

ANNUAL REPORT

2017-18



भा.कृ.अनु.प.-भारतीय बागवानी अनुसंधान संस्थान

हेसरघट्टा लेक पोस्ट, बैंगलूरु - 560 089

ICAR-Indian Institute of Horticultural Research

Hessaraghatta Lake Post, Bengaluru - 560 089





ICAR-IIHR Varieties released during 2017-18



Onion - Arka Yojith



Rose - Arka Savi



Okra - Arka Nikita



**Velvet bean - Arka Charaka,
Arka Daksha,**



Arka Shubra and Arka Shukla

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Director

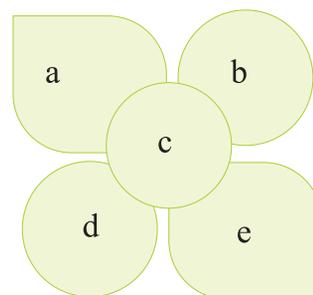
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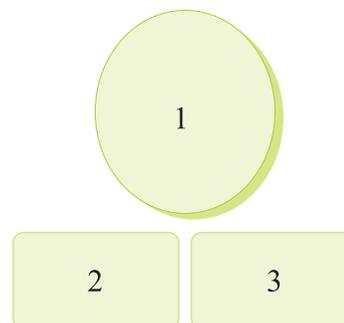
Front cover

a) Arka Siri (Muskmelon) (b) IIHR Rose breeding line 2-28-1
c) Arka Poorna (Guava) (d) Arka OM-1(Pink oyster mushroom)
e) Arka Divya (*Centella Asiatica*)



Back cover

- 1) Release of Jackfruit Variety “Siddu” by
Shri Vajubhai Rudabhai Vala, Hon'ble
Governor of Karnataka at ISH, Bengaluru
- 2) A view of the audience at ISH, Bengaluru
- 3) Release of mango catalogue in CD form



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PREFACE

Horticulture is playing an increasingly important role in the life of Indian farmers. In addition to meeting the nutritional requirement of consumers, horticulture has improved the economic status of farmers and have resulted in doubling the farmer's income in several cases. Availability of fruits and vegetables throughout the year has increased per capita consumption of fruits of vegetables. It has also played a significant role in providing employment opportunities in several sectors from planting material production in nursery to seed production to fruit, vegetable ornamental crop cultivation etc. Medicinal crops research is becoming more relevant with increased importance given to herbal remedies in day to day life. ICAR- Indian Institute of Horticultural Research, the first horticultural research Institute established in the country, has been in the forefront in providing solutions to the problems faced by horticultural farmers and stakeholders, improving production, ensuring quality of produce and providing opportunities to entrepreneurs in horticulture sector.

ICAR-IIHR celebrated its Golden Jubilee during the year 2017-18. The celebration was marked by series of programs at its main campus as well as in the regional centres. The biggest among these were the "International Symposium on Horticulture: Priorities and Emerging trends" and the "National Horticultural Fair". Several eminent personalities viz., Dr. G. G. Gangadharan, Ayurvedacharya, M.S. Ramaiah Indic Centre, Bengaluru, Dr. Tejaswini Anantkumar, President, Adanya Chethana Foundation, Bangalore, Dr. P.V. Ramachandra, IISc and others from various walks of life on different occasions visited the Institute and addressed the staff.

During the year under report, the Institute has released seven new varieties and seventeen new technologies besides expanding the label claim of an existing highly popular technology, Arka Microbial Consortium. The Institute conducted a large number of 'on campus' as well as 'off campus' training programs and also five international trainings for subject matter specialists of African and Asian countries. Under the tribal sub plan program, IIHR-CHES, Bhubaneswar demonstrated and disseminated several mango production technologies to farmers in Rayagada district of Odisha.

The model of horticultural technology licensing, incubation and handholding support for incubation provided by the BPD unit of the Institute has proved successful and has helped the Institute reach out to over 400 stakeholders besides earning revenue.

I congratulate the staff members of this Institute whose hard work has made ICAR-IIHR a name to reckon with. I feel happy to present the Annual Report for the year 2017-18 of this illustrious Institute. I take this opportunity to express my gratitude to the Institute Management Committee, Research Advisory Committee and the Quinquennial Review Team for reviewing the institutional programs and activities and offering valuable guidance for the same.

I wish to place on record my deep sense of gratitude to Dr. Trilochan Mohapatra, Secretary, DARE and DG, ICAR, New Delhi and Dr. A. K. Singh, Deputy Director General (Horticultural Science), ICAR, New Delhi for their unstinted support and able guidance.

Bengaluru
June 25, 2018



M.R. Dinesh
Director

1. EXECUTIVE SUMMARY

Research work at ICAR-IIHR during the year under report was carried out under 26 projects and 143 sub projects including 12 subprojects from CHES, Chettalli and CHES, Bhubaneswar. Work was also carried out under 66 externally funded projects including two internationally aided projects, one national fellow project and eight All India Coordinated Projects under operation in the Institute. In the field of education, training and capacity building, the Institute has signed an MoU with Indian Agricultural Research Institute, New Delhi and the Post Graduate School of Horticultural Sciences has been established at Indian Institute of Horticultural Research, Bengaluru in 2014 at present 55 students are pursuing their Ph.D program in Horticulture. As part of capacity building program, a total of 53 employees belonging to various categories underwent training to improve their knowledge and skills. On transfer of technology front, ICAR-IIHR and its regional stations conducted 33 on campus and 38 off campus trainings. 58 on campus and 59 off campus trainings were conducted by KVK, Hirehalli and KVK Gonikoppal.

During the year under report, an “International Symposium on Horticulture : Priorities and Emerging trends” was organized to commemorate the Golden jubilee year of inception of the Institute and this was attended by more than 500 delegates including 26 foreign delegates from 11 different countries. A National Horticultural Fair was conducted in March 2018 demonstrating technologies and varieties of ICAR-IIHR. It was attended by 6000 farmers mainly from South India. A Referral laboratory on food safety is operational in the Institute providing service to stakeholders in analysis of food contaminants in horticultural produce. A ‘National Test Laboratory for import and export of horticultural crops quarantine centre’ at the Institute is recognized by DBT for certification of imported as well as to be exported plant materials. The quality policy of the Institute has been defined and the ICAR- Indian Institute of Horticultural Research, Bengaluru has been certified for ‘Quality Management System ISO 9001:2008 during the year. Highlights of the research achievements in various projects under operation are presented below.

Management of crop genetic resources

The Institute is recognized as a nodal centre for management of plant genetic resources related to horticultural crops in the country. During the year under report, several explorations were carried out by the scientists of the Institute for collection of germplasm. Seventeen accessions of indigenous pickling varieties of mango, 25 wild pomegranate types, seven rootstock

accessions of grapes, 10 accessions of jamun, and two self fruiting accessions of custard apple were collected from different parts of India. In vegetables, six chilli and 17 capsicum accessions, 11 trait specific multi rib germplasm of okra, nine F₁ hybrids of gherkin, nine of French bean, five accessions of cowpea, four each in garden pea and dolichos, two germplasm lines of pumpkin and 45 radish germplasm were collected for different traits. Besides cultivable species, seventy nine collections of 20 species of wild fruits and vegetables, which are of future importance, were collected from the Western Ghats and BR hills. At CHES Chettalli, 20 accessions of avocado, eight of Malabar tamarind, three of mangosteen, six of kokum, four of dragon fruit and two each of passion fruit, karonda, and Macadamia nut were collected through explorations. In mushrooms, wild edible mushroom collected from Tripura was cultured, purified and validated on straw based substrate which was identified as *Pleurotus tuber-regium* based on cultural, morphological and molecular characters.

A large number of germplasm accessions of horticultural crops is being conserved and maintained in the field gene banks. Among fruit crops, mango has the largest field gene bank collection with 728 accessions followed by tamarind (278), jamun (75), guava (60), sapota (52), papaya (32) and custard apple (12). For jackfruit, the NAG site has been established. In vegetable crops, the total germplasm strength of chilli stands at 2006, okra at 1553, cucurbits at 239, French Bean at 311, cowpea at 409, garden pea at 114, and Dolichos at 212 accessions. In flower crops, germplasm strength of different crops stands at: rose (320), bougainvillea (98), chrysanthemum (83), carnation (80), gladiolus (65), marigold (54), jasmine (39), China aster (25) and indigenous ornamentals (12). In medicinal crops, 51 germplasm lines in kalmegh, 33 in *Aloe vera*, 84 in mucuna and 109 in betelvine are being maintained. At CHES, Bhubaneswar, about 200 germplasm collections of fruit crops and 700 germplasm collections of vegetable crops are being maintained and evaluated for their traits. Indigenous collection (IC) numbers for 29 accessions of underutilized fruit crops have been obtained from NBPGR, New Delhi.

The germplasm collected and conserved has also been characterized using Bioversity International or NBPGR descriptors. In fruit crop, 68 accessions of mango, 35 of jackfruit, 56 of karonda, 42 of avocado 71 of bael were morphologically characterised. *In situ* evaluation of wild pomegranate trees from 22 locations from Himachal Pradesh was carried out. In vegetables, six accessions of chilli, nine of cucumber, 1300 of okra,

114 of garden pea and 34 of *Dolichos* were characterized and evaluated for desirable traits. Seeds of 11 *Solanum* species with 19 accessions were established in the field and morphologically characterized using NBPGR descriptor. In flower crops, 25 genotypes of China aster were characterized as per DUS test guidelines. Besides morphological characterization, molecular characterization was also carried out. Twenty three jamun accessions from Godhra and Varanasi, were characterized using 16 SSR primers. A total of 300 genomic microsatellite markers were used for molecular characterization of 120 pomegranate accessions obtained from USDA for studying the genetic diversity. In Custard apple, molecular characterization was carried out by isolating DNA from leaves of 10 voucher samples collected from Solapur and one accession from Nilgiris, Tamil Nadu. Twenty four karonda collections were analyzed for phenols, flavonoids, FRAP, DPPH, anthocyanin etc. and 12 avocado accessions were analysed for fats and other related biochemical parameters.

Out of 39 mango hybrids (Amrapali x Vanraj) evaluated for fruit yield and quality, three hybrids (R3P19, R4P18 and R6P17) were selected. Twenty eight jamun collections were evaluated for fruit quality parameters. Accession IC-715 (seedless Jamun from Lucknow) had highest pulp to seed ratio (11.05%) with very small seeds size. In Jack fruit, three selections viz. CHESHJF-1 CHESHJF-2 CHESHJF-3 were found promising for desirable fruit characters. In vegetable crops, of 42 *Capsicum* lines screened 6 (IIHR 4598, IIHR 4593, IIHR 3915, IIHR 4600, IIHR 4608 and IIHR 3014) were identified with high cellular level of tolerance to high heat stress. Twenty ridge gourd lines were evaluated during summer for 13 yield and yield related parameters. Twenty five germplasm lines of French Bean were evaluated for yield and yield attributing traits.

Studies on ultra dry (< 3.5 – 4.5% moisture) seed storage were conducted in 21 important horticultural crops. Seeds with low moisture levels maintained original seed quality in all crops tested after 24-36 months of storage at both temperatures. Irrespective of moisture levels the seed quality was maintained under both controlled (15 °C) and ambient temperatures up to 24-36 months in eggplant, ridge gourd, onion, carrot, watermelon, bottle gourd, bitter gourd, okra, kalmegh and peas.

Crop Improvement

Ten SWEET (Sugars Will Eventually be Exported Transporters) genes were identified in cv Alphonso at fruit ripening stage from annotated mango (cv. Alphonso) scaffold data.

Two guava hybrids viz., H 13-14 and H 12-5 of the combination Purple local X Allahabad Safeda were

proposed for Institute VTIC approval. H 13-14 has been isolated for medium to big sized round fruits (180 to 220 g) with smooth shiny surface, white pulp, firm with thick outer pulp (1.2 to 1.4 cm), medium seed softness (9.0-12 kg/ cm²) with a TSS of 10.0-12.0°B suitable for both table and processing. H 12-5 has been isolated for red pulp with medium sized, round fruits (180-220 g), smooth shiny surface, having medium soft seeds (9.5 to 12.0 kg/ cm²) with good TSS (10.0 to 12.0°B), keeping quality and suitable for both table and processing. Initiation and establishment of healthy in vitro cultures of guava cv Arka Kiran was successfully accomplished after controlling the problem of phenolic exudation through use of antioxidants and PVP. Sprouting of guava cv Arka Kiran explants to the extent of 36-45% was obtained with the incorporation of putrescine in the culture medium with season playing a major role in the initiation and establishment of cultures.

Twenty one genotypes including six wild accessions of tomato were screened for resistance to South American tomato moth *Tuta absoluta* under polyhouse conditions. Wild accessions *Solanum arcarnum* LA2157, *Solanum pennellii* LA 1940 and *Solanum comeliomulleri* LA1292 were found to be good sources of resistance. Out of 55 tomato hybrids developed for fresh market, six semi-determinate F₁ hybrids viz; H-387, H-391, H-392, H-397 and H-423 were developed for open cultivation, H-391 was also found suitable for processing. Five indeterminate F₁ hybrids viz; PH-1021, PH-6321, PH-1025, H-501 and H-506 were bred for polyhouse cultivation. All the above hybrids were found promising for yield (>75tons/ha) and fruit quality attributes. An inter-specific hybrid (15 SB SB x *Solanum habrochaites* LA-1777) of tomato was confirmed as drought tolerant root stock in tomato.

Water stress adaptation through grafting in bell pepper was evaluated under field conditions. Bell-pepper (CHT3-2) was grafted on Arka Mohini (AM), Arka Gaurav (AG) and Bullet Chilli (BC). The grafted plants maintained higher leaf turgidity as indicated by less reduction in RWC and water potential. Among the grafts, CHT3-2/ AM maintained highest RWC (71-79%) and showed higher photosynthetic rate, fluorescence efficiency, better electron transport and higher activities of antioxidant enzymes compared to non-grafted plants under stress. Bacterial wilt resistance in chilli was shown to be a polygenically controlled trait and two chilli lines viz., EC769375 and EC769430 showed tolerance to *Bemisia tabaci*. Four Extant chilli varieties viz., Arka Lohit, Arka Suphal, Arka Meghana and Arka Harita were registered with PPV&FRA.

