
13. AINP on Agricultural Acarology, NCIPM, New Delhi
14. AINP on Pesticides Residues, New Delhi
15. AINP on Vertebrate Pest Management, Jodhpur
16. Network O&G
17. Network Project on Buffalo Improvement, Hisar
18. Network on Sheep Improvement, Avikanagar
19. Network on Gastro Intestinal Parasitism, Izatnagar
20. Network Programme on Blue Tongue Disease, Izatnagar
21. All India Network Program on Neonatal Mortality in Farm Animals, Izatnagar
22. All India Network Program on Diagnostic Imaging and Management of Surgical Condition in Animals, Izatnagar
23. Network Project on Animal Genetic Resources, Karnal
24. AINP Mericulture
25. AINP on Fish health

APPENDIX 10

AGRICULTURAL UNIVERSITIES

State Agricultural Universities

1. Acharya NG Ranga Agricultural University, Guntur
2. Dr YSR Horticultural University, Venkataramannagudem
3. Sri Venkateswara Veterinary University, Tirupati
4. Assam Agricultural University, Jorhat
5. Bihar Agricultural University, Sabour, Bhagalpur
6. Bihar Animal Sciences University, Patna
7. Indira Gandhi Krishi Vishwavidhyalaya, Raipur
8. Chhattisgarh Kamdhenu Vishwavidyalaya, Durg
9. Sardar Krushinagar Dantiwada Agricultural University, Dantiwada
10. Anand Agricultural University, Anand
11. Navsari Agricultural University, Navsari
12. Junagarh Agricultural University, Junagarh
13. Kamdhenu University, Amreli
14. Chaudhary Charan Singh Haryana Agricultural University, Hisar
15. Lala Lajpat Rai University of Veterinary & Animal Sciences, Hisar
16. Haryana State University of Horticultural Sciences, Karnal
17. Ch. Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya, Palampur
18. Dr. Yaswant Singh Parmar University of Horticulture & Forestry, Solan
19. Birsa Agricultural University, Ranchi
20. Sher-e-Kashmir University of Agricultural Sciences & Technology, Srinagar
21. Sher-e-Kashmir University of Agricultural Sciences & Technology, Jammu
22. University of Agricultural Sciences, Bangalore
23. Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar
24. University of Agricultural Sciences, Raichur
25. University of Agricultural Sciences, Dharwad
26. University of Horticulture Science, Bagalkot
27. University of Agriculture & Horticulture Sciences, Shivamogga
28. Kerala Agricultural University, Thrissur
29. Kerala University of Fisheries and Ocean Studies, Panangad, Kochi
30. Kerala Veterinary and Animal Sciences University, Pookode, Wayanand, Kerala
31. Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior
32. Nanaji Deshmukh Pashu Chikitsa Vishwavidyalaya, Jabalpur
33. Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur
34. Dr. Balaesahib Sawant Kokan Krishi Vidyapeeth, Dapoli
35. Maharashtra Animal & Fisheries. Sciences University, Nagpur
36. Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani
37. Mahatma Phule Krishi Vidyapeeth, Rahuri
38. Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola
39. Orissa University of Agricultural & Technology, Bhubaneswar
40. Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana
41. Punjab Agricultural University, Ludhiana
42. Maharana Pratap University of Agriculture & Technology, Udaipur
43. Swami Keshwanand Rajasthan Agricultural University, Bikaner
44. Rajasthan University of Veterinary & Animal Sciences, Bikaner
45. SKN Agriculture University, Jobner
46. Agriculture University, Kota
47. Agriculture University, Jodhpur
48. Tamil Nadu Agricultural University, Coimbatore
49. Tamil Nadu Veterinary & Animal Sciences University, Chennai
50. Tamil Nadu Dr J Jayalalithaa Fisheries University , Nagapattinam
51. Sri Konda Laxman Telangana State Horticultural University, Hyderabad
52. Sri PV Narsimha Rao Telangana Veterinary University, Hyderabad
53. Professor Jayashankar Telangana State Agricultural University, Hyderabad
54. G.B. Pant University of Agriculture & Technology, Pantnagar
55. VCSG Uttarakhand University of Horticulture & Forestry, Bharsar
56. Chandra Shekhar Azad University of Agricultural & Technology, Kanpur
57. Narendra Deva University of Agriculture & Technology, Faizabad
58. Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut
59. U.P. Pt. Deen Dayal Upadhyaya Pashu Chikitsa VigyanVishwavidhyalaya Evem Go Anusandhan Sansthan, Mathura
60. Banda University of Agricultural and Technology, Banda
61. Bidhan Chandra Krishi Vishwavidhyalaya, Mohanpur
62. West Bengal University of Animal & Fishery Sciences, Kolkata
63. Uttar Banga Krishi Vishwavidhyalaya, Cooch Behar

Central Agricultural Universities

1. Central Agricultural University, Imphal
2. Rani Laxami Bai Central Agricultural University, Jhansi
3. Dr. R.P. Central Agricultural University, Pusa, Samstipur, Bihar

Deemed Universities

1. Indian Agricultural Research Institute, New Delhi
2. Central Institute of Fisheries Education, Mumbai
3. Indian Veterinary Research Institute, Bareilly
4. National Dairy Research Institute, Karnal

Central Universities with Agricultural Faculty

1. Aligarh Muslim University, Aligarh
2. Nagaland University, Medziphema
3. Banaras Hindu University, Varanasi
4. Vishwa Bharti, Sriniketan

APPENDIX 11

Total number of employees in the ICAR and its Research Institutes and number of employees of Scheduled Castes, Scheduled Tribes, Other Backward Classes and PwD Employees

S.No.	Class of post	Total posts sanctioned	Total employees in position	SC employees		ST employees		OBC employees		PwD employees	
				No.	% to total employees	No.	% to Total employees	No.	% to total employees	No.	% to total employees
1	**Scientist Posts**										
	a Scientist	4451	3776	542	14.35	214	5.67	1047	27.73	28	0.74
	b Senior Scientist	1 295	889	60	6.75	16	1.80	113	12.71	0	0.00
	c Pr. Scientist	665	323	15	4.64	3	0.93	26	8.05	1	0.31
	d RMP	175	94	2	2.13	0	0.00	1	1.06	0	0.00
	Total	**6586**	**5082**	619	12.18	233	4.58	1187	23.36	**29**	0.57
2	**Technical Posts**										
	a Category I	3699	2512	502	19.98	275	10.95	455	18.11	52	2.07
	b Category II	2555	1689	297	17.58	126	7.46	339	20.07	28	1.66
	c Category III	502	244	43	17.62	19	7.79	39	15.98	5	2.05
	Total	**6756**	**4445**	**842**	**18.94**	**420**	**9.45**	**833**	**18.74**	**85**	**1.91**
3	**Administrative Posts**										
	a Category 'A' posts: Director (SD)/ Director/ JD-cum-Registrar/ Dy. Secretary/ Under Secretary/CAOs/ SAOs/AOs/ Director (F)/Comptroller/ CF&AO/ SFAO/F&AO/ LA/ Director(OL)/ DD(OL)/AD(OL)/PPS	333	253	39	15.42	16	6.32	32	12.65	5	1.98
	b Category 'B' posts: AF&AO/AAO/SO/PS/LO/ALA/Assistant/ PA/JAO	2808	1921	307	15.98	153	7.96	233	12.13	35	1.82
	c Category 'C' posts: UDC/Steno/LDC	1719	1042	194	18.62	94	9.02	240	23.03	23	2.21
	Total	**4860**	**3216**	**540**	16.79	**263**	**8.18**	sos	**15.70**	**63**	**1.96**
4	**Supporting Skilled Staff**										
	Total	**5039**	**3829**	**1075**	**28.08**	**321**	**8.38**	**652**	**17.03**	**47**	**1.23**

APPENDIX 12

ICAR AWARDS 2019

AWARDS	AWARDEES
Sardar Patel Outstanding ICAR Institution Award 2019	**Large Institute** 1. ICAR-Central Marine Fisheries Research Institute, Kochi, Kerala **Small Institute** 1. ICAR-Central Institute for Research on Cotton Technology, Mumbai **University** 1. Govind Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand
Chaudhary Devi Lal Outstanding All India Coordinated Research Project Award 2019	1. All India Coordinated Research Project on Sorghum, Hyderabad 2. All India Coordinated Research Project on Maize, Ludhiana
Vasant Rao Naik Award for Research Application in Agriculture 2019	1. **Dr Suresh Pal Singh Tanwar (Team Leader)** ICAR-Central Arid Zone Research Institute, Jodhpur 2. **Dr Akath Singh (Associate)** ICAR-Central Arid Zone Research Institute, Jodhpur 3. **Dr M Patidar (Associate)** ICAR-Central Arid Zone Research Institute, Jodhpur 4. **Dr B K Mathur (Associate)** ICAR-Central Arid Zone Research Institute, Jodhpur 5. **Dr Praveen Kumar (Associate)** ICAR-Central Arid Zone Research Institute, Jodhpur
Rafi Ahmed Kidwai Award for Outstanding Research in Agricultural Sciences 2019	**Crop and Horticultural Sciences** 1. **Dr Rajeev K Varshney** Research Program Director – Genetic Gains, ICRISAT, Patancheru, Hyderabad **Natural Resource Management and Agricultural Engg.** 1. **Dr Cherukumalli Srinivasa Rao** Director, ICAR-National Academy of Agricultural Research Management (ICAR-NAARM), Hyderabad 2. **Dr Anandharamakrishnan Chinnaswamy** Director, Indian Institute of Food Processing Technology (IIFPT), Ministry of Food Processing Industries (MoFPI), Govt. of India, Thanjavur, Tamil Nadu **Animal and Fisheries Sciences** 1. **Dr Raghavendra Bhatta** Director, ICAR- National Institute of Animal Nutrition and Physiology, Bengaluru, Karnataka 2. **Dr Kishore Kumar Krishnani** Principal Scientist, Division of Aquaculture, ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra **Social Sciences** 1. **Dr Suresh Pal** Director, ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi
Lal Bahadur Shastri Outstanding Young Scientist Award 2019	**Crop and Horticultural Sciences** 1. **Dr Jagesh Kumar Tiwari** Senior Scientist, Division of Crop Improvement, ICAR-Central Potato Research Institute, Shimla, Himachal Pradesh **Natural Resource Management and Agricultural Engineering** 1. **Dr Mohammad Shahid** Senior Scientist, Soil Science and Microbiology, Crop Production Division, ICAR-National Rice Research Institute, Cuttack, Odisha **Animal and Fisheries Sciences** 1. **Dr Neeraj Kumar** Scientist (Fish Nutrition), ICAR-National Institute of Abiotic Stress Management Baramati, Pune, Maharashtra