Arka Nikita, was identified and released by IIHR VTIC as a early flowering (33-36 days) okra variety which takes 49-50 days for first picking of fruits. The fruits are dark green, medium long, tender, smooth with 5 ribs, one

side petal base color purple, 3-4 narrow angle branches, yielding 21-24 t/ha in 115-120 days duration suitable for both *Kharif* and Summer season. It is first commercial geneic male sterile based F_1 hybrid from India and the world. Among 8 okra F_1 hybrids (GMS based) evaluated during summer season at (Vangalapalyam) of Guntur, GMS-OKMSH-3 was found superior for high fruit yield (21.80t/ha) with medium length and girth and also resistance to YVMV (4.5 % incidence) under natural field condition. The fruits of appeared dark green, smooth, thin, free from hairs and 5 ribs early maturing type SH-7.

A total of 340 germplasm accessions of watermelon have been artificially screened for resistance against two isolates of *Fusarium oxysporum* fsp. *niveum*. While all the commercial hybrids were susceptible to both the isolates, 19 germplasm accessions were identified to possess resistance to both isolates, most promising being IIHR-9 and EC-759804. Micro propagated triploid watermelon was grown in the open field and in polyhouse. Plants in the open field showed vulnerability to Watermelon bud necrosis virus (WBNV) and appeared better suited for protected cultivation under polyhouse conditions where plants showed good growth and flowering with controlled pollination for good fruit set and yields.

Resistant breeding for rust disease by crossing identified resistance sources is of paramount importance in garden pea. Out of 130 germplasm lines (including 12 released lines of IIHR) screened two (IIHR 13-11 and IIHR 13-18) were found resistant to rust.

Twenty advanced lines of onion were evaluated for combined resistance to purple blotch, basal rot and white rot during *Kharif* season. Three advanced lines namely PBR- 405-564, PBR-407-207 and PBR- 372-203 showed combined resistances to these diseases under field condition.

In tuberose, the hybrid IIHR-4 with double type florets, medium-tall spikes with spike length (65.0 cm), rachis length (26.0 cm), numbers of flowers (50.0) and floret diameter (5.2 cm) was found promising as cut flower. Rose hybrid IIHRR 11-2 was identified as 'Arka Savi' by VTIC of IIHR for commercial production of loose flower. The hybrid was developed by hybridisation using gametophytic selection. It is a spray category of rose belonging to floribunda group with purple pink flowers produced in bunches having high shelf life (5-6 days) and potential yield of flowers as 30 tons/acre/year. IIHRP-7 is a rose hybrid rich in total anthocyanin content (1.5 g/100 g dry weight of petals) and can be a good candidate for developing value added products.

Gerbera hybrid, IIHR 10-3 is a promising line developed through hybridization (half-sib) between IIHR10 and mixed pollen of 10 varieties followed by selection. It

produces double type flowers with yellow purple colour group, 24A, performs well under polyhouse with 50% shade net and on par with commercial varieties. Floral traits of the line are flower diameter (10.91 cm), flower stalk length (60.38 cm), flower stalk diameter (6.62 mm) and 2.96 numbers of flower/month. It has black center and is therefore a novelty in the market. Another hybrid IIHR 15-7 was developed through hybridization (half-sib) between IIHR15 and mixed pollen of 10 varieties followed by selection. It has double type with preferred white colour group

Four elite lines of velvet bean (*Mucunapruriens* var. *utilis*) viz., Arka Shubra, Arka Charaka, Arka Shukla and Arka Daksha were identified for release by VTIC based on their consistent superior performance over four years. Arka Shubra (IIHR PS 2) is a white seeded line with high seed yield, high L dopa content & yield (5.43% ; 269.67 kg/ha) with non-irritant trichomes on pods, produces white flowers on medium long rachis and matures in 180-190 days. Arka Charaka (IIHR PS 6) is a black shiny seeded line with high seed yield, high L dopa content & yield (4.80%; 200 kg/ha) and non-irritant trichomes on pods, and bears purple flowers on medium long rachis. Arka Shukla (IIHR Sel 3) is a pureline selection with white medium bold size seeds. It gives a seed yield of 3.0 to 3.5 t/ha under support, 2.0 t/ha under surface cultivation with an L dopa content & yield of 3.86%. It produces purple flowers on short rachis and pods with non-irritant trichomes and matures in 155-165 days. Arka Daksha (IIHR Sel 8) is also a pure line selection having bold black seeds with brown mottling with L-dopa content (3.72%) and L dopa yield (150.39 kg/ha). It bears purple flowers on short rachis and matures in 150 to 160 days. In *Centella asiatica* variety Prabhavi polyploidy was attempted in the shoot tips, roots and *in vitro* cultures using colchicine. Colchicine treated plant (IIHR-CA-28) was found superior to the control with respect to all quantitative and biomass characters. The dry biomass yield of treated plant was higher (357.04 kg/ha) than the control (303.63 kg/ha).

Crop Production

Of eight rootstocks, Olour was the most vigorous in influencing the fruit yield (128.7 kg/ tree) and fruit quality of Totapuri, during the eleventh orchard year. Evaluation of 10 polyembryonic rootstocks for zygotic and nucellar seedlings revealed the emergence of 25% zygotic seedlings in Kensington and 100% in Peach. These rootstocks were susceptible to chloride toxicity above 3 dS/m. Optimum soil volume wetting (70%) and higher soil moisture (12.8%) was achieved in 6m x 6 m spacing of an 18 years old mango (variety Raspuri) for the second year, with higher fruit yield (33.7 kg/plant, 41.27 kg/ha.mm); however water use efficiency was higher at

30% soil volume wetting (57.58 kg/ha.mm).

Study on the effect of pollen and stigma metabolites on bearing revealed that low fruit setting variety Alphonso recorded lower spermine, salicylic acid and amino acids in the stigma, and lower spermidine in pollens. Alphonso mango trees sprayed with an environmentally safe formulation developed at ICAR-IIHR showed increase in flowering, due to the mobilization of starch, total and soluble sugars in leaves and bark and GA3:ABA ratio in leaves, and altered the hormonal balance (GA:ABA) in favor of flower induction.

The efficacy of training system assessed in mango for mango var., Arka Neelachal Kesari at CHES, Bhubaneswar, for the second year showed minimum light interception (55.7), tree volume, leaf area index (2.96), better light distribution inside the canopy and maximum intensity of productive shoots (66.4), number of fruits (84.6) and fruit yield (15.7 kg/plant) under the 'Y-shaped trellis system' (YSTS). To harness the potential of high density planting system in mango, maximum mango yield was obtained by regulating 'plant canopy architecture' through the 3 Ps – practicing, 'pruning' and using 'paclobutrazol' which substantially increased yield and quality of Alphonso mangoes. The benefit–cost ratio was substantially high (>2.3) in this method despite high cost of cultivation.

It was observed that jelly seed incidence in mango was associated with the accumulation of heat unit. In Arka Neelachal Kesari, an extra early variety, jelly seed usually developed when heat unit exceeded 800 degree days and fruit was at advanced ripening stage. Harvesting of mango fruit at early maturity stage i.e. when pulp colour turns light yellow, minimised the incidence of disorder significantly.

Pineapple (variety Queen) was found to be a suitable intercrop in bearing low density mango plantation (100 plants/ ha) at CHES, Bhubaneswar. Good quality fruits were obtained from January–May. By covering 50% area of mango plantation under pineapple cultivation, 1.8-2.0 lakh/ ha can be earned from fruits and about 1.00–1.20 lakh from sucker and slips. There was a subsequent increase in income in next two years as the cost of cultivation was reduced substantially.

Enriched coir pith (10 cm height) and polythene mulching in the basins of guava trees conserved significantly higher soil moisture *in situ* (55 and 33%), and higher fruit yield (31.8 and 39.8%) respectively, compared to no mulching. Fruit size was higher with the placement of coconut husk (208 g) and polythene mulching (183 g). The B:C ratio (4.16) was thus higher in these treatments.

In the hot, humid climate of CHES, Bhubaneswar, branch bending during both summer and winter, in guava,

contained the shoot growth and improved flushing, flowering and crop yield. The number of shoots, flowering intensity, yield and fruit quality was optimum in January branch bending in *Ambe Bahar* while May branch bending was effective in *Mrig Bahar*.

The problem of delayed graft compatibility in Red Globe grapes grafted on Dogridge rootstock, was overcome by treating preconditioned scions with 100 ppm BAP, resulting in higher graft success of 75% (supported by anatomical studies) in 90 days of grafting compared to control (45%). This technology will help growers to achieve uniform plant growth in the first year itself so that other cultural operations can be taken up in subsequent years.

In a third year study on canopy management practices on bunch and berry quality parameters of Red Globe and Crimson Seedless grapes, berry thinning at 8-10 mm stage + ethrel application + basal leaf removal at veraison stage produced good quality bunch with good berry diameter and berry length, and less compact bunches compared to other treatments.

Tissue cultured plants of pomegranate cv. Bagwa had higher number of hermaphrodite flowers (261.60), fruit weight (192.70 g), fruit length (6.54 cm), fruit width (6.80 cm), fruit volume (167.55 ml), number of fruits/plant (169.00) and percentage of fruit set (63.41%) with highest yield (32.88 kg /plant) compared to grafted and air layered plants, for the third year.

Variations in growth and gas exchange characteristics in one year old custard apple Arka Sahan grafted on other spp. and Arka Sahan hybrid, revealed higher tree height in Arka Sahan grafted on *A. muricata* (90.34 cm). The diameter of rootstock and graft union was higher in *A. glabra* L. rootstock, photosynthesis Rate (A) was maximum in Arka Sahan grafted on *A. reticulata* (6.36 $\mu\text{mol m}^{-2} \text{s}^{-1}$). Early intense pruning of Arka Sahan annona trees - pruning all the previous season's shoots to half their length during first week of November - had a significant favorable influence on earliness of cropping, higher fruit yield and fruit quality. Low fruit setting in Arka Sahan compared to *A. Squamosa* (cv. Balanagar) was explained by the higher polyamines in pollen and stigma of *A. Squamosa*; stigma was also high in salicylic acid. Pollen of Arka Sahan had higher sugars, amino acids and hormone profiles.

Field experiments on partial root zone drying irrigation in papaya indicated that for the same level of evaporation replenishment, shifting of irrigation recorded lower fruit cavity index (0.25) compared to fixed laterals (0.34). But, significantly higher water productivity (9.27 kg/ m³) was obtained by scheduling the irrigation at 40% evaporation replenishment through shifting of laterals at fortnightly

intervals with substantial saving of water (1118 m³/ ha).

Arka Prabhat and CO-4 cultivars of papaya are more tolerant to salinity and drought stress. Root anatomy under drought stress in Arka Surya, Arka Prabhat, Red Lady and CO-4, showed distinct contraction in vascular system as evident from reductions in xylem bundle thickness and cortex cross sectional area. Cultivars CO-4 and Arka Prabhat showed up-regulation of 17, 26 and 55 kDa proteins and down-regulation of 130 kDa protein under stress. Pre-treatment of Arka Surya and CO-4 papaya varieties with *Bacillus amyloliquefaciens*, was effective in ameliorating drought stress in papaya.

An experiment on phenophase based nutrient scheduling through drip fertigation was conducted during *khariif* 2017, in tomato. The fertigation treatments increased yield by 8.86 to 39.58% and fertilizer use efficiency in the range of 165–211 kg/ kg compared to soil application (151 kg/ kg).

A fertigation trial conducted with ten treatments in three hybrids of chilli - Arka Meghana, Arka Harita and Arka Khyati showed that bi-weekly application of 100% RDF of NPK (125:100:125 kg/ ha) through water soluble fertilizers maximized yield (31.00, 29.88 and 28.15 tons/ ha).

Bi weekly application of 100% RDF of NPK (150:125:150 kg/ ha) through water soluble fertilizers resulted in higher yield in brinjal hybrid Arka Anand (51.72 t/ ha) and Arka Harshita (41.89 t/ ha). In comparison, soil application of nutrients gave low yields in both the cultivars. .

In organic farming trials, integrated nutrient management with 100% RDF (25:60:50 kg N:P₂O₅:K₂O/ ha and 25 tons of FYM) resulted in higher yield of bottle gourd, garden pea and dolichos. High temperature stress reduced photosystem II (PSII) efficiency by 7-23% in pea genotypes. Arka Sampoorana and Oregon Sugar maintained higher PSII efficiency.

Nutrient requirement in rose was quantified under polyhouse and open conditions based on biomass and nutrient removal pattern resulting in reduction of P dose by 37-69% over present recommendation of 32 g P₂O₅/ m². The growth and yield was better at lower doses of nutrients (64-67 flower stalks/ m²) than at higher level (57 flower stalks/ m²). In open condition, performance of cut flower to two irrigation levels (0.75 and 1.0 Ep) and three nutrition levels was positive in terms of flower stalk yield (29-33/ m²/ month) and length. Irrespective of treatments, seasonal variability in flower diameter was noticed both in polyhouse and open field with lesser diameter of 2-3 cm during summer months than in winter. In rose, nutrient use efficiency in cut flower cultivars was quantified as 32% for N, 16% for P and 30% for K in

polyhouse condition.

Two varieties of mandukaparni (Arka Divya and Arka Prabhavi) were evaluated under open and 50% shade with graded doses of nitrogen through FYM and RDF. Arka Divya produced maximum fresh herbage yield (cumulative of four harvests taken at 60 days interval) of 21,777 kg/ ha with application of recommended FYM (5 ton/ ha) + RDF (100:60:60 NPK kg/ ha. The same treatment also produced maximum fresh herbage yield of 13,830 kg/ ha under 50% shade.

Grafting in tomato increased the dry weight of plants by nearly 66% compared to ungrafted plant. Minerals constituted 8.69% of dry weight in grafted and 6.98% in ungrafted plants. At harvest, there was an increase of 20% in dry matter accumulation of grafted plants compared to ungrafted plants. Specialty fertilizers in fertigation have not shown any significant effect on tomato growth. Height of tomato was maximum when N and K were provided through specialty fertilizers, followed by the treatment where N and K were given through conventional fertilizers and P as conventional fertilizers in basal application.

Highest yield was recorded in fertigation with water soluble fertilizers @100% RDF and polyethylene mulching (13.08 t/ ha) followed by fertigation with water soluble fertilizers @75% RDF and polyethylene mulching (11.10 t/ ha) in marigold cv.Arka Agni. Among irrigation treatments, 1.0 ER resulted in highest N, P and K removal by plants at harvest and among fertigation and mulching treatments nutrient uptake by plant was maximum in fertigation with WSF @100% RDF and mulching.