AWARDS	AWARDEES
	Social Sciences 1. **Dr Mir Asif Iquebal** Senior Scientist, Centre for Agricultural Bioinformatics, Computer Building, ICAR-Indian Agricultural Statistics Research Institute, Library Avenue, PUSA, New Delhi
Panjabrao Deshmukh Outstanding Women Scientist Award 2019	1. **Dr Rashmi Aggrawal** Dean and Joint Director (Edu.), Additional Charge, Division of Plant Pathology, ICAR-IARI, New Delhi 2. **Dr Padma Venkitachalam Devarajan** Member Board of Governors, ICT, Institute of Chemical Technology (ICT), Mumbai 3. **Dr Archana Sachdev** Professor, Division of Biochemistry, ICAR-Indian Agricultural Research Institute, New Delhi
Bharat Ratna Dr C Subramaniam Award for Outstanding Teachers 2019	**Crop and Horticultural Sciences** 1. **Dr Manish Srivastav** Principal Scientist, Division of Fruits and Horticultural Technology, ICAR-Indian Agricultural Research Institute, New Delhi 2. **Dr Narayana Kashi Hegde** Professor of Horticulture & Dean (I/C), College of Horticulture, SIRSI, Karnataka **Natural Resource Management and Agricultural Engg.** 1. **Dr Tapas Kumar Das** Professor & Principal Scientist, Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi **Animal and Fisheries Sciences** 1. **Dr Rajan Sharma** Principal Scientist, Dairy Chemistry Division, ICAR-National Dairy Research Institute, Karnal, Haryana **Social Sciences** 1. **Dr Atmakuri Ramakrishna Rao** Principal Scientist and Professor (Bioinformatics), Centre for Agricultural Bioinformatics, ICAR-Indian Agricultural Statistics Research Institute, New Delhi 2. **Dr Rabindra Nath Padaria** Principal Scientist and Professor, Division of Agricultural Extension, ICAR-Indian Agricultural Research Institute, New Delhi
Fakhruddin Ali Ahmed Award for Outstanding Research in Tribal Farming Systems 2019 (I)	1. **Dr P Rajeev (Team Leader)** Principal Scientist, Agricultural Extension, ICAR-Indian Institute of Spices Research, Kozhikode, Kerala 2. **Dr V Sivakumar** Scientist (Horticulture) and Head, Horticultural Research Station, ICAR-AICRP on Spices Centre, Dr YSR Horticultural University, Visakhapatnam 3. **Dr D Prasath** Principal Scientist (Horticulture), ICAR-Indian Institute of Spices Research, Kozhikode, Kerala 4. **Dr E Jayashree** Principal Scientist, ICAR-Indian Institute of Spices Research, Kozhikode, Kerala 5. **Dr Lopamudra Sahoo (Team Leader)** Senior Scientist (Aquaculture), ICAR Research Complex for NEH Region, Tripura Centre Centre, Lembucherra, Tripura 6. **Dr Gulab Singh Yadav** Scientist (Agronomy),), ICAR Research Complex for NEH Region, Tripura Centre Centre, Lembucherra, Tripura 7. **Dr Chandan Debnath** Scientist (Fisheries Resource Management)), ICAR Research Complex for NEH Region, Tripura Centre Centre, Lembucherra, Tripura 8. **Dr Basant Kumar Kandpal** Joint Director, ICAR Research Complex for NEH Region, Tripura Centre Centre, Lembucherra, Tripura

AWARDS	AWARDEES
Fakhruddin Ali Ahmed Award for Outstanding Research in Tribal Farming Systems 2019 (II)	1. **Dr Adikant Pradhan (Team Leader)** Chief Scientist, AICRPDA, S. G. CARS, IGKV, Jagdalpur, Bastar, Chhattishgarh 2. **Dr S K Nag** Sr. Scientist and Head, Krishi Vigyan Kendra, IGKV, Jagdalpur, Bastar, Chhattishgarh 3. **Dr Abhinav Sao** Scientist, Department of Genetics and Plant Breeding, IGKV, Raipur, Chhattishgarh 4. **Dr A Dixit** Principal Scientist ICAR-National Institute of Biotic Stress Management, Raipur, Chhattishgarh 5. **Dr Anurag Saxena (Team Leader)** Principal Scientist and Head, I/C, ICAR-Central Arid Zone Research Institute, Regional Research Station, Leh, Ladakh 6. **Dr Mahendra Singh Raghuvanshi** Principal Scientist (Agronomy), ICAR-National Bureau of Soil Survey and Land Use Planning, Nagpur, Maharashtra 7. **Dr Sanjeev Kumar Chauhan** Professor and Head, Dept. of Forestry and Natural Resources, PAU, Ludhiana
Jawaharlal Nehru Award for P G Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences 2019	**Crop Sciences** 1. **Amit Kumar** Scientist (Plant Breeding), ICAR Research Complex for NEH Region, Umiam, Meghalaya 2. **Dr Vidya Sagar** Scientist (Genetics and Plant Breeding), ICAR-IIVR, Varansi **Animal Sciences** 1. **Dr Jess Vergis** Assistant Professor, Department of Veterinary Public Health, College of Veterinary and Animal Sciences, KVASU, Kerala 2. **Dr Mohd Iqbal Bhat** Animal Biochemistry Division, National Dairy Research Institute, Karnal, Haryana **Natural Resource Management** 1. **Dr Thombare Nandkishore Sudhakarrao** Scientist (Agricultural Chemistry), ICAR – Indian Institute of Natural Resins and Gums, Namkum, Ranchi, Jharkhand 2. **Dr Sumit Pal** Water Technology Centre, ICAR-Indian Agricultural Research Institute, Pusa Campus, New Delhi **Crop Protection** 1. **Dr Vinod Kumar Selvaraj** Kalapakulam, Tamil Nadu 2. **Dr T R Resmi** Pulari, Kerala **Fisheries** 1. **Dr Nithin Chakkarezhath Thilakappan** Ernakulam, Kerala 2. **Dr Selsa J Chakkalakal** Ernakulam, Kerala **Horticulture** 1. **Dr Chavlesh Kumar** Scientist, Division of Fruits and HorticulturalTechnology, ICAR-IARI, New Delhi 2. **Dr Nangsol Dolma Bhutia** Assistant Professor, Department of Vegetable Science, College of Horticulture and Forestry,Central Agricultural University, Pasighat, Arunachal Pradesh

AWARDS	AWARDEES
	Agricultural Engineering 1. **Dr Ashok Kumar** Bharimalla Matunga East, Mumbai 2. **Dr Sandip Mandal** ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh **Social Sciences** 1. **Dr Anirban Mukherjee** Scientist (AE), Division of Socioeconomics and Extension, ICAR-Research Complex for Eastern Region, Patna, Bihar 2. **Dr Shruti** Scientist (Agricultural Extension), ICAR-Directorate of Mushroom Research, Himachal Pradesh **Biotechnology** 1. **Dr Alice Kujur** Centre of Excellence in Genomics & Systems Biology (CEGSB), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, Telangana 2. **Dr Hirpara Darshna Gordhanbhai** Department of Biotechnology, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat
Jagjivan Ram Abhinav Kisan Puruskar/ Jagjivan Ram Innovative Farmer Award (National/ Zonal) 2019	**National** 1. **Major Manmohan Singh Verka** Amritsar, Punjab **Zone I** 1. **Smt. Yangchen Dolma** Village-Saboo, B P O-Choglamsar, Leh, Ladakh **Zone II** 1. **Sh. Jagdish Chandra Prajapat** Village – Bangreda Mamadev, Tehsil- Nimbahera Chittorgarh, Rajasthan **Zone III** 1. **Sh. Vigyan Shukla** Village- Brahm Nagar Atarra, District- Banda, Uttar Pradesh **Zone IV** 1. **Shri Shiv Prasad Sahani** Village-Mahmadpur, PO-Arua, PS + Block-Bhagwanpur Hat, Distt.-Siwan. Bihar 2. **Shri Ram Shankar Singh** Village: Chanpur Parari PO: Madwan District: Muzaffarpur, Bihar **Zone V** 1. **Shri Sudam Sahu** Village - Katapali, PO - Katapali, Via - Bardol, Dist. - Bargarh, Odisha **Zone VI** 1. **Sh. Bipul Haloi** Vill : 3 No. Balitara, PO: Balitara, Dist: Nalbari, Assam **Zone VII** 1. **Sh. N Devnath** PO: Brahmanpuskuni, P.S: Lefunga, Tripura West, Tripura **Zone VIII** 1. **Sh. Vinod Gopal Bharve** H. No. 20/1, Satode, Valpoi, Sattari, Goa 2. **Smt. Vidya Baburao Rudraksha** At. Post. Digholamba, Tq. Ambajogai, Dist. Beed (Maharashtra) **Zone IX** 1. **Sh. Vishal Katre** Balaghat, Madhya Pradesh **Zone X** 1. **Smt. Rupireddy Laxmi** Vill: Kondapalkala, Mdl: Manakondur, Dist: Karimnagar, Telangana

AWARDS	AWARDEES
	Zone XI 1. **Sh. S C Thimmaiah** Nalloor Village, Kirgoor Post, Gonikoppal, Kodagu, Karnataka 2. **Sh. T Purushothaman** Azad Bhavan, PayyanurPost, Kannur District, Kerala
N.G. Ranga Farmer Award for Diversified Agriculture 2019	1. Sh. Raghupat Singh, S/o Late Sh. Sitaram, Vill.-Samathal, The.-Bilari, Distt.-Muradabad, Uttar Pradesh
Swami Sahajanand Saraswati Outstanding Extension Scientist Award 2019	1. **Dr Meraj Alam Ansari** Scientist (Agronomy), ICAR Research Complex for NEH Region Manipur Centre, P.O. Lamphelpat, Imphal Dist. Imphal West, Manipur 2. **Dr Bharat Shankar Sontakki** Head, Extension Systems Management Division, ICAR-National Academy of Agricultural Research Management, Rajendranagar, Hyderabad 3. **Dr Gulab Singh Yadav** ICAR Research Complex for NEH Region, Tripura Centre, Limbucherra, Tripura
NASI-ICAR Award for Innovation and Research on Farm Implements-2019	1. **Dr Devvrat Singh** Principal Scientist (Farm Machinery and Power), ICAR-Indian Institute of Soybean Research, Khandwa Road, Indore, MP
Dr. Rajendra Prasad Puruskar for technical books in Hindi in Agricultural and Allied Sciences 2019	**Crop and Horticultural Sciences** 1. **Dr D R Bhardwaj** Principal Scientist, Vegetable Crops Improvement Division, ICAR-Indian Institute of Vegetable Research, Varanasi, U.P. **Natural Resource Management and Agricultural Engineering** 1. **Dr U K Behara (Team Leader)** Dean, College of Agriculture, Central Agriculture University, Imphal, Kyrdemkulai, Ri-Bhoi, Meghalaya 2. **Sh. Ranbir Singh (Associate)** Senior Technical Officer (T-6), Farm Operation Service Unit, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi 3. **Dr Pramod Kumar Sahoo (Associate)** Principal Scientist, Division of Agricultural Engineering, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi **Animal and Fisheries Sciences** 1. **Dr Niteen Manmohanrao Markandeya** Associate Dean, College of Veterinary & Animal Sciences, Parbhani, Maharashtra 2. **Sh. Amit Vinayak Gadre (Associate)** Chief Sub-Editor, 'Agrowan' (Associate) **Social Sciences** 1. **Dr Rekha Singh** Subject Matter Specialist (Home Science), KVK Bhadohi, ICAR-Indian Institute of Vegetable Research, Varanasi, U.P.
Pandit DeenDayal Upadhyay Antyodaya Krishi Puruskar, 2019	**National** 1. **Sh. Narpinder Singh** S/o Sh. Jangir SinghVPO Chuharchak, Teh. &Distt.-Moga, Punjab **Zone I** 1. **Sh. Chamkaur Singh** S/o Sh. Midda Singh, VPO Gholia Khurd, Teh.-Baghapurana, Distt.-Moga, Punjab 2. **Sh. Karan Singh** Village- Dharon Ki Dhar, PO- Kotla,Tehsil and District, Solan, Himachal, Pradesh **Zone II** 1. **Sh. Kulbir Singh** S/o Sh.Surjan Singh Village-Mangoli Jattan, PO-Sanghor, The-Babain, Distt.-Kurukshetra, Haryana