Crop Protection

An IIHR developed oil formulation of *M. anisopliae* (0.5ml/L) which gave 85.2 % reduction in hopper and 74% reduction in thrips population in mango has been found superior over use of different formulations of entomopathogens. Multilocus gene sequence analysis revealed that *C. siamense* was responsible for both pre as well as post-harvest anthracnose rot in mango. A chemical control method for the same has been standardized.

The distribution of invasive fruit borer, *Citripestis eutrapphera* on mango was studied in collaboration with centres of AICRP on Fruits and distribution map was prepared. The borer, which was earlier reported to be confined to Andaman and Nicobar islands has spread to several mango belts in the country since its first report in 2013 in the mainland. A citrus rootstock, Alemow, was found resistant against both species of *Phytophthora* viz. *Phytophthora nicotianae* and *Phytophthora palmivora* at CHES Chettalli, with low disease severity.

A disease prediction model for grape rust disease in

Bangalore District has been developed. The correlation coefficient (r) between mean disease severity indices and the weather parameters has indicated that severity of rust disease was positively correlated with maximum temperature, relative humidity during evening, rainfall and number of rainy days. In the case of high severity about 89.8% variability in per cent disease incidence followed the equation of $Y = -39.02 + 0.148 \text{ Max. temp.} + 1.164 \text{ Min. temp.} + 3.16 \text{ Rainfall}$ where Y = Percent disease Index (PDI). A significant positive correlation between the aphid population and maximum temperature and relative humidity in the morning hours influenced the incidence and spread of PRSV in papaya. Integrated disease management (IDM) modules comprising of border cropping with castor and sesbania, silver mulching and spraying of TDS1 (4.0 ml/L) and Viroguard (2.0 ml/L) along with neem oil significantly reduced virus spread and increased the yield.

Soil application of FYM enriched with *Bacillus amyloliquefaciens* or *B. megaterium* at 5 kg/plant before planting and further application of neem cake enriched with bioagents at 200 g/plant at six month intervals was found to reduce population of *Meloidogyne incognita* by 55.8 - 57.3% in soil and by 71.42% in roots of pomegranate. Ceratoplatinin, a protein of low molecular weight secreted by pomegranate wilt pathogen, *Ceratocystis fimbriata* was isolated and partially purified to prove that complete drying of the pomegranate trees infected by *C. fimbriata* is due to this toxin production. This method can be employed to screen seedlings, root stock etc. for pomegranate wilt tolerance. A total of 286 olfactory related genes could be identified in the antennal transcriptome of fruit piercing moth (FPM), *Eudocima materna* in pomegranate in addition to chemosensory, sensory neuron and ionotropic receptors.

Two fungal and one bacterial strain were isolated from the mid gut of wax moth *Galleria melonella* of which the fungal isolate-1 and *Bacillus pumilus* were found promising to be used for mealybug management in annona.

Tuta absoluta is a new invasive and highly destructive insect pest in tomato. Screening of tomato accessions confirmed wild accessions *S. arcanum* (LA2157); *S. pennellii* (LA 1940) and *S. corneliomulleri* (LA1292) as good source of resistance against *T. absoluta*. In the field, six sprays of silica (Potassium Silicate) @ 4 ml/l at weekly interval significantly reduced (about 70%) live mines of *T. absoluta*. Among insecticides, cyantraniliprole (10.26% OD @ 1.8 ml/L), chlorantraniliprole (18.5% SC @ 0.3 ml/L) and indoxacarb (14.5% SC @ 1 ml/L) were effective for the management *Tuta absoluta* with 2.9, 2.1 and 5.1 per cent fruit damage, respectively, compared to 35.8 per cent damage in control. Natural infection of *T.*

absoluta with an entomopathogenic fungus, *Metarhizium anisopliae* was observed to an extent of 35 per cent. Severity of bacterial leaf spot caused by *Xanthomonas axonopodis* pv. Vesicatoria in tomato was highest (50%) was in Kolar District and lowest in Chitradurga District of Karnataka. Synthetic insecticide use could however inhibit up to 60 per cent of the fungus growth.

The residues of forchlorfenuron in grapes degraded with the half-life of 8 days and pre-harvest interval calculated based on the maximum residue limit (MRL) of 0.01 mg/kg was 36.3 days and grapes were free from residues of forchlorfenuron at harvest. Residues of fosetyl aluminium on grapes persisted beyond 30 days and since it has a high MRL of 100mg/kg the PHI was 1 day only. A herbal veggie wash has been developed for dislodging pesticide residues from surfaces of fruits and vegetables. A combination of two herbal extracts in the proportion of 3:1, the 'veggi wash' was found to be superior to all other treatments including a commercial veggie wash product and resulting in up to 76% dislodging of surface residues which was up to 37 % higher than washing with water alone.

Crop utilization and farm mechanization

A process was developed for making dehydrated mango slices containing low sugar by vacuum infusion of ripe juice of Amrapali and Raspuri mango varieties into Totapuri mango slices. The infused dried mango slices were superior in colour and flavour than untreated control, carotenoid content of 1765 µg /100g as compared to 335 µg/100g in osmo treated samples.

A probiotic mango RTS beverage prepared using the screened *Lactobacillus helveticus* strain showed an average sensory score of 6.8 on a scale of 9 after storage for four months under refrigerated conditions. There was a slight increase in acidity and decrease in sugar content during storage. A cell population of 4×10^8 cells/mL could be maintained during the storage period.

A mango bar prepared incorporating moringa leaf powder at different concentrations had significantly higher carotenoids (7.60 mg/100g) and polyphenols (2.32 mg GAE/g) compared to control after 90 days of storage. It exhibited similar organoleptic scores as that of control and was found to be safe with respect to aerobic plate count, yeast, mold and coliforms after 90 days of storage. Jackfruit seed powder fortified chapathi (Indian bread) at 15% substitution showed reduction in total sugars by 23%, crude fibre increased by 600%, flavonoids increased by 30% and anthocyanins increased by 150%. In jackfruit seed powder (JFSP) fortified biscuits, refined wheat flour (maida) in biscuits could be substituted by upto 20% without affecting its sensory quality.

Protocols for extending the shelf life of minimally processed fenugreek leaves and microgreens were standardized. In both cases, use of the optimized protocol resulted in an additional shelf life of 13 days during storage at 8 °C, compared to control samples.

Tamarind seed powder was added to biodegradable fruit tray cushions made of recycled paper and banana pseudostem to improve strength and this was tested as packing guava in CFB boxes and transported by road for long distance. Polyethylene package (conventional method) resulted in higher per cent physiological loss in weight (PLW) of 6.2 in stem below the tuberos flower and higher fresh weight of flower head resulted in stem breakage/bending. A novel packing bag was developed and tuberos flowers packed in these had lesser PLW (3.22%) and spoilage (25.64 %) as compared to control (PLW-7.95% and spoilage- 54.35%), two days after road transportation. Marketable quality of tuberos flowers in these newly developed bags remained good for 2 days as compared to a single day in conventional bags.

A power operated onion de-topper was designed and developed for de-topping of leaves from the harvested onions. A portray dibbler cum vacuum seeder was developed to sow single seed in plug tray of 50 and 98 cells for growing nursery seedlings. The capacity of the machine is ~100 protrays/h which is extremely useful for vegetable nurseries. A fruit and vegetable vending van consisting of evaporating, cooling and misting systems for providing higher humidity required to maintain the moisture in fresh fruits and vegetables even under normal ambient conditions was fabricated out of SS 304 with 30 - 50 mm PUF insulation. Food grade plastic crates are used to store and handle fruits and vegetables. Arka High Humidity storage boxes designed and developed by ICAR-IIHR, Bengaluru are also included in the van for storage of green leafy vegetables. The vending van structure is mounted on the prime mover TATA Ace HT diesel operated vehicle.

Social Sciences

Extent of spread, pattern of adoption and economic benefits due to adoption of popular IIHR technology 'Arka banana special' distributed through IIHR's licensees since 2009 was evaluated. The cumulative production of this technology by all the licensees was 201.6 tons, which covered 47000 acres and 32000 farmers across growing regions. Similarly economic impact analysis of another popular technology, Arka Microbial Consortium licensed to 12 clients showed that during 2013-2017, 376 tons was produced, 83,000 acres area was covered and 46,000 farmers used the produce. Use of AMC on pomegranate

helped farmers in reducing the cultivation costs by 40% and helped increase yield up to 33%. In pepper, cost of cultivation was reduced by 14% while yield increased by 22%. A score card for evaluating technologies and feed-back from the licensees was developed based on the concept of 'Competitive Performance Matrix'.

A robust ANOVA approach methodology was suggested to deal with high CV in perennial crop experimental data of Totapuri rootstock trials. In order to analyse experimental data having aberrant replication values in one or more treatments under comparison, without deleting the same using robust ANOVA approach in China Aster was suggested. This significantly reduced probability of type-I error and precision gained was in the range of 42.2 % to 55.7 %. The reduction in error sum of squares of 7.50% to 29.7% across traits was also observed.

Two mobile applications were developed for tomato cultivation and its crop management and onion crop production aspects respectively. So far more than 12500 users downloaded the tomato app across the country. Two decision support system (DSS) on guava and grapes were developed for cultivation and crop management. The applications were developed in windows platform with GUI using HTML and CSS scripting languages. An interactive query window through which farmers can get answers for their queries on guava cultivation has also been included.

A desktop windows based application for collection of germplasm passport information by a hand-held device (smart phone/ tablet) has been developed. Data can be captured directly using the desktop software or an Android or Windows mobile device.

A study listed out factors affecting spread of ICAR-IIHR technologies based on survey among farmers, entrepreneurs, officers, executives, marketing agencies, researchers etc. A study on communication behavior of Arka Rakshak Growers was conducted in 5 states based on proportionate random sampling in Mizoram, Maharashtra, Odisha, Uttar Pradesh, Kerala. A strategic communication model was suggested based on the findings of the study.

A study on effectiveness of FPOs based on perception of producer members towards overall performance indicators showed that there is need for FPOs to concentrate on elimination of political intervention, opportunity for participation in decision making, selection/ election, transparency in financial transactions, adhering to rules, ways of raising funds, fixing the reserve funds, sharing the profit and dovetailing of government schemes.

2. Introduction

The ICAR-Indian Institute of Horticultural Research, an ISO 9001:2008 certified organization is a premier Institute conducting basic, strategic, anticipatory and applied research on all aspects of fruits, vegetables, ornamentals, medicinal and aromatic plants and mushrooms. The Institute was the first horticultural research Institute in the country established by the Indian Council of Agricultural Research (ICAR), New Delhi on September 05, 1967 which was initially established at the ICAR headquarters, New Delhi and subsequently shifted to Bengaluru in Karnataka on February 01, 1968. Dr. G.S. Randhawa was the Founder Director, whose vision and dynamism helped the Institute grow rapidly. The Institute took over the erstwhile National Hortorium of the government of Karnataka spread over an area of 24.7 ha at Hesaraghatta and later on acquired an additional 238 ha of land from the surrounding village of Ivarkandapura. The Institute expanded the ambit of its research activities to the length and breadth of the country by establishing experimental stations at Lucknow, Nagpur, Ranchi, Godhra, Chettalli and Gonikoppal. Over the years, the experimental stations at Lucknow, Nagpur, Ranchi, and Godhra have grown in size and have attained the status of independent Institutes. As of today, the IIHR, Bengaluru has three Central Horticultural Experiment Stations at Bhubaneswar in Odisha and Chettalli and Hirehalli in Karnataka and two Krishi Vigyan Kendras located at Gonikoppal and Hirehalli. The Institute houses the Project Coordinating Unit of All India Coordinated Research Project on Fruits at its main campus.

Mandate

- ◆ To undertake basic and applied research for developing strategies to enhance productivity and utilization of tropical and sub-tropical horticulture crops viz., fruits, vegetables, ornamentals, medicinal and aromatic plants and mushrooms.
- ◆ To serve as a repository of scientific information relevant to horticulture.
- ◆ To act as a center for training for up gradation of scientific manpower in modern technologies for horticulture production and
- ◆ To collaborate with national and international agencies in achieving the above objectives.

Mission

The mission of the Institute is to undertake research, education and extension in horticultural crops for enhancing productivity, sustainability and quality to achieve food, nutritional and livelihood security. Towards

this end, the IIHR, Bengaluru has been carrying out research on fruits, vegetables ornamental, medicinal and aromatic plants and mushrooms.

Vision

The Vision of the Institute has been defined as “Technology-led, demand-driven and need-based sustainable horticulture for attaining food and nutritional security, better livelihood options and ultimately, economic development”. Accordingly, the research programs of the Institute have been planned with a vision of meeting the challenges ahead. New technologies are developed to help farmers double their income.

Objectives

To achieve the vision of the Institute with a mission mode approach, the following broad objectives have been set.

- ◆ Increasing productivity and quality of horticultural crops through improvement.
- ◆ Enhancing productivity and quality of horticulture crops through sustainable integrated crop production practices.
- ◆ Dissemination, popularization, adoption, refinement and impact assessment of IIHR technologies.

Main Station, Hesaraghatta, Bengaluru

The main station is located at Hesaraghatta, 25 kms towards north of Bengaluru city. The institute has laboratory complex, experimental farms, administrative block and staff quarters located at Hesaraghatta campus spread over 263 ha land. Recently the Institute has also taken over 24 acres of land of IVRI at Yelahanka, Bengaluru and also about 2 acres of land in UHS, Bengaluru campus.

Growth

The physical growth of the Institute can be viewed in two phases. In the initial years upto 1990, wherein emphasis was laid on development of land and infrastructure. The blueprint of the entire farm area for carrying out experimental trials and laboratories for research and administrative office buildings was prepared. The entire arable land was divided into well-defined experimental blocks for carrying out field experiments and independent laboratory buildings for all the major scientific divisions were built. After 1990, stress has been laid on developing state-of-the-art facilities for basic and applied research. Currently, the research activities are being carried out by 11 crop divisions viz., Divisions of Fruit Crops, Vegetable Crops, Floriculture and Medicinal Crops, Post-Harvest Technology and Agricultural Engineering, Plant

Pathology, Entomology and Nematology, Soil Science and Agricultural Chemistry, Plant Physiology and Biochemistry, Plant Genetic Resources, Biotechnology and Social Sciences with more than 65 purpose oriented laboratories having state of art equipments like electron microscope, ultra-centrifuge, LC-MS/MS, GC-MS/MS, ICP-OES, HPLC, GLC, SFE, AAS, Rapid microbial identification systems, RT-PCR, *etc.*, field facilities such as, poly houses, net houses, growth chambers, mist chambers, Gamma chamber, temperature gradient chambers and phenomics facility. Facilities like, cold storage chambers, gene banks, seed processing and nursery units and communication channels like, local area network with video conferencing facilities, *etc.* are available. The Institute has also created cryopreservation facilities for the long-term preservation of germplasm of various crops. A Referral laboratory for food safety has been established in the year 2017 for analysis and certification of food contaminants in stakeholder's samples. Apart from this, the Institute houses an ultra-modern library, committee rooms, auditorium, food court, training hostel, bank, post office, dispensary, essential quarters and facilities for the students for research in horticultural sciences.

Central Horticultural Experiment Station (CHES), Chettalli, Kodagu, Karnataka

The Station was established in 1972 at Chettalli with Citrus Experiment Sub-station at Gonikoppal. In the year 1992, the Citrus Experiment Sub-station at Gonikoppal was converted into a full-fledged KVK and all the research work along with the research laboratories of the erstwhile substation were shifted to Chettalli. The station occupies an area of 92 ha.

The mandated crop of the centre is Coorg mandarin with major emphasis on citrus die-back disease. The Station also works on underutilized fruit crops like, pummello, avocado, mangosteen, karonda, rambutan *etc.* The Station has a well-developed nursery unit for production and distribution of true-to-type disease-free citrus and other planting materials, *Trichoderma* cultures. Transfer of Technology under the Tribal Sub-plan project is also being taken up at the Station.

Central Horticultural Experiment Station (CHES), Bhubaneswar, Odisha

The Station was established on November 6, 1992 to cater to the research and development needs in horticulture for the tribal and coastal belts of Odisha and the adjoining region. Transfer of Technology in NEH region and Tribal Sub plan is also being taken up by the Station. The Station is spread over an area of 40 ha housing a full-fledged laboratory and office building and the experimental farm. It has strong unit production of disease free planting

materials of fruit crops for distribution to the farmers of Eastern region of the country.

Central Horticultural Experiment Station (CHES), Hirehalli, Tumkuru, Karnataka

The regional station of Central Plantation Crops Research Institute, Kasargod at Hirehalli, Tumkuru district, Karnataka was transferred to the IIHR, Bengaluru on February 01, 2004 and renamed as Central Horticultural Experiment Station, Hirehalli. Presently the Station has a total area of 68 acres involved in breeder seed and foundation seed production of IIHR released vegetable varieties and research work on fruit crops, particularly maintenance of jackfruit germplasm, breeding work on betelvine and a few flower crops in collaboration with ICAR-IIHR, Hesaraghatta, Bengaluru. During 2013 the Station acquired additional 26 acres of adjoining area for research purpose.

Krishi Vigyan Kendra (KVK), Hirehalli, Tumkuru, Karnataka

KVK, Hirehalli was sanctioned in the year 2009. Apart from the activities of a Krishi Vigyan Kendra, it has taken up popularization of IIHR developed technologies and production and distribution of seeds and planting material and technological products developed by IIHR, Hesaraghatta, Bengaluru

Krishi Vigyan Kendra (KVK), Gonikoppal, Kodagu, Karnataka

The KVK, situated in Kodagu district of Karnataka was established in the year 1954 by the Karnataka State Govt as Citrus Research Station and was transferred to IIHR, Bengaluru on February 1, 1972 under CHES, Chettalli as Sub-station with the objective of investigating the nature and causes of citrus die-back disease in Kodagu and nearby areas till 1991. In 1992, the Citrus Research Sub-station was converted into a full-fledged KVK. The Kendra has an area of 17.5 ha.

AICRP on Fruits

The Institute houses the Project Coordinating Cell of All India Coordinated Research Project (AICRP) on Fruits. The AICRP on Tropical Fruits and Sub-Tropical Fruits were amalgamated and named as AICRP on Fruits with effect from August 21, 2013. The project has the objectives of collection, conservation and evaluation of germplasm, along with standardization of production technologies, viz., rootstocks, population density, nutrition and water management and evolution of cost-effective, integrated insect pest and disease management practices under different agro-climatic conditions in citrus, grapes, guava, litchi jackfruit, mango, papaya and sapota. There are 11 centres throughout the country working on banana,

10 on citrus, 5 on grapes, 11 on guava, 6 each on litchi and jackfruit, 12 on mango, 6 on papaya and 5 on sapota. At present, there are 39 centres including 27 SAU-based centres, 10 ICAR-Institute-based centres, one CAU-based centre and one Private unit.

The Main station at Hesaraghatta, Bengaluru, under the leadership of the Director, ICAR-IIHR, implements and monitors all the activities of the Institute. Considering the importance given to horticultural research and development in the country, IIHR has the mandate to serve various stake-holders of horticultural sector and for carrying out this mandate the Institute has established various service-oriented units as follows:

Prioritization, Monitoring and Evaluation Cell (PME)

The Prioritization, Monitoring and Evaluation Cell (PME) of the Institute is an apex technical body that assists the Director in evaluation, monitoring, management and coordination of all the ongoing as well as externally aided research projects. The PME also oversees all the activities of the Institute and makes appropriate recommendations to the Director for the smooth functioning.

Institute Technology Management Unit (ITMU) and Consultancy and Processing Committee including Horti-business incubation facility

ICAR has adopted its IPR policy in 2006 and set up technology transfer offices known as Institute Technology Management Units (ITMUs). The technologies developed by the Institute are being commercialized through ITMU. 'ARKA', the trade mark for the varieties/hybrids and technologies developed by the Institute have been registered. All the varieties /hybrids and technologies recommended by the Institute Variety and Technologies' Identification Committee are handled by the ITMU for commercialization. Besides, it also looks after consultancy, contract research, contract services etc. apart from addressing intellectual property related matters of the Institute like, IP protection, patents, technology protection protocols, licensing, and related legal issues. The Institute has established Horticultural Technology Management-Business Planning and Development (HTM-BPD) unit to assist, develop, and strengthen the entrepreneurs, start-ups, technology based horti-business ventures for commercialization of horticultural technologies. Currently, the Institute Technology Management Unit at ICAR-IIHR has been upgraded to Zonal Technology Management Centre (ZTMC) of the South Indian Horticulture, including 11 sister ICAR institutes of horticultural sciences as members. The Horti business incubation facility is also being operationalized through funds from ICAR's Intellectual Property and Technology Management unit.

Agricultural Technology Information Centre (ATIC)

The Agricultural Technology Information Centre (ATIC) serves as a single window agency for dissemination of information on the technologies developed by the Institute. The technological products, extension pamphlets and technical publications of the Institute are distributed to farmers, students and interested general public through this centre.

Agricultural Knowledge Management Unit (AKMU)

Agricultural Knowledge Management Unit (formerly known as ARIS Cell) implements and manages research information and e-governance. The AKMU has also created video conferencing facilities. The Website of the Institute is also developed, hosted and managed by AKMU.

Regional Centre (South), ICAR-National Agricultural Education Accreditation Board (NAEAB)

In order to hasten the process of accreditation of agricultural education in SAUs/ Agricultural Education Institutions, ICAR established four Regional Centres of ICAR-National Agricultural Education Accreditation Board (NAEAB) in India. The Regional Centre for South covering the states of Karnataka, Andhra Pradesh, Telangana, Kerala, Tamil Nadu and Pondicherry has been established at ICAR-IIHR, Bengaluru with effect from February 2015 with a Regional Coordinator and an Honorary Regional Advisor to facilitate and liaise between the SAUs/Agricultural Education Institutes and SMD of Education, ICAR, New Delhi.

Vigilance Cell

A Vigilance Cell has been created at the Institute during February 2015. The Vigilance Cell under the Vigilance Officer and the Vigilance Team constituted at the Institute level maintain a close watch on the functioning and performance of the Institute at different levels from vigilance point of view, review periodically and modify the working procedures so as to minimize the scope of malpractices and harassment to public. The Vigilance Cell assists and guides the Director in all administrative, financial and vigilance matters for the overall improvement of the organization. The Cell website link and mail ID have been uploaded in the Institute website for the benefit of staff members. Efforts are made to create awareness among all the staff of the Institute about functioning of the Vigilance Cell and vigilance matters from time to time and Preventive Vigilance Mechanism has been implemented.

P. G. Education

The Institute has been recognized as Post Graduate Research Centre by more than 17 Agricultural/Horticultural and

other universities in which the students can register for doctoral studies with the concerned university (including master's degree studies in horticultural sciences with UAS, Bengaluru and UHS, Bagalkot) and continue their research work at IIHR, Bengaluru under the guidance of the scientists of the Institute. The Institute also offers short term training in selected disciplines to the needy clients. Apart from this, the Division of Extension and Training conducts regular training programs for farmers and development personnel of State Governments on various advanced technologies in horticultural sector.

A Post Graduate School in Horticultural Sciences has been established by signing an MoU with IARI, New Delhi for initiation of Ph.D. Program as an Outreach program of PG School, IARI, New Delhi during August 2014. The Institute is now offering Ph.D. program in the disciplines of Fruit Science, Vegetable Science, Floriculture & Landscape Architecture and Post-Harvest Technology.

Library

Due to technological developments, the availability and access of information has changed the complexion of information seekers. Of late, the trend is on accessing the e-contents rather than the browsing of physical documents. The Library has a total collection of 28489 documents: 11549 books, 16135 back volumes, 143 theses, 114 reports, 48 bulletins and 261 other documents & proceedings, 239 newsletters, which are received on gratis or complimentary this year. A good number of Indian scholarly journals are subscribed keeping in view the objective of the Institute to meet the information requirements of the research staff. Presently, the Institute subscribes 63 Indian Journals for its Main station, Regional Stations and KVK libraries. Apart from this, 10 Indian journals and 11 Foreign journals are received on gratis to supplement the information needs. Using the infrastructure developed in the Library continued to provide the access of library services through LAN and internet. A list of research articles published by our Institute Scientists since 1969 to 2010 was digitized. To supplement the research activities further, online databases have been set up and on-line full text articles of journals are also made accessible through "Open J-Gate plus" – a journal database with journals published by international publishers, Indian journals, ICAR & SAU libraries subscribed journals.

Accomplishments of ICAR-IIHR

Research work carried out during the last four decades has paid rich dividends in terms of release of 258 varieties and hybrids and development of a number of sustainable production, protection and post-harvest management technologies. The Institute maintains a

wealth of varied collection of germplasm (11427) in various horticultural crops reflecting considerable genetic biodiversity including potential sources of resistance to various biotic and abiotic stresses and also those with high nutritional, health care and medicinal values and quality traits. The main station at Hesaraghatta, Bengaluru holds 9685 germplasm comprising of 1642 in fruits, 6884 in vegetables, 621 in ornamentals and 505 in medicinal plants apart from 33 in mushroom and betel vine. CHES, Chettalli, CHES, Bhubaneswar and CHES, Hirehalli have a collection of 759, 929 and 54 germplasm in fruits and vegetables respectively. The Institute has the largest ex situ field gene bank of mango comprising of 120 germplasm, besides *ex situ* field gene bank of over 125 collections of herbal and RET medicinal plants including tree species. Morphological characterization, molecular characterization and DNA finger printing have been carried out for majority of the accessions. About 600 genotypes including indigenous and exotic accessions of fruits, vegetable and ornamental crops have been evaluated for resistance to major insect pest and diseases and sources of resistance have been identified. The Institute has developed and standardized technologies for in vitro conservation of fruits and medicinal species, cryo preservation of pollen apart from low cost techniques for storage of vegetable seed germplasm. A pollen cryobank was established for the first time in the country at the Institute in 1983 in which nearly 675 collections of various horticultural crops are cryo preserved.

The Institute has so far developed over 260 improved varieties and hybrids of fruit, vegetable, ornamental, medicinal, aromatic crops and mushroom, of which many have been released at the national/state level for commercial cultivation. In fruit crops, the Institute has developed 33 varieties; three in papaya, seven in mango, five in guava, 11 in grapes, one each in annona, ber, litchi, lime and passion fruit and two in pomegranate. Recently released high yielding pink fleshed Arka Prabhat papaya hybrid, Arka Kiran, a red fleshed hybrid guava and Arka Sahan, a hybrid of annona with large globules and less seeds hold excellent promise and are gaining in popularity within the country and abroad.

In vegetable crops, the Institute has so far developed and released 104 high yielding open pollinated varieties and 23 F1 hybrids of vegetable crops viz., tomato, brinjal, chilli, capsicum, water-melon, muskmelon, long melon, round melon, cucumber, pumpkin, bush squash, bottle gourd, bitter gourd, ridge gourd, pointed gourd, spine gourd, Ivey gourd, teasel gourd, okra, French bean, cowpea, cluster bean, dolichos bean, garden pea, radish, carrot, onion, amaranth, palak, cauliflower, coriander etc resistant to pests and diseases for commercial cultivation. Varieties like Arka Manik of Watermelon – triple resistant

to pests and diseases, Arka Anamika of okra resistant to Yellow Vein Mosaic Virus and Arka Komala, a high yielding French bean have spread throughout the length and breadth of the country. High yielding varieties of tomato, Arka Vikas, Arka Kalyan and Arka Niketan of onion have made significant impacts. In recent years, the Institute has released the first triple disease resistant tomato hybrid Arka Rakshak and Arka Samrat with combined resistance to Tomato Leaf Curl Virus and bacterial wilt and early blight, chilli hybrid Arka Meghana, tolerant to thrips and viruses, Arka Harita and Arka Suphal of chilli tolerant to powdery mildew, high yielding male sterility based chilli hybrid Arka Swetha, bacterial wilt resistant brinjal hybrid Arka Anand, high yielding onion hybrids based on male sterility Arka Lalima and Arka Kirthiman, high yielding string-less varieties of French bean, Arka Suvidha and Arka Anoop; are a few released varieties which have made significant impact on production and enhanced economic gains.

In the area of ornamental crops, the Institute has evolved 101 improved varieties having high yield, attractive colour, novelty and improved shelf life in gladiolus, chrysanthemum, bougainvillea, hibiscus, tuberose, rose, China aster, carnation, gerbera, crossandra and centella. Many of the gladiolus varieties, China aster varieties - Poornima, Kamini, Viletcushion and Shashank, The tube rose cultivar Arka Prajwal has become highly popular among farmers in eastern as well as other parts of the country. Crossandra varieties –Arka Kanana and Arka Ambara have also gained popularity among the farmers.