AWARDS	AWARDEES
	Zone III 1. **Sh. Agya Ram Verma** Village -Kharkadewri,Post-Kodai Distt-Basti, Uttar Pradesh Zone IV 1. **Sh. Gandura Oraon** Village-Gurgurjari, Block-Mandar, Ranchi, Bihar **Zone V** 1. **Sh. Chandan Ray** Village-Bhogdabri Keshari Bari, PO- Elajaner Kuthi, Ps-Kotwali, Distt.-Coochbehar, West Bengal **Zone VI** 1. **Sh. Biju Kalita** Village-Pub Balitara, Distt.- Nalbari, Assam **Zone VII** 1. **Sh. Atheo Lotha** Humtso Village, Wokha, Nagaland **Zone VIII** 1. **Sh. Pralhad Gulabrao Vare,** A/p Malad, tal-Baramati, Distt.-Pune, Maharashtra **Zone IX** 1. **Sh. Jiyalal Rahangdale** At- Bagadmara, Post- Rajegaon. Th.- Kirnapur, Distt.- Balaghat, Madhya Pradesh **Zone X** 1. **Smt. Tellam Ramana** W/o. Tellam Chinna Rao, East Rekulakunta, Buttaigudem Mandal, West Godavari Distt., Andhra Pradesh **Zone XI** 1. **Sh. Sannayamanappa Bheemappa Rajapure** Basava Nagar, Pamaladinni, Tq: Gokak, Dist: Belagavi, Karnataka
Pandit Deen Dayal Upadhyay Krishi Vigyan Rashtriya Protshahan Puraskar 2019	**National** 1. Krishi Vigyan Kendra, Datia, Madhya Pradesh 2. Krishi Vigyan Kendra, Venkataramannagudem, Andhra Pradesh **Zone I** 1. Krishi Vigyan Kendra, Amritsar, Punjab 2. Krishi Vigyan Kendra, Leh-II, Ladakh **Zone II** 1. Krishi Vigyan Kendra, Pali-Marwar, Rajasthan **Zone III** 1. Krishi Vigyan Kendra, Basti, U.P. **Zone IV** 1. Krishi Vigyan Kendra, Gumla, Jharkhand **Zone V** 1. Krishi Vigyan Kendra, Kalyan, West Bengal **Zone VI** 1. Krishi Vigyan Kendra, Namsai, Arunachal Pradesh **Zone VII** 1. Krishi Vigyan Kendra, Imphal East, Manipur **Zone VIII** 1. Krishi Vigyan Kendra, Beed-I, Ambajogai, Maharashtra **Zone IX** 1. Krishi Vigyan Kendra, Ujjain, Madhya Pradesh **Zone X** 1. Krishi Vigyan Kendra, Wyra, Khammam, Telengana **Zone XI** 1. Krishi Vigyan Kendra, Bagalkote, Karnataka

AWARDS	AWARDEES
Haldhar Organic Farmer Award 2019	1. **Smt. Sarika Patidar** Borlai, Teh. & Distt. – Barwani, Madhya Pradesh 2. **Sh. Surendra Awana** Village-Bhairana, Post-Bichoon, The.-Dudu, Distt.-Jaipur, Rajasthan
Nanaji Deshmukh ICAR Award for Outstanding Interdisciplinary Team Research in Agricultural and Allied Sciences 2019	**Animal Sciences & Fisheries** 1. **Dr P S Yadav (Team Leader)** Principal Scientist, Animal Physiology and Reproduction Division, ICAR-Central Institute for Research on Buffaloes, Hisar, Haryana 2. **Dr Dharmendra Kumar (Associate)** Sr. Scientist (Animal Biotechnology), ICAR-Central Institute for Research on Buffaloes, Hisar, Haryana 3. **Dr Naresh Selokar (Associate)** Scientist (Animal Biotechnology), ICAR-Central Institute for Research on Buffaloes, Hisar, Haryana 4. **Dr R K Sharma (Associate)** Principal Scientist (Animal Reproduction), ICAR-Central Institute for Research on Buffaloes, Hisar, Haryana 5. **Dr Pradeep Kumar (Associate)** Scientist (Animal Reproduction), ICAR-Central Institute for Research on Buffaloes, Hisar, Haryana **Social Sciences** 1. **Dr Rajbir Singh** Director, ICAR-ATARI Zone-I, PAU Campus, Ludhiana 2. **Dr Jaskarn Singh Mahal (Associate)** Director of Extension, PAU, Ludhiana 3. **Dr Arvind Kumar (Associate)** Principal Scientist, ICAR-ATARI, Ludhiana 4. **Dr Subhash Chander Sharma (Associate)** Programme Coordinator, KVK, Samrala & Ropar 5. **Dr Jagdish Grover (Associate)** Programme Coordinator, KVK Faridkot 6. **Dr Jitender Singh Brar (Associate)** Programme Coordinator, KVK Bathinda 7. **Dr Vipin Rampal (Associate)** Programme Coordinator, KVK Fatehgarh 8. **Dr Jugraj Singh Marok (Associate)** Programme Coordinator, KVK Kapurthala 9. **Dr Gurjinder Pal Singh (Associate)** Programme Coordinator, KVK Mansa 10. **Dr Mandeep Singh (Associate)** Programme Coordinator, KVK, VPO Kheri, Sangrur 11. **Dr Amandip S Brar (Associate)** Programme Coordinator, KVK Moga 12. **Dr Bhupinder Singh Dhillon (Associate)** Programme Coordinator, KVK Amritsar 13. **Dr Gurjant Singh Aulakh (Associate)** Programme Coordinator, KVK Ferozepur 14. **Dr Balwinder Kumar (Associate)** Programme Coordinator, KVK Tarantaran 15. **Dr Maninder Singh Bons (Associate)** Programme Coordinator, KVK Hoshiarpur 16. **Dr Jasvinder Singh (Associate)** Programme Coordinator, KVK patiala 17. **Dr Nirmaljit Singh Dhaliwal (Associate)** Programme Coordinator, KVK Muktsar 18. **Dr Kuldeep Singh (Associate)** Programme Coordinator, KVK Jallandhar 19. **Dr Manoj Sharma (Associate)** Programme Coordinator, KVK Nawashar 20. **Dr Sarbjit Singh (Associate)** KVK, Gurdaspur