In the field of medicinal and aromatic plants, the Institute has developed ten varieties, two in *Dioscorea floribunda* and *Solanum viarum* and 6 varieties in *Mucuna pruriens* having higher content of active principles and three varieties of aromatic plants, jasmine having higher percentage of essential oil.

In the area of mushrooms, Pink oyster mushroom, *Pleurotus djamor* (Western ghats), wild strain of *Pleurotus cystidiosus* (Bengaluru), *Macrocybe crassa* (Bengaluru), *Pleurotus tuber-regium* (Tripura), *Clitocybe* and *Calocybe* species (Gujarat) are some of the wild mushroom species which have been domesticated. End to End technologies of oyster, mliky and shiitake mushrooms has been developed. Value added products like Arka Mushroom rasam powder, Mushroom nutritive powder (chutney powder, chutney poodi) have been developed through dehydrated mushrooms to enhance nutrition in daily diet and also prevent post harvest losses due to surplus production. ICAR-IIHR was the first institution in the country to develop indigenous spawn production machinery, systems to integrate solar energy in spawn production and cultivation processes to make the entire

mushroom technology more labour, energy and time efficient. Mushroom Research lab has been supporting the mushroom farmers through the supply of quality spawn (35-40 tons per annum). Ready to fruit (RTF) bags is a novel concept initiated by ICAR-IIHR in 2013 to enable women to grow mushrooms at home and utilize it in their daily diet.

The Institute has concentrated its work on increasing productivity by standardizing high density orcharding, use of growth regulators, training and pruning, cropping systems like, inter cropping, sequential cropping, mixed cropping, crop rotation etc., sustaining productivity under adverse situation, integrated water management, fertigation, integrated nutrient management through need-based fertilizer application, proper timing and placement of fertilizer, quality improvement through protected cultivation, precision farming and organic horticulture, developing good agriculture practices (GAP) for crops and sustainable technologies resulting in higher yields and better quality produce. The salient achievements in this direction include - Technology for high density planting of banana and pineapple which are being practiced by majority of fruit growers; Grape rootstock, Dogridge identified and released by the Institute has revolutionized grape cultivation in dry land and problematic soils;

Application of fertilizer in the active root feeding zone, etc., for optimum utilization of resources by crops; Standardization of leaf and petiole diagnostics for recommendation of optimum fertilizers for respective crops; Technology for foliar nutrition of micro nutrients viz., mango special, banana special, citrus special and vegetable special for higher and quality yields; Technology of distal end nutrient feeding of banana bunch to increase yield and enhance quality of banana; Development of Arka microbial consortium, Arka fermented cocopeat and Arka Actino-plus for use in horticultural crop production; Technology to boost seed yield in China aster; identification of causative factor for the formation of spongy tissue and jelly seed, (major physiological disorders in Alphonso and Amrapali mangoes respectively), and development of a nutrient formulation for management of spongy tissue in mango; Technology for production of tomato, colored capsicum, cucumbers and melons under protected conditions; Refinement in the technology for production of nursery seedlings using protrays.

One of the major limiting factors influencing productivity is the loss caused by insects, nematodes and diseases. Horticultural crops are host to a wide array of pests causing huge economic damage to the tune of 40-50% and in severe cases up to 90% crop loss by insects like *Helicoverpa* or epidemic of disease like *Phytophthora* have been reported. The Institute, has worked out management practices for

control of major insects, nematodes and diseases using chemical pesticides which have been included in package of practices as recommendations for plant protection. Simultaneously, management of pesticide residue in horticultural ecosystems, particularly safety of application of pesticides, persistence, mobility, adsorption, and uptake of pesticides from plants and soil, determination of safe waiting period for pesticides, methods of dislodging of surface residues of pesticides from fruits and vegetables, biodegradation of pesticides, suitability of pesticides for inclusion in integrated pest management etc. have also been worked out. A herbal veggie wash has recently been developed to dislodge surface residues of pesticides from horticultural produce. With changing weather parameters due to global warming, changing cropping patterns, shrinking forest cover and arable land caused by urbanization, continuous use of pesticides to protect crops from pests over extended periods have worsened the situation and created pest complex. This has resulted in emergence of new pests, new races in the pest complex due to host-plant resistance and pesticide resistance, development and use of newer and stronger molecules to manage the pests, indiscriminate use of pesticides resulting in higher pesticide residue in the crop produce as well as in the biosphere – all leading to increased cost of production. To overcome these problems, the Institute initiated work on integrated pest management using botanicals, plant products, biocontrol measures, trap crops, pheromone traps, etc. and has developed a good number of sustainable technologies, some of which have become popular and commercialized for wider adaptability. Pesticide residue free IPM technologies for management of insect pests and diseases in cabbage, tomato and chilli have been developed and validated in farmer's fields. IPM modules have also been developed for control of fruit fly and stone weevil in mango, sapota seed borer, citrus leaf miner, borer in tomato, brinjal, chilli, DBM in cabbage and cauliflower, okra, onion, leguminous vegetables and various other vegetables. IDM strategies for major diseases of fruits, vegetables and ornamental crops, bio-intensive management of nematodes in fruits and vegetables, biological control of insect pest and diseases and microbial control of pest complex have also been successfully worked out. Some of the technologies that have made significant impact are- Use of botanicals and plant products like, neem soap and pongamia soap for control of major pests in vegetables; Use of microbial bio-control agents like, *Trichoderma harzianum*, *Pseudomonas fluorescens*, *Paecilomyces lilacinus*, *Pochonia chlamydosporia* for control of soil borne diseases and nematodes; Pheromone trap for mango fruit fly and cue lure trap for cucurbit fruit fly; Diagnostic kits for plant viruses; Sealer and healer technique for management of mango stem bore;

Liquid and talc based formulations of *Bacillus subtilis* for nematode management.

Post-harvest management and value addition to horticultural crop produce attains highest priority because of the high perishable nature of horticultural commodities. IIHR, Bengaluru has been recognized as the Center of Excellence in Post-Harvest Technology. The Institute has standardized the technology to extend the storage life of fruits and vegetables at various temperatures, standardized the protocol for MAP and shrink wrapping. Value addition through product development has been a priority area, in which the Institute has developed and standardized protocols for preparation of osmo-dehydrated products, fruit based beverages like mango squash, passion fruit squash, aonla squash, passion fruit-banana blends, various culinary pastes and purees, lactic acid fermentation of vegetables and protocols for minimally processed foods. As a part of farm mechanization, the Institute has developed a number of machineries for cultivation, harvesting and processing of horticultural crops. The important ones are, power operated machineries for ridging, weeding, seed drilling, planting, spraying, nursery raising machineries for vegetable crops like, media sieving, mixing, portray filling, seed dibbling, tractor operated seedling, transplanter for vegetable crops, mango, sapota, guava and lime harvesters, tractor operated hydraulic platform for spraying, pruning and harvesting of fruits, hot water treatment plant for mango, pickle making machineries for mango and garlic, mushroom spawn production machinery etc.

The Institute has been identified as a Center of Excellence for Research in Biotechnology. State-of-art facilities in terms of equipments and infrastructures like, Automated DNA sequencer, Gene gun, Gel documentation unit, Thermal cycler, Ultra centrifuge, Micro-propagation facilities, Isolation chambers, etc. are available to carry out research in frontier areas of biotechnology like, genetic engineering, DNA finger printing, genomics, development of molecular markers, marker assisted selection studies, development of micro propagation protocols, regeneration protocol, development of transgenics etc. The Institute has developed and standardized protocols for micro propagation of banana, grape root stocks, pomegranate, pointed gourd, triploid seedless watermelon, bougainvillea, carnation, orchids, anthurium, rose, day lily, chrysanthemum etc. In vitro shoot tip grafting technique for citrus for true to type virus free planting material has been developed. Hybrid embryo cultures have been developed from mango and grape. In the field of genetic engineering, double constructs for replicase gene of tomato leaf curl virus (TLCV) nucleocapsid gene of PBNV and plant body construct for coat protein of CTV have been generated.

Two chitinase genes from local isolates of *Trichoderma harzianum*, STMS markers to identify specific genomes, species-specific primers for molecular identification of virus have been developed and antimicrobial peptide (AMP) genes for onion has been isolated. Apart from this, the Institute has developed transgenic plants in tomato and brinjal resistant to pests and viruses which are in advanced stages of testing.

On the social sciences front, the Institute has been working on economics of production of various horticultural crops, input use pattern and efficiency studies, economics of marketing, economics of post-harvest losses, market intelligence studies, impact assessment studies for IIHR technologies, economics of farming systems, development of various statistical models like crop logging model, selection indices model, disease forecasting model price prediction model, biometrical model, substrate dynamics model, pest population model, ideotype canopy architecture model, etc. Computer application in horticultural research and information technology, gender sensitization and women empowerment, participatory rural appraisal for understanding gaps in adoption and assessing the research needs, validation of technologies developed and technological interventions to refine the technologies, assessment of IIHR training programs, identification of training needs, use of innovative extension methodologies for transfer of technology etc. have also been carried out.

The Institute is involved in first line transfer (or demonstration) of technology for dissemination of information and technologies developed by the Institute. So far the Institute has organized more than 429 on campus trainings, several off-campus and 5 International training programs on various aspects of horticulture and trained more than 5668 personnel, apart from training a huge number of farmers, farm women and private entrepreneurs. In addition to this, the institute organises farmers-scientists interaction meetings. Some of the innovative extension methods like mobile messaging, farmers' field school, and techno-agents for promotion of sustainable horticultural activities, video conferencing for training, interactive meets etc. have been successfully employed. The Institute has also conducted 341 demonstrations on 194 innovative IIHR technologies on farmers' fields in 7 states to popularize the technologies. More than 47 field days on IIHR developed technologies and varieties have been organized both at the Institute and on farmers' fields. About 129 radio and 183 TV programs on various technologies and aspects have been given by the scientists of the Institute apart from producing video films on important aspects in horticulture. Popular literature in Kannada, Hindi and English languages in the form of extension bulletins and folders on various

aspects of horticulture have been brought out and are being distributed to extension personals and farmers. The Krishi Vigyan Kendras at Gonikoppal and Hirehalli are involved in transfer of technology at the grass root levels by organizing training programs to farmers, farm women, rural youth, school drop outs etc., and conduct of Front Line Demonstrations and On Farm Testing. The Institute offers consultancy services on various aspects of horticulture in the form of general consultancy on horticulture production, advisory service, project preparation and project appraisal, technology development etc. The other services like contract service, paid up trials, product testing and analysis, soil, water and leaf analysis and advisory, technology assessment and refinement etc. are also under taken on payment basis.

Intellectual Property Rights (IPR) is taking the center stage in research and development worldwide. Realizing the importance of IPR in agriculture and recognizing the need for becoming competitive in the IPR rights regime so as to ultimately bring the Indian farmers away from subsistence farming with the transfer of IPR enabled technologies through commercial, cooperative and public route, IIHR, Bengaluru takes up protection and commercialization of technologies developed by the Institute. The Institute Technology Management Unit (ITMU) established in 2006 shoulders the responsibility of commercialization and as a first step in this direction has registered a trade mark, 'ARKA' (with a logo) for sale of its technological products and also took up patenting/registering its technologies. So far the Institute has obtained eight international patents and has already filed 16 protocols of the technologies developed for patenting in India. Potential technologies, parental materials of varieties/hybrids, potential breeding lines of vegetables, ornamental and fruits crops are commercialized by sale of these severally to entrepreneurs, private companies, KVKs, NGOs, etc. as a part of revenue generation for the Institute and more so mainly for wider spread of these technologies. More than 370 clients have been successful in dissemination of these technologies through commercialization across the country by marketing the products.

Physical and Financial

The Institute (including its regional stations) has a sanctioned staff strength of 607 staff members (153 scientific, 226 technical, 83 administrative and 145 supporting) as detailed in the table below. The expenditure during 2016-17 including regional stations under plan and non-plan was Rs. 575.93 and Rs. 18.34 lakhs respectively. Revenue generated through commercialization of technologies, consultancy services, analytical testing and sale of farm-produce and other means at the main Station and the CHES including the KVKs was Rs.3,77,39,497.00

Staff Position

Category	Sanctioned	Filled	Vacant
Scientific	152+1*	138+1*	04
Technical	226	139	77
Administrative	83	57**	25
Supporting	145	101	33
Total	606+1*	435+1**	139

* Director

** Excess due to revised cadre strength under Admn. Category to be adjusted in the future vacancies as per instructions of the Council.

STATEMENT SHOWING STATION-WISE REVENUE REALISED FOR THE PERIOD

ROM 1-4-2017 TO 31.03.2018

Rs.in lakhs

Sl. No	Head of Account	IIHR B'lore	CHES Chethalli	CHES B'war	CHES Hirehalli	TOTAL
1	Sale of Farm produce	20.07	28.08	19.30	1.60	69.05
2	Sale of Publication	7.31	0.00	0.00	0.00	7.31
3	Licence Fee/Guest House	11.94	3.76	0.05	0.02	15.77
4	Interest earned on Loans & Advances	18.24	0.10	0.00	0.00	18.34
5	Leave Salary & Pension Contribution	0.00	0.00	0.00	0.00	0.0
6	Analytical Testing fee	12.36	0.00	0.00	0.00	12.36
7	Application fee from candidate	0.00	0.00	0.00	0.00	0.0
8	Receipts from Service rendered	0.00	0.00	0.00	0.00	0.0
	a. Fee/Subscription	7.85	0.00	0.00	0.00	7.85
9	a. Consultancy Service	1.18	0.00	0.00	0.00	1.18
10	Misc. receipts	85.39	1.54	1.70	0.00	88.63
	Total	164.34	33.48	21.05	1.62	220.49

UNIFIED - BUDGET ALLOCATION 2018-19 (BE)

Rs.in lakhs

Sl. No.	Heads	IIHR B'lore	CHES Chethalli	CHES B'war	CHES Hirehalli	TOTAL
A 1.	Capital	175.00	0	0	0	175.00
	Total – Non-Plan Capital	175.00	0	0	0	175.00
B	Revenue					
I	i. Establishment Charges					
	ii. Wages					
	iii. Overtime allowance					

II	Travelling Expenses					
III	Research & Operational	1288.00	0		0	1288.00
IV	Administrative Expenses	0.0	0	0	0	0.0
V	Miscellaneous	23.00	0	0	0	23.00
VI	Pension & Retirement	0.0	0	0	0	0.0
	Total Non-Plan Revenue	1311.00	0	0	0	1311.00
	Total Non-Plan (Capital + Revenue)	1486.00	0	0	0	1486.00
	Loans & Advances	0.00	0	0	0	0.00
	TSP	18.00	0	0	0	18.00
	NEH	5.00	0	0	0	5.00

UNIFIED - BUDGET ALLOCATION 2017-18 (RE)

Rs. In lakh

Sl. No.	Heads	IIHR B'lore	CHES Chethalli	CHES B'war	CHES Hirehalli	TOTAL
A 1.	Capital	37.75	5.00	0.25	0.00	43.00
	Total – Non-Plan Capital	37.75	5.00	0.25	0.00	43.00
B	Revenue					
I	i. Establishment Charges	4604	230.00	300.00	66.00	5200.00
	ii. Wages	0.00	0.00	0.00	0.00	0.00
	iii. Overtime allowance	0.00	0.00	0.00	0.00	0.00
II	Travelling Expenses	43.00	4.25	7.00	0.75	55.00
III	Research & Operational	576.50	78.00	56.00	24.50	735.00
IV	Administrative Expenses	856.00	27.00	40.00	27.00	950.00
V	Miscellaneous	46.50	2.00	1.00	0.50	50.00
VI	Pension & Retirement	3700.00	100.00	0.00	0.00	3800.00
	Total Non-Plan Revenue	9826.00	441.25	404.00	118.75	10790.00
	Total Non-Plan (Capital + Revenue)					
VII	Loans & Advances					
	TSP	0.00	6.00	9.00	0.00	15.00
	NEH	5.00	0.00	0.00	0.00	5.00

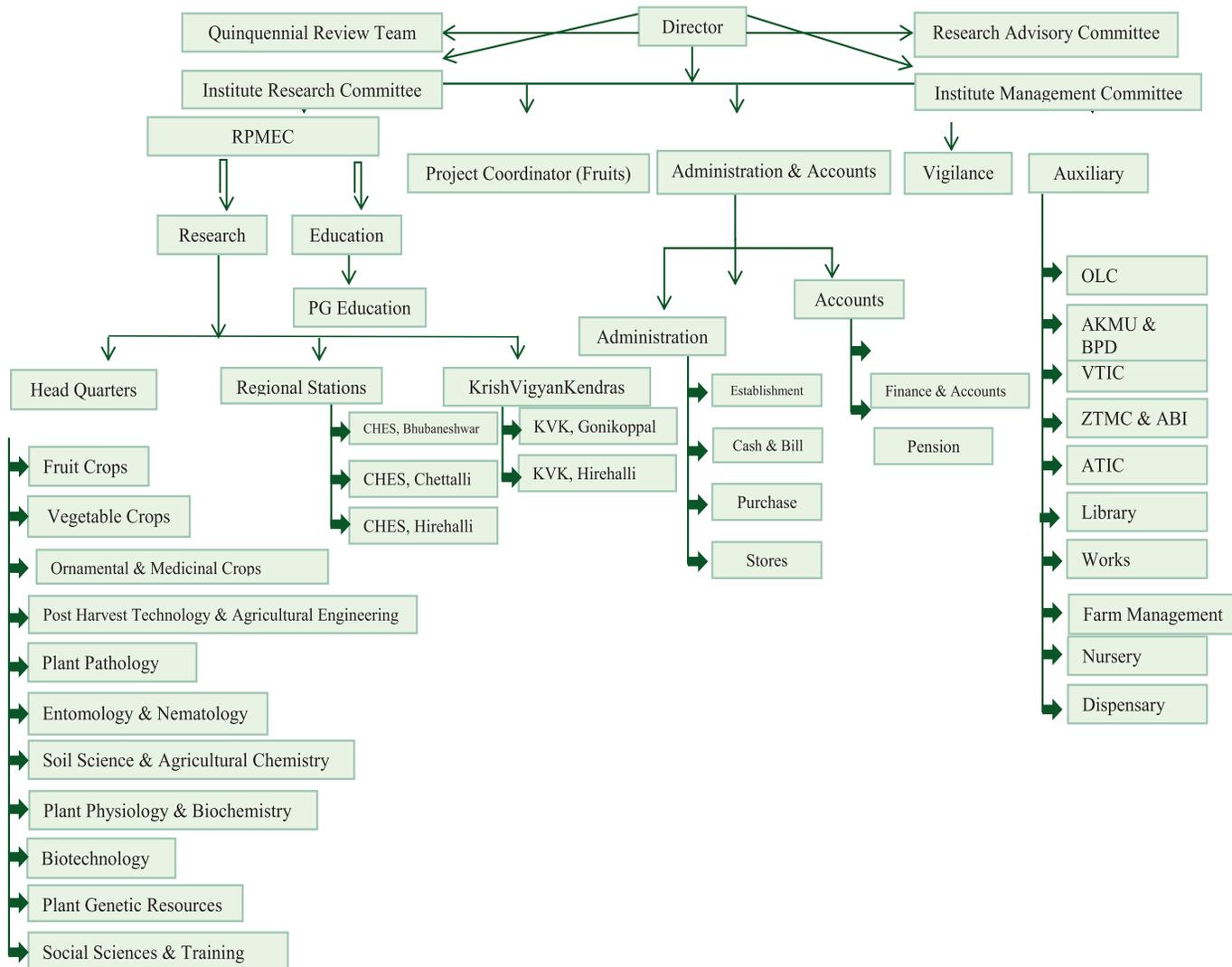
EXPENDITURE - NON-PLAN FOR THE PERIOD FROM 1.4.2017 TO 31.03.2018
NON-PLAN

Rs. In lakh

Sl. No.	Heads	IIHR B'lore	CHES Chethalli	CHES B'war	CHES Hirehalli	TOTAL
A 1.	Capital	25.77	4.85	0.16	0.00	30.78
	Total – Non-Plan Capital	25.77	4.85	0.16	0.00	30.78
B	Revenue					
I	i. Establishment Charges	4590.24	230.49	296.53	65.90	5183.16
	ii. Wages	0.00	0.00	0.00	0.00	0.00
	iii. Overtime allowance	0.00	0.00	0.00	0.00	0.00
II	Travelling Expenses	42.86	4.42	6.95	0.77	55.00
III	Research & Operational	576.52	78.05	56.09	24.34	735.00
IV	Administrative Expenses	856.01	26.84	39.90	27.25	950.00
V	Miscellaneous	46.39	1.96	1.07	0.58	50.00
VI	Pension & Retirement	3613.13	99.28	5.78	0.60	3718.79
	Total Non-Plan Revenue	9725.15	441.04	406.32	119.44	10691.95
	Total Non-Plan (Capital + Revenue)	9750.92	445.89	406.48	119.44	10722.73
	TSP	0.00	6.00	9.00	0.00	15.00
	NEH	5.00	0.00	0.00	0.00	5.00
	Total					20.00
VII	Loans & Advances	7.00	0.00	0.00	0.00	7.00



ICAR-Indian Institute of Horticultural Research Organogram



3. Research Achievements

3.1. Crop Genetic Resources

3.1.1. Germplasm Exploration and Collection

Fruit Crops

Mango: Seventeen accessions of indigenous pickling varieties were collected from Sirsi and Siddapura areas of Karnataka

Pomegranate: Twenty five wild pomegranate types were collected across Darlaghat-Solan region from 22 locations along with passport data. The cuttings of the collected accessions have been established in the nursery. *In situ* evaluation data was recorded on plant growth habit, tree height, girth, vigour, flowering and fruiting and incidence of pests and diseases. Plants are robust, healthy with 2-5 stems. Morphological characterization carried out using DUS characters. Two accessions AS/NN 17 and AS/NN27 are free from pest and disease incidence.



Wild pomegranate in Darlaghat

Variability in Wild pomegranate types

Variability for arils

Grapes: Seven rootstock accessions viz., Ramsey (*Vitis champini*), SO4 (*V. berlandieri* x *V. riparia*), St. George (*V. rupestris*), 110R (*V. berlandieri* x *V. rupestris*), Freedom ((*V. solonis* x Othello) x *V. champini*), de Grasset (*V. champini*), 99R (*V. berlandieri* x *V. rupestris*) and four scion accessions viz., *Vitis flexuosa* var. *parviflora*, Carolina Black Rose, Khalili and Bianca were collected from National Research Centre for Grapes, Pune and established at IIHR, Bengaluru. Root stock material has tolerance to drought and salinity while scion accessions were resistant/tolerant to downy and powdery mildew.

Jamun: Ten accessions were collected from places in and around Ranchi and Jabalpur, 14 from Godhra and surrounding areas in Gujarat and 27 collections from Varanasi and surrounding areas in Uttar Pradesh.



Variability in Jamun Collections

Custard apple: Two self fruiting accessions of atemoya were collected from Yercaud, Tamil Nadu. Average fruit weight ranged from 320.0 g to 460.0g while TSS ranged

between 26.4°B to 29.5°B. They were of less seeded (10.4/100g pulp) type with a shelf life of five days.

Under exploited species: Seventy nine collections of 20 species of wild fruits and vegetables were collected from the Western Ghats and BR hills. They include *Eleagnus conferta*, *Flacourtia monatna*, *Chrysophyllum roxburghii*, *Zyzyphus regusa*, *Physali spruniosa*, *Carrisa*, *Syzygium* spp, *Cinnamomum verum*, *Syzygium cumini*, *Artocarpus heterophyllus*, *Micheliachan*, *Cinnamomum verum*, *Citrus aurantium*, Karonda, wild cucurbit, etc. Eight minor fruits viz., *Artocarpus integer*, *Phyllanthus acidus*, *Ancardium* sp., *Annona* sp., Peanut butter fruit, *Bunchosia arggentea*, *Ferronia elephantum*, *Synsepalum dulcificum* were also collected. Seven collections of bael were made from Chhattishgarh and 11 collections of *Ferronia* made from Karnataka and Telangana. In tamarind, the germplasm collection stands at 260 which includes 60 accessions from Bastar, Narayanpur and Kondagaon areas of Chattisgarh, 72 accessions from Mehbubnagar and Adilabad in Telangana, 87 accessions from Koraput and Rayagadha areas of Odisha and 41 accessions from Ratlam area of Madhya Pradesh.

Jackfruit: Novel jackfruit selections with high nutritive value and attractive coppery red flakes for homesteads identified during 2017 in the traditional Jackfruit growing tracts of Southern Karnataka, through survey of Tumakuru and adjoining districts. During survey, 128 samples were shortlisted out of which 42 samples were evaluated for basic horticultural traits including colour of flakes and organoleptic evaluation.

Tamarind: Germplasm collection stands at 278 which includes 64 accessions from Bastar, Narayanpur and Kondagoan (Chattisgarh), 62 from Mehbubnagar and Adilabad (Telangana), 57 from Korapet and Rayagada (Odisha), 30 from Ratlam (MP), 15 from Maharashtra and 50 from Mizoram.

Vegetable Crops

Chilli: Six lines were collected from Gujarat during the period and with this the viable germplasm strength of *Capsicum* sp. at ICAR-IIHR went up to 2006. In bell pepper, 17 accessions were collected from both public and private organisations within India.

Okra: Eleven trait specific long thin multi rib germplasm were collected from Dakshina Kannada, Karnataka and 1200 accessions were received from NBPGR, New Delhi. With this, the total strength of viable germplasm stands at 1553.



Okra accession with long, thin, cream multiple ribs collected from Panja (Sullia)

Cucurbits: Nine F_1 hybrids of gherkin (pickling cucumber) were collected from Bengaluru and Poona markets and four new accessions of ridge gourd belonging to *Luffa acutangula* were collected from Assam, Telangana, New Delhi and Uttar Pradesh. With this the viable germplasm strength increased to 113. In bitter gourd, six new accessions were collected from Telangana, Karnataka, New Delhi and Uttar Pradesh raising the viable germplasm strength to 146. Similarly, eleven accessions of cucumber were collected from local market and also from Dakshina Kannada district, thus taking the strength of viable cucumber germplasm to 239.

Radish: Forty five germplasm accessions were collected for heat tolerance, yield and quality evaluation. Of them 25 belonged to tropical types from Uttarpradesh (NBPGR) and 20 were released varieties.

French bean: Nine new germplasm Slenderette, Crockett, Fantastic File, Blue Lake, Moraleda and four raikia beans were collected, raising the collections to 311.

Cowpea: Five new germplasm were collected from Karnataka, raising the collections to 409.

Garden pea: Four new germplasm lines of garden pea were collected from Andhra Pradesh and Karnataka and present viable germplasm collection is raised to 114.

Dolichos: Four new germplasm bush dolichos were collected from Karnataka and present viable germplasm collection is raised to 34 in bush and 178 in pole types

Pumpkin : Collected 2 germplasm lines comprising of very small fruit (<0.5kg) and oblong types from farmers field and Mogaralputhur from Dakshin Kannada.

3.1.2. Germplasm Conservation and Domestication

Fruit Crops

Mango: At IIHR, a total of 728 accessions of mango are being maintained in the field gene bank. Forty two

pickling mango accessions were multiplied for obtaining the IC numbers and are being maintained in the field gene bank.

Papaya: Total collection including 4 wild species stands at 32 accessions, and are being maintained through selfing and sib-mating. Besides field genebank, seed conservation is also being followed. In addition, cryo-preservation of pollen of wild species viz., *Vasconcellea cauliflora*, *V. cundinamarcensis*, *V. goudotiana* and *V. parviflora* has also been initiated.

Gauva: Total collection stands at 60 accessions including three wild species and are being maintained in the field gene bank. In addition to this, cryo-preservation of pollen of wild species viz., *Psidium cattelianum*, *P. guineense*, and *P. chinensis* has also been initiated.

Sapota: Fifty two accessions of sapota are being maintained in field gene bank.

Jamun: Seventy five accessions of jamun including closely related species like *S.alternifolium*, *S.samarangense* and *S.operculatum* are being maintained in field gene bank.

Pomegranate: *In situ* evaluation of pomegranate wild trees from 22 locations in and around Darlaghat, Himachal Pradesh was carried out for morphological traits following pomegranate DUS characters. Plants were robust, healthy and very few instances of pest and diseases observed. Bacterial blight symptoms were not recorded in any of the leaf and fruit samples collected. Leaf length ranged from 3.6 cm to 6.6 cm; Petiole length 0.38 to 0.68 cm. Fruit weight ranged from 30-90 g; fruit length 32 to 58.67 mm; fruit width- 31 to 56.3 mm; crown length 0.37 to 0.70 mm. Aril length ranged from 5.93 to 8.42 mm, aril width 3.81 to 5.98 mm, seed length 5.13 to 6.96 mm, seed width 2.17 to 3.01 mm, seed weight 4.9 to 201.55g, rind thickness 1.48 to 5.45mm and TSS ranged from 14.4 to 20.00 °B.