AWARDS	AWARDEES
	21. **Dr Ashish SantoshMurai (Associate)** Scientist, ICAR-ATARI Ludhiana 22. **Dr Rajesh Kumar Rana (Associate)** Principal Scientist, ICAR-ATARI, Ludhiana
Chaudhary Charan Singh Award for excellence in Journalism in Agricultural Research and Development 2019	**Print Media– (English Language)** 1. **Sh. Gurpreet Singh Nibber** Journalist, Hindustan Times **Print Media- (Hindi Language)** 1. **Sh. Brihaspati Kumar Pandey** Journalist, Farm N Food **Regional Language/Telegu** 1. **Sh. Amirneni Hari Krishna** Executive Editor, Annadata **Regional Language/ Marathi** 1. **Sh. Vinod DnyandeoIngole** Journalist, 'Agrovan' **Electronic Media** 1. **Sh. Shiv Nandan Lal** All India Radio, New Delhi **Electronic Media** 1. **Sh. Umashankar Mishra** Digital Media
Cash Awards Scheme 2019	**Administrative Category** 1. **Sh. Rajeev Lal** CAO, ICAR-CIFRI, Barrackpore 2. **Smt. N. Vijaya Lakshmi,** JAO, ICAR – NAARM, Hyderabad 3. **Sh. Prabhat Kumar Nayak** AF&AO, NRC on Pig, Guwahati **Technical Category** 1. **Dr Sivakumar T.** SMS (Agrl. Entomology), ICAR-KVK-Alappuzha, ICAR-CPCRI(RS), Kayamkulam, Kerala 2. **Dr Uttam Kumar** CTO (Agronomy), ICAR-NDRI, Karnal 3. **Dr Monika Jolly** CTO (Biochemistry), ICAR-IARI, New Delhi 4. **Dr Ashwin Trivedi** STO, DMAPR, Anand **Supporting Category** 1. **Sh. Guru Dutta Sharma** ICAR-NRC on Equines,Hisar 2. **Sh. S N Rasool** NAARM, Hyderabad 3. **Vijender Kumar** ICAR-NDRI, Karnal

Acronyms

AARDO	: African-Asian Rural Development Organization
ABI	: Agri-business Incubation
ACI	: Adaptive Capacity Index
AER	: Agro-ecological Region
AES	: Agriculture Expert System
AESR	: Agro-ecological Sub-region
AFC	: Age at First Calving
AFLP	: Amplified Fragment Length Polymorphism
AGID	: Agar Gel Immunodiffusion
AI	: Avian Influenza
AICRP	: All India Coordinated Research Project
AINP	: All India Network Project
AKAP4	: A-kinase Anchor Protein 4
AKMU	: Agricultural Knowledge Mangement Unit
ALV	: Avian Leukosis Virus
AMAAS	: Application of Micro-organisms in Agriculture and Allied Sectors
AMPs	: Antimicrobial Peptides
ANASTU	: Afghan National Agricultural Sciences and Technology Unit
APCTT	: Asia-Pacific Centre for Technology Transfer
ARYA	: Attracting and Retaining Youth in Agriculture
ASAM	: Alkaline Sulfite Anthraquinone Methanol
ASEAN	: Association of South-East Asian Nations
ASRB	: Agricultural Scientists' Recruitment Board
ATARI	: Agricultural Technology Application Research Institutes
ATIC	: Agricultural Technology Information Centre
ATP	: Annual Training Programme
BAT	: BAIT Application Technique
BOD	: Biochemical Oxygen Demand
BoHV	: Bovine Herpes Virus
BRICS	: Brazil, Russia, India, China and South Africa
BTV	: Blue Tongue Virus
BVDV	: Bovine Viral Diarrhoea Virus
BVS	: Bovine Vaccinate Serum
CA	: Conservation Agriculture
CAFT	: Centres of Advanced Faculty Training
CAU	: Central Agricultural University
CAZRI	: Central Arid Zone Research Institute
CC	: Cellular Component
CCA	: Climate Change adaptation
CER	: Carbon enrinchment ratio
CeRA	: Consortium for e-Resources in Agriculture
CFL	: Current Fallow Land
CFLD	: Cluster Frontline Demonstration
CFT	: Complement Fixation Text
CGIAR	: Consultative Group on International Agricultural Research
CHC	: Custom Hiring Centres
CIAE	: Central Institute of Agricultural Engineering
CIARI	: Central Island Agricultural Research Institute
CIMMYT	: Centro International de Mejormento de Maize Trigo
CLA	: Conjugated Linoleic acid
CP	: Crude Protein
CPE	: Cumulative Pan Evaporation
CPP	: Caseinophosphopeptides
CRD	: Chronic respiratory disease
CSFV	: Classical Swine Fever Virus
CVM	: Congenital Vascular Malformation
DAS	: Days After Sowing
DAT	: Days After Transplanting
DEs	: Directorates of Extension
DG	: Distillers' Grains
DHA	: Docosahexanoid acid
DI	: Drip Irrigation
DSn	: Diagnostic sensitivity
DSS	: Decision Support System
DSWP	: Defatted Silkworm Pupae Meal
EAS	: Extension and Advisory Services
ECPI	: Empowerment of Crop Production Index
EEE	: Eastern Equine Encephalitis
EHV	: Equine Herpes Virus
EIA	: Enzyme Immuno Assay
EIV	: Equine Influenza Virus
ELISA	: Enzyme-linked Immunosorbent Assay
EPA	: Eicosapentanoic acid
EPN	: Entomopathogenic Nematode
ETL	: Economic Threshold Level
EXPSS	: Expert System on Seed Spices
FAO	: Food and Agriculture Organization
FCR	: Feed Conversion Rate
FEC	: Faecal Egg Count
FFP	: Farmers FIRST Project
FINE	: Festival of Innovation and Entrepreneurship
FLD	: Frontline Demonstrations
FMD	: Foot-and-Mouth Disease
FPT	: Field Progeny Testing Project
FSH	: Follicle-stimulating Hormone
FWKGs	: Farm Women Knowledge Groups
FYM	: Farmyard Manure
GADVASU	: Guru Angad Dev Veterinary and Animal Sciences University
GBNV	: Groundnut Bud Necrosis Virus
GBPUAT	: Govind Ballabh Pant University of Agriculture and Technology
GDP	: Gross Domestic Production
GEF	: Global Environmental Facility
GHGs	: Greenhouse Gases
GIS	: Geographical Information System
GO	: Gene Ontology
GPA	: Global Plan of Action
GPS	: Global Positioning System

HAB : Hyper Ammonia Producing Bacteria
HAPA : Hybridization-supplemented Apomixis Components Partitioning Approach
HPAI : Highly Pathogenic Avian Influenza
HPNA : Highly Pathogenic Notifiable Avian Influenza
HPTLC : High Performance Thin Layer Chromatography
HRR : Head Rice Recovery
HS : Haemorrhagic Septicaemia
HSP : Heat Shock Protein
IAA : Integrated Agri-aquaculture
IBR : Infectious Bovine Rhinotracheitis
ICARDA : International Centre for Agricultural Research in Dry Areas
ICMV : Indian Cassava Mosaic Virus
ICRISAT : International Crops Research Institute for Semi-Arid Tropics
ICT : Information and Communication Technologies
IDM : Integrated Disease Management
IDS : Integrated Drying System
IFS : Integrated Farming System
IHC : Immuno-histochemistry
IPM : Integrated Pest Management
IPNS : Integrated Plant Nutrient System
IPR : Intellectual Property Rights
IRES : Internal Ribosomal Entry Site
IRR : Internal Rate of Return
ITK : Indigenous Technical Knowledge
IWMI : International Water Management Institute
JE : Japanese Encephalitis
JNKVV : Jawaharlal Nehru Krishi Vishwa Vidyalaya
KKA : Krishi Kalyan Abhiyan
KVAFSU : Kerala Veterinary, Animal Sciences and Fisheries University
KVK : Krishi Vigyan Kendra
LAMP : Loop Mediated Isothermal Amplification
LAT : Latency Associated Transcript
LC-MS/MS : Liquid chromatographs/ Mass spectrometry
LD : *Longissmus dorsi*
LDF-Mobile App : Livestock Disease Forewarming-Mobile App
LEU : Landscape Ecological Unit
LFA : Lateral Flow Assay
LRI : Land Resource Inventory
MABB : Marker Assisted Backcross Breeding
MAS : Molecular Marker-assisted Selection
MAT : Macroscopic Agglutination Test
MAT : Male Annihilation Technique
MF : Molecular Function
MGMG : Mera Gaon Mera Gaurav
MoU : Memorandum of Understanding
MPP : Methane Production Potential
MS : Mass Spectrometry
MW : Molecular Weight
NABG : National Agricultural Bioinformatics Grid
NADRES : National Animal Disease Referral Expert System
NAE : Niche Area of Excellence
NAEAB : National Agricultural Education Accreditation Board
NARD : National Agricultural Research Database
NARS : National Agricultural Research System
NASF : National Agricultural Science Fund
NBSS&LUP : National Bureau of Soil Survey and Land Use Planning
NDF : Non-detergent Fibre
NDMI : Normalized difference moisture index
NDVI : Normalized difference vegetation index
NDWI : Normalized difference water index
NEH : North-Eastern Hills
NET : National Eligibility Test
NGOs : Non-Government Organizations
NIABI : Network of Indian Agri-business Incubators
NICRA : National Innovations in Climate Resilient Agriculture
NISAGENET : National Information System on Agricultural Education Network
NLS : Nano-lignocellulose
NPOP : National Programme for Organic Production
NRC : National Research Centre
NSP-Ab : Non Structural Protein Antibody
NSSO : National Sample Survey Office
NTM : Non-tuberculous *Mycobacterium*
NTS : National Talent Scholarship
NUE : Nitrogen Uptake
OAS1 : Oligoadenylate Synthase 1
ODR : Overall Discomfort Rating
OMF : Organo-mineral Fertilizer
OTC : Open Top Chamber
PBMCS : Peripheral Blood Mononuclear Cells
PCA : Principal Component Analysis
PCR : Polymerase Chain Reaction
PCZ : Potentila Crop Zone
PDDUUKSY : Pandit Deen Dayal Upadhyay Unnat Krishi Shiksha Yojana
PFA : Pschological First Aid
PGDTMA : Post-graduate Diploma in Technology Management in Agriculture
PGFM : Prostagladin F2 Alpha Metabalite
PGRC : Plant Germplasm Registration Committee
PIADC : Plum Island Animal Disease Center
PID : Participating Technology Development
PME : Priority Setting, Monitoring and Evaluation
PMIS : Personal Management Information System
PPGSE : Plausible Potato Growing Seasons Estimator
PPR : *Peste des Petitis Ruminants*
PPV and FRA : Protection of Plant varieties and Farmers' Rights Authority
PPV : Porcine Parvovirus
PRRSV : Porcine Reproductive and Respiratory Syndrome Virus
PSR : Polymerase Spiral Reaction
PSVs : Peer Support Volunteers
PUFAs : Polyunsaturated fatty acids
QPM : Quality Protein Maize
QTL : Quantitative Trait Loci
RAWE : Rural Agricultural Work Experience
RDF : Recommended Dose of Fertilizers
RE : Revised Estimate
RFD : Results-Framework Document