Custard apple: Twelve varieties of custard apple (Balanagar, Raidurg, APK-1, Red Sitaphal, Mammoth, Barbados, Taiwan, Washington 07005, Washington 98797, NMK-1, Arka Neelachal Vikram, and Arka Sahan), three varieties of Atemoya (Island Gem, Pink's Mommoth, Bullock's Heart) and four species of Annona (*Annona reticulata*, *Annona cherimola*, *Annona glabra* and *Annona muricata*) have been maintained in the field gene bank.

Jackfruit : NAGS site have been established in new farm area. Thirty five clones planted.

Vegetable Crops

Okra: A total of 1200 okra germplasm accessions received from NBPGR, New Delhi under CRP on Agrobiodiversity, were multiplied and larger quantity was supplied back to NBPGR for long term conservation.

Cucumber: Eight accessions along with local check (Swarna Agethi) were evaluated under ORT for yield and resistance to downy mildew disease. Among them, Boston has recorded highest fruit yield of 800 g per plant. The Multistar, a market collection of English cucumber was found promising with highest fruit yield of 4-6 kg per plant under open field condition during summer. These accessions are being utilized for breeding programme.



Multistar market collection

Radish: Forty five accessions were multiplied through seed and conserved at IIHR, Bengaluru

Seed conservation: Seeds of 11 *Solanum* species with 19 accessions (including accessions collected from Nagaland) were germinated and transplanted to field and morphologically characterized using NBPGR descriptor. Pollen of all accessions was collected, viability assessed *in vitro* and cryo-stored for future use in liquid nitrogen. Methods for pollen extraction, viability assessment, media for *in vitro* germination were optimised for each species of *Solanum*. Seeds of 9 accessions were submitted to NBPGR for long-term conservation. The accessions were mapped using DIVA-GIS. The prediction maps using maxen were also prepared for entire *Solanum* gene pool. Using these maps the gaps in collection could be identified. Areas with rich diversity of *Solanum* was also found using the mapping software.

Ultra dry storage for seed conservation: Studies were conducted with seeds of 21 important horticultural crops at 3 levels of moisture *viz.*, recommended (6-8%);

low (3.5-6%) and ultra low (<3.5-4.5%). The results revealed that seeds with low moisture levels maintained original seed quality in all crops tested after 24-36 months of storage at both temperatures. Irrespective of moisture levels the seed quality was maintained under both controlled (15 °C) and ambient temperatures up to 24-36 months in eggplant, ridge gourd, onion, carrot, watermelon, bottle gourd, bitter gourd, okra, kalmegh and peas. Seeds with recommended moisture levels were as good as low moisture seeds in tomato, coriander, French bean, cowpea, dolichos, marigold and papaya after 24-36 months of storage under ambient temperature while ultra low moisture affected seed quality in these crops. In chilli and pumpkin both recommended and ultra low moisture levels showed reduced germination but low moisture seeds maintained very high germination and vigour. Seed quality parameters *viz.*, first count per cent, seedling vigour index I and field emergence per cent also followed the same trend as germination per cent in all crops studied among various moisture levels and between temperature levels.

Brinjal: Five germplasm lines namely IIHR-593, IIHR-540, IIHR-411, IIHR-806 and IIHR-644 were collected, evaluated and seeds were multiplied for further use in breeding and total viable germplasm strength was raised to 343.

Flower and Medicinal Crops

Tuberose: Twenty two accessions have been maintained

Gladiolus: Sixty five genotypes were maintained. Two hybrid selections *viz.*, IIHRG6 (INGR17088) and IIHRG12 (INGR17089) were registered with NBPGR, New Delhi for novel traits. The hybrid selection IIHRG6 had floret colour purple (78.A), middle portion red-purple (72.A) and margin green-yellow (1.D) blotch. Floret type is open faced and floret placement is in double rows. The hybrid selection IIHRG12 had floret colour of purple-violet (82.A) with purple (77.A) margin and green-white (157.C) line on lower lip. It is an early flowering type (61 days).



IIHRG-6



IIHRG-12

Rose: A total of 320 genotypes including twelve species are being maintained. One variety of *Rosa damascena* and three varieties of Bourbon roses were added to germplasm collection. Screening of spray category in germplasm collection for their reproductive ability has resulted in identification of eight genotypes for seed setting ability and two genotypes for seed germination ability.

Carnation: Eighty accessions of carnation are being maintained.

Gerbera: Two germplasm accessions viz., INGR17090 and INGR17091 have been registered with NBPGR, New Delhi for their novelty.

Chrysanthemum: Eighty three genotypes maintained. Two lines viz., INGR 17059 (flower colour 77.B, purple group, Fan 2 and stellate ray florets) and INGR17060 (flower colour 162.D, grey yellow group, Fan 4 and stellate ray florets) were registered with NBPGR, New Delhi for unique traits. Two lines received IC numbers IC0623437 and IC0623438.



INGR17059

INGR17060

China aster: Twenty-five genotypes have been maintained. IC numbers for five lines viz., IC0624507, IC0624508, IC0624509, IC0624189 and IC0624490 were received from NBPGR, New Delhi. Seed storage studies showed that seeds with recommended moisture levels had drastic reduction in seed quality after 30 months of storage under ambient temperature and reached almost zero germination after 36 months whereas low and ultra low moisture maintained high seed quality.

Marigold: A total of 54 genotypes including genotypes belonging to *Tagetes erecta*, *T. patula* and *T. minuta* are being maintained. Based on propagation methods, germplasm is classified into two groups i.e. propagated by vegetative method and by seeds. Based on season, germplasm is classified into two groups i.e. photosensitive (flower only during winter) and photoinensitive (flower round the year).

Jasmine: Thirty-nine accessions belonging to four commercially cultivated species viz., *Jasminum sambac*, *J. auriculatum*, *J. grandiflorum*, *J. multiflorum* and six other lesser known species (*J. rigidum*, *J. nitidum*, *J. flexile*, *J. malabaricum*, *J. humile* and *J. primulinum*) are being maintained and characterized based on the morphological descriptors.

Bougainvillea and indigenous ornamentals: Ninety-eight germplasm of bougainvillea and 12 different indigenous ornamentals are conserved under field gene bank.

Medicinal Crops: Fifty-one germplasm lines in Kalmegh, 33 in *Aloe vera*, 84 in *Mucuna*, 109 in betelvine are being maintained. Two germplasm accessions (IIHR-CA-26 and IIHR-CA-27) of *Centella asiatica* were collected from Tumkur, Karnataka and Bhubaneswar, Orissa. A total of 27 accessions of *C. asiatica* are being conserved in the field.

Mushrooms: The wild edible mushroom collected during 2016-17 from Lembucherra, Tripura was cultured, purified and validated on straw based substrate. Tissue cultures were raised from the validated sporophores and conserved. Based on cultural, morphological and molecular characters, it was identified as *Pleurotus tuber-regium*. The species could tolerate temperature range of 10-40°C. The optimum temperature for mycelium growth was 30°C. Lethal temperature was 45°C.


 Pure culture of *Pleurotus tuber-regium*

Microscopic confirmation



Validation through fruiting

3.1.3. Germplasm Characterization

Fruit Crops

Mango: A total of 68 mango accessions from FGB were characterised as per Bioversity International descriptors. The proportion of bisexual flowers was recorded for 23 varieties of which variety 'Irfan' recorded the highest (30.73%). Extent of polyembryony in Nekkare and Vellaikolumban was recorded. In Nekkare, out of 173 stones, majority (21.9%) gave only one seedling/stone, while 7.9% produced two seedlings/stone. 1.9% had three seedlings each and 0.50% had four seedlings. In Vellaikolumban, single seedling/stone recorded was 28.7%, while 11.5% had two seedlings/ stone and 2.6% had three seedlings/ stone. Genotyping of Nekkare and Vellaikolumban open pollinated derived seedling populations using capillary electrophoresis for 191 seedlings with 8 fluorescent labelled SSR primers analysed, primers LMMA 12 and MiIHR 18 primers recorded segregating alleles. Among 6 primers, MiIHR 23 identified maximum zygotics in Nekkare (21.59 %) and in Vellaikolumban (36.84%). Pickling types (Appemidi) of mango collected from Yellapura, Kumta and Honnavar taluks of Karnataka and progenies of polyembryonic mango genotypes – Chandrakaran, Vellaikulamban and EC 95862 were characterized employing eight SSR markers.

Jackfruit: A total of 35 jackfruit genotypes at FGB were characterized for their suitability as vegetable using eight morphological traits viz., fruit weight, fruit width, length, shape, rachis length and width. The accession 'NAH-5' recorded highest per cent edible portion (51%) while least was in IIHR-1 (19.96%). Seventeen genotypes were evaluated for their cooking quality parameters viz., cooking time, water uptake ratio and solids in cooking water. Singapore-2 took highest time for cooking whereas SSB-15F and A-5 took least time. Water uptake ratio ranged between 0.95 and 1.18. High solid in cooking water was observed in Singapore-2 and least was found in Hurulichikkanahalli.

Jamun: Sixteen floral characters and eight plant morphological characteristics were recorded from 20 accessions which attained flowering stage. There were significant variations among different characteristics, e.g., inflorescence length ranged from 3.0 to 9.14 cm, number of flower clusters ranged from 5.0 to 16.6, number of flowers per cluster were 5.0 to 15.0, leaf length was 12.65 cm to 16.6 cm and leaf breadth varied from 3.72 to 8.92 cm. Jamun accessions from different locations were analysed for polyembryony and about 50% of the seeds were found to be polyembryonic. Morphological characterization of jamun accessions carried out as per Bioversity descriptors. Leaf shape varied from lanceolate

to ovate oblong while fruit shape was generally oblong; fruit colour varied from deep purple to bluish black. Fruit base varied from flat to projected as recorded on mature fruit. Fruit maturity was late. Taste of mature fruit was sub-acidic. Ode-1 recorded higher values for fruit size (33mm x 23.6 mm), fruit weight (10.7 g) and pulp weight (7.1g). Accession from Khambolaj had highest TSS (15.92%) with high pulp to seed ratio.

Karonda: Morphological characterization of 56 collections of karonda was carried out using minimum descriptor of NBPGR. The leaf length ranged between 1.50 to 6.2 cm and leaf width between 1.30 to 4.37 cm. The fruit weight ranged between 2.9 to 16.57 g, fruit length between 1.32 to 2.85 cm and fruit width between 1.32 to 3.28 cm. Fruit shape ranged from round to oblong. Fruit colour ranged between light pink to dark purple and pulp colour from creamy to pinkish red and TSS ranged between 11.0°B to 16.6 °B.

Avocado: Morphological characterization of 42 collections using IBPGR descriptor showed that leaf length ranged between 10.82 to 16.88 cm and leaf width between 6.51 to 9.37 cm. Fruit weight ranged between 245.8 to 871.0 g, fruit length between 7.94 to 22.5 cm and fruit diameter between 13.2 to 22.0 cm. Fruits were oblong to pyriform. Fruit colour ranged from green to dull red while pulp colour ranged from creamy white to whitish yellow.

Bael: Seventy one collections were characterised. Plant height ranged from 3.30 m to 6.35 m. The growth habit spreading to upright. Leaflet length varied from 2.32 cm to 10.2 cm, leaflet width from 1.30 to 12.9 cm, leaflet shape from ovate to lanceolate. The number of fruits per tree varies from 0 to 400. The fruit shape varies from spherical to oblong, pyriform and cylindrical. Almost 60 % accessions have spherical fruits.

Wood apple: Morphological characterization of 19 collections of *Ferroniaelephantum* was carried out. Plant height ranged from 2.80 m to 9.50 m. The growth habit of all the collections was upright. Leaflet length varies from 2.28 cm to 4.18 cm. Leaflet width varies from 1.12 to 4.38 cm. Leaflet shape varied from ovate to oblong. The number of fruits per tree varies from 3 to 250. The fruit shape was spherical in all the collections.

Tamarind: The accessions collected from Chattisgarh were used for morphological and biochemical characterization. The pod length was found to range from 4.5-23.5cm, pod mass ranged from 4.5-28.00 g, pulp mass ranged from 1.5-12.5g. The average pod length, pod mass, pulp mass and sugar content were higher in samples collected from Narayanpur than in those collected from Bastar. The acidity and sugar content in accessions

ranged from 3.52-10.5% and 10.18-50.61% respectively. The shape of pods varied from U shaped to straight and tree architecture varied from upright to drooping.

Underexploited species of Western Ghats: Morphological Characterization of all the species in biodiversity block was completed. Some of the species with edible fruits are marking nut, wild *Syzygium memusopselengi*, *Flacourtia enermis*, *Ferronia*, *Aegle marmelos*, *Phyllanthus acidus*, *Artocarpus* spp. The yield and fruit quality characters of edible species showed that higher yield were recorded in *Phyllanthus emblica* (33.0 kg), *Sapinduslaurifolius* (10.5 kg), *Memusopselangi* (8.5 kg), *Tamarindusindica* (12.0kg), *Phyllanthus acidus* (4.5 kg). Most of the species produce large quantity of seeds viz . *Melia dubia* (53kg), *Red Sandal wood* (13 kg), *Azadiractaindica* (21 kg), *Terminalia bellarica* (27 kg).

Jamun : Molecular characterisation of twenty three jamun accessions from Godhra and Varanasi, were done using 16 SSR primers. Based on molecular distance, accessions were grouped into four clusters.

Mangosteen : Fruit size was small to medium with thick fruit skin, mature fruit colour from red to deep purple, aril flavor intermediate, aril taste acidic and creamy white in colour. Fruit length ranged from 45.46-52.86 mm, fruit breadth from 44.57-60.74 mm; fruit weight 46.44-116.29g ; TSS 6.90-16.06 °B. Molecular characterization analysis was carried out 31 samples to confirm variability at DNA level. DNA was isolated from young leaves of 31 accessions of mangosteen using CTAB protocol. Thirty SSR primer (GG) series with optimum temperature of *Garcinia gummighatta* were screened and 20 primers were selected with optimum amplification. DNA profiles were generated with 16 SSR primers. The cluster analysis using UPGMA revealed variability in mangosteen accessions. The polymorphism and genetic diversity observed in mangosteen may be the result of several events such as accumulation of DNA mutations in the maternal genome that control apomictic behavior and/or variations caused by the presence of transposable elements.

Pomegranate: A total of 300 genomic microsatellite markers were used for molecular characterization of 120 pomegranate accessions obtained from USDA for studying the genetic diversity available in the collection and 29 primers showed clear, reproducible polymorphism between the accessions.

Custard apple : Molecular characterization was carried out by isolating DNA from leaves of 10 voucher samples collected from Solapur and one accession from Nilgiris, Tamil Nadu. DNA recovered was of good quality and PCR was optimized using *Annona cherimoya* primers (LMCH series) for cross species amplification. Of 30

primers tested, 20 have given amplification.

Karonda and Avocado : Molecular characterization of 30 and 29 collections respectively showed that collections from different regions formed different clusters.

Chemical characterization

Karonda: Twenty four karonda collections were analyzed for phenols, flavonoids, FRAP, DPPH, anthocyanin, reducing sugar and total sugars. The phenol content ranged from 427.15 mg/100g to 1027.11 mg/10g in K-40. The flavonoids ranged from 96.02 mg/100g in K-50 to 273 mg /100g in K-40. FRAP ranged from 443.68 mg/100g in K-50 to 786.86 mg/100g in K-34. DPPH ranged from 250.15 mg/100g in K-46 to 279.61 mg/100g in K-4. Anthocyanin content ranged from 37.16 mg/100in k-50 to 368.50 mg/100g in K-52. Reducing sugar ranged from 6.51 mg/100g in K-52 to 22.06 mg/100g in K-29. Total sugars ranged from 6.955 mg/100g in K-52 to 22.63 mg/100 g in K-29.

Avocado: Twelve accessions of avocado were analysed for fats and other parameters. Fat content ranged from 14.0 % in A-18 to 26.0 % in A-27. Protein content ranged from 2.1% in A-26 to 3.5% in A-27. Total sugar ranged from 3.1% in A-27 to 4.6 % in A-26. Total soluble solids ranged from 3.6 °B in A-28 to 8.4 °B in A-22.

Vegetable Crops

Chilli: Six new and 115 old germplasm lines were characterized and maintained during the period.

Cucumber: Nine accessions of *Cucumis hardiwikii* were evaluated and characterized for nine traits. Among them, two accessions viz., IC-550199 and IC-277030 were found promising for sequential fruiting habit, early female flowering (34 days after sowing), number of branches (6-8), fruit number (55 and 178), fruit yield (4.8 kg and 11 kg per plant) and resistance to downy mildew disease. There was large variability in terms of fruit size and shape, spine colour and bitterness.



Variability of fruit parameters in *Cucumis hardiwikii*

Okra : About 1300 accessions were characterized as per the NBPGR descriptor. Among them highest marketable yield was recorded in IC-111478 (548 g/plant) and lowest in IC-0523715 (106 g/plant). Early flowering (30-40 days after sowing) was observed in 351 accessions and very late flowering (90 days after sowing) in nine accessions and remaining accessions flowered 45-50 days after sowing. Significant variations were recorded in fruit length (10 - 27 cm), fruit diameter (1cm to 5.5cm) and pubescence. Number of ridges ranged from 5-8, with 580 lines having 6-8 ridges and 11 lines with more than eight ridges. Total number of fruits ranged from 10 to 36, and the highest was recorded in IC-111478 (36 fruits/plant). Plant height ranged from 0.5 m to 3.5 m and >615 accessions were of medium height. Fourteen accessions were found susceptible to YVMV.



Variability in okra fruits

Garden pea: A total of 84 germplasm of garden pea were evaluated for root rot resistance under natural field conditions and disease incidence was recorded. Seven genotypes viz., IIHR-3, IIHR-582, IIHR-623, IIHR-18xOregon-1, IIHR-698, Pusa Pragathi and 9414x19-1 BK were resistant and forty two were moderately resistant, twenty nine were susceptible and six were highly susceptible.

Muskmelon: A total of 114 germplasm lines of muskmelon have been evaluated and seed has been regenerated during late *kharif* 2017-18.

Solanum spp: Seeds of 11 *Solanum* species with 19 accessions (including accessions collected from Nagaland) were germinated and transplanted to field and morphologically characterized using NBPGR descriptor.

Summer Squash: Evaluation of 15 summer squash lines showed wider variation for plant morphology, fruit shape and yield and number of fruits per plant. The higher no. of fruits per plant was recorded by SQ-134, SQ-135, SQ-

136, SQ-133-1. Fruit size ranged from 0.300 kg (SQ-133) to 1.330kg (SQ-138) was observed. The yield per plant was recorded higher in SQ-134, SQ-136, SQ-146-2 and SQ-147 (> 5.0kg/plant).

French bean: Twenty germplasm including nine new lines (Slenderette, Crockett, Fantastic File, Blue lake, Moraleda and four raikia beans) were evaluated as per NBPGR minimum descriptor. Of them 16 lines were pole types and 4 new lines were bush types. All the lines were vegetable poded with pod width ranging from 0.9 to 1.5 cm. Thirteen lines were flat and remaining seven lines were round poded. Pod color ranged was Yellow- (3); Purple- (4); Dark green-(2); green with red mottling- (4); green-(5); light green-(2). Pod yield ranged from 130 g to 325 g/ plant.

Cowpea: Thirty germplasm were evaluated and maintained. The pod yield ranged from 55 to 220 g per plant. EC-769250 gave maximum pod yield of 220 g/ plant. Pod maturity ranged from 60 to 64 days. Pod length ranged from 15 to 70 cm (EC-769255) and variability was observed for pod color; light green (15), green (3), dark green (12), purple (1), etc. Incidence of cowpea aphid mosaic virus and rust was not observed.

Garden pea: Totally 114 germplasm including new collections were evaluated for various traits. Pod yield in these lines ranged from 38.5-74.4 g/ plant.

Dolichos: Totally 34 germplasm lines of dolichos were collected germplasm including new collections were evaluated for yield and yield related traits. Pod yield in these lines ranged from 95-400g/plant in 120 days.

Flower Crops

Twenty-five genotypes of China aster were characterized as per DUS test guidelines and were categorized into different colour groups such as pink/red/brick red, violet/purple and white. Forty-three genotypes of chrysanthemum and 33 genotypes of gladiolus were characterized as per DUS test guidelines.

3.1.4. Evaluation of Germplasm for Yield, Quality and Biotic Resistance

Fruit Crops

Mango: Out of 39 mango hybrids (Amrapali x Vanraj) evaluated for fruit yield and quality, three hybrids (R_3P_{19} , R_4P_{18} and R_6P_{17}) were selected. Among the half sibs evaluated, one half sib progeny (R_1P_{15}) from the mango variety Vellaikulamban was selected for desirable quality. This progeny bears fruits of 350-400 g weight with orange pulp and TSS of 17-19° Brix and pulp recovery of 70-80 percent.

In another study, of eleven mango varieties screened, two had < 20% stone weevil infestation. Manjeera and Sitabhog varieties displayed 10% infestation of fruit fly, when exposed under laboratory conditions. Varieties Nati, Manjeera, Narela, Sitabhog and Santhoor showed zero infestation in field. No variety was found disease resistant among 11 varieties screened.

Jamun: Twenty eight jamun collections were evaluated for fruit quality parameters. Accession IC-715 (seedless Jamun from Lucknow) had highest pulp to seed ratio (11.05%) with very small seeds size. Fruit weight varied from 0.98 to 16.0g, seed weight between 0.30 to 3.76g and pulp to seed ratio in the range of 1.19 to 11.05. Analysis of biochemical parameters revealed that collection-5 had highest contents of DPPH, FARP, anthocyanins and total phenols in fruit pulp and total flavanoids and total tannin in seed.

Jackfruit : Three selections namely CHESHJF-1 CHESHJF-2 CHESHJF-3 were promising. They have deep coppery red and yellowish orange colour flakes with high amounts of carotenoids and lycopene ranging from 1.64 to 5.83 mg/100 g and 0.17 to 2.26 mg/100 g, respectively as compared to white colour flakes. Total antioxidant activity ranged from 8.95 to 11 and 9.42 to 14.93 mg AEAC/100g in FRAP and DPPH assay, respectively.



CHESHJF-1

CHESHJF-2

CHESHJF-3

"SIDDU" Jackfruit Farmers variety was released by IIHR, the jackfruit farmer variety tree was identified from Chelur, Tumakuru district. The weight of fruits is 2.44 kg, fruit shape is irregular, flakes colour is coppery red, weight per flake (24.5 g), flake thickness (8.5 mm) and highest total soluble solids (31.0 OB).

Vegetable Crops

Capsicum: Forty two *Capsicum* lines were screened through Temperature Induction Response (TIR) technique for heat tolerance. Six lines (IIHR 4598, IIHR 4593, IIHR 3915, IIHR 4600, IIHR 4608 and IIHR 3014) were identified with high cellular level of tolerance to high heat stress pertaining to their high recovery growth and less reduction in recovery growth after stress treatment.

Okra: Significant variations were recorded for yield. The

minimum yield was observed in accession IC-0362451 (46.88 g/plant) and maximum yield (1200 g) was observed in IC-506182.



IC-506182 (1200 g/pl)

IC-0444700 (66 fruit/pl)

Ridge gourd: Twenty ridge gourd lines were evaluated during summer for 13 yield and yield related parameters. Based on the mean performance, IIHR -79 was early flowering (50.75 days), IIHR-108 had the first female flower appearance at 5th node and maximum fruit length was recorded in IIHR -114 (29.00 cm) followed by IIHR -90 (28.50 cm). Twenty nine lines were screened against leaf miner during summer season. Out of these, only one line, IIHR-90 showed resistance with 10% leaf damage and eight lines were moderately resistant (12.3-19.9% damage) whereas IIHR-82 had maximum leaf miner damage of 37.5%.



Genetic variability in the ridge gourd germplasm

Sponge gourd: Out of 20 sponge gourd lines evaluated, line IIHR-114 recorded highest per plant yield (0.93 kg) followed by ridge gourd lines, IIHR -126 (0.63 kg) and IIHR -112 (0.54 kg). One sponge gourd line, IIHR -114 (PDI=5.19) and a ridge gourd line, IIHR-79 (PDI=5.56) were resistant to powdery mildew. IIHR -114 was the only line having moderate resistance to ToLCNDV (VI=10.33), while IIHR -121 was highly susceptible (VI=80.00).

Garden pea: Four new germplasm lines of garden pea were collected and evaluated for pod yield and yield related traits during *rabi* 2017. Pod yield ranged from 38.53-74.37 g/ plant.

Dolichos: Four germplasm lines were evaluated for yield and yield related traits. Pod yield ranged from 95-400g/plant in 120 days.

Cluster bean: Evaluated 38 cluster bean germplasm for yield and attributing traits during *rabi* 2017-18 and identified 10 vegetable type lines.

Summer Squash: Evaluation of 15 summer squash lines showed wider variation for plant morphology, fruit shape and yield and number of fruits per plant. The higher no. of fruits per plant was recorded by SQ-134, SQ-135, SQ-136, SQ-133-1. Fruit size ranged from 0.300 kg (SQ-133) to 1.330kg (SQ-138) was observed. The yield per plant was recorded higher in SQ-134, SQ-136, SQ-146-2 and SQ-147 (> 5.0kg/plant).

French bean: Twenty five germplasm lines were evaluated for yield and yield attributing traits. All lines were vegetable poded. Pod width ranged from 0.9 to 1.2 cm. 10 lines was flat and remaining 15 lines were round poded. 19 lines were green, three lines were purple poded, one line was dark green and remaining two lines had light green pod colour. The treatments were highly significant for all the traits studied. Pod yield ranged from 42 to 160 q/ha. IIHR -278 gave maximum pod yield.

Medicinal Crops

Kalmegh: Twenty-one lines were assessed for total biomass and andrographolide (AP) content at 120 DAP. Total andrographolide (AP) content constituted relative concentrations of andrographolide AP1, 14-deoxy andrographolide AP 2, neo-andrographolide AP3 and neoandrograpanin AP 4. Among the accessions, leaf AP content varied from 1.74 to 3.565%, stem AP content varied from 1.33 to 2.62% and dry biomass yield ranged from 15 to 25 g/plant.

Centella: Of eight accessions of *Centella asiatica* evaluated, IIHR-CA-17 and IIHR-CA-18 were found superior for dry biomass yield.

3.1.5. At CHES - Bhubaneswar

Status of germplasm

About 200 germplasm collections of fruit crops and 700 germplasm collections of vegetable crops are being maintained and evaluated for their traits. Among fruit crops, germplasm of mango (107), pineapple (21), jackfruit (25), bael (13), custard apple (06), and underutilized fruit crops (46) is under evaluation. Indigenous collection (IC) numbers for 29 accessions of underutilized fruit crops (watery rose apple, jamun, bilimbi, star gooseberry, rambutan, longan, avocado, egg fruit, avocado, karonda, jackfruit, bael, custard apple,

cherry and guava) has been obtained from NBPGR, New Delhi. In addition, the station also maintains more than 100 varieties of fruit crops like mango (54), sapota (15), guava (16), bael (9) and aonla (10). Among vegetable crops, germplasm of moringa (80), chilli (140), dolichos beans (122), field bean (35), French bean (6), bitter gourd (48), leafy vegetables (274) and pointed gourd (12) are being evaluated.

Germplasm Evaluation

Mango: Fifty six accessions of mango were evaluated for their fruit maturity behaviour, yield and fruit quality. IIHR-B-M-3 (IC-0598379), IIHR-B-M-21 (IC-0598393) and IIHR-B-M-60 showed early maturity habit (April), better yield potential, fruit size and fruit quality in terms of TSS and pulp content, hence these may be exploited for table purpose. IIHR-B-M-8 had bunch bearing habit. IIHR-B-M-59 (IC-0598408) was identified as a sucking variety due to high juice content.

Underutilized fruit crops: Germplasm of watery rose apple (*Syzygium aqueum*, Myrtaceae) was evaluated at CHES, Bhubaneswar for their fruiting behaviour, yield and fruit quality. Among them IIHR-B-WRA-1 (IC0624441) and IIHR-B-WRA-3 (IC0624441) have been found better in quality (TSS 12 -13 °C acidity – 0.16-0.20) and yield potential. Nutrient analysis indicated that rose apple and watery rose apple were rich in calcium and magnesium whereas, tamarind and karonda were rich in potassium. Star aonla (68 ppm), tamarind (55 ppm) and karonda (53 ppm) possessed high iron (Fe) content.



IIHR-B-WRA-1



IIHR-B-WRA-2



IIHR