RFLP	: Restricted Fragment Length Polymorphism	TKP	: Tamarind Kernel Powder
RH	: Relative Humidity	TL	: Truthfully Labelled
RIL	: Recombinent Inbred Line	TLCV	: Tomato Leaf Curl Virus
Risk MAP	: Risk Mapping, Assessment and Planning	TLR-1	: Toll Like Receptor-1
RMP	: Research Management Positions	TNA	: Training Needs Analysis
RNFE	: Rural Non-farm Employment	ToT	: Transfer of Technology
RVF	: Rift Valley Fever	TSP	: Tribal Sub-Plan
SAARC	: South Asian Association for Regional Co-operation	TSS	: Total Soluble Solids/Sugars
SAH	: Solar Air Heater	TTV	: Transfusion Transmitted Virus
SAUs	: State Agricultural Universities	UAN	: Urea Ammonium Nitrate
SCC	: Somatic Cell Count	UGC	: University Grants Commission
SCS-CN	: Soil conservation Service-Curve Number	USST	: Udder Skin Surface Temperature
SCSMV	: Sugarcane Streak Mosaic Virus	UV	: Ultra Violet
SNP	: Single Nucleotide Polymorphism	VACV	: Vaccinia Virus
SOC	: Soil Organic Carbon	VNTR	: Variable Number Tandem Repeats
SPR	: Surface Plasmon Resonance	VPKAS	: Vivekananda Parvatiya Krishi Anusandhan Sansthan
SRF	: Senior Research Fellowship	VRFA	: Variable Rate Granular Fertilizer Applicator
SRI	: System of Rice Intensification	VS	: Vesicular Stomatitis
SSD	: Surface and Subsurface Drainage	VTCC	: Veterinary Type Culture Centre
SSLUP	: Small Scale Lac Processing Units	WB	: Western Blot
SSR	: Simple Sequence Repeat	WBUFAS	: West Bengal University of Fisheries and Animal Sciences
SWYMOD	: Surface-Water Yield Model	WCL	: Whole Cell Lysate
TDC	: Technology Demonstration Component	WDCM	: World Data Centre for Microorganisms
TEM	: Transmission Electron Microscope	WSSV	: White Spot Syndrome Virus
TFP	: Total Factor Productivity	WUE	: Water Use Efficiency
TiLv	: Tilapia Lake Virus		

❑

Index

Published by Dr. S.K. Singh, Project Director (DKMA), Indian Council of Agricultural Research, Krishi Anusandhan Bhavan, Pusa, New Delhi 110 012; Lasertypeset by M/s Xpedite Computer Systems, WZ-276/F1B, Inderpuri, New Delhi-110 012 and Printed at M/s Royal Offset Printers, A-89/1, Naraina Industrial Area, Phase-I, New Delhi 110 028

King Bhumibol World Soil Day Award to ICAR

The Indian Council of Agricultural Research (ICAR), has bagged the prestigious International King Bhumibol World Soil Day Award conferred by the Food and Agriculture Organization (FAO), Rome. Her Royal Highness, Princess Maha Chakri Sirindhorn of Thailand, will give the award to the ICAR in an official ceremony that will take place in Bangkok in January 2021. The announcement to this effect was made on a virtual function by the FAO on the World Soil Day (5 December 2020). The prestigious global award was conferred to the ICAR for its commitment to raising awareness about the importance of healthy soils. World Soil Day Award was conferred to the ICAR for last year's World Soil Day celebration, which addressed soil erosion under the motto "Stop soil erosion, save our future". ICAR organised "Soil Health Awareness Week" during 1-7 December 2019 with participation of more than 13,000 people, including scientists, government institutions, officials, students, farmers and the general public, in the social media campaign "SOIL – Our Mother Earth" on 5 December 2019.

ICAR conferred with Digital India Awards - 2020 under Open Data Champion Category

The Hon'ble President of India, Shri Ram Nath Kovind on 30 December, 2020, virtually conferred the Indian Council of Agricultural Research, New Delhi with the "Digital India Awards - 2020" under the Open Data Champion category. The ICAR was felicitated with the Award for its Research Data Management Portal. The 'Digital India Awards – 2020' to ICAR under Open Data Champion Category, is given for the invincible contributions in the field of digitalization and preserving the research data in a digital form that may be accessed by the future generations anywhere, at any point of time with ease, and will also reduce the communication divides in the society.

The Indian Council of Agricultural Research is committed for organizing its knowledge and making it available to the fullest extent possible through Open Government Data Platform (https://data.gov.in) and its own Portal - KRISHI (Agricultural Knowledge Resources and Information System Hub for Innovations) Portal (https://krishi.icar.gov.in). The Portal has been developed as a centralized data repository system for Research Data Management in the Council.

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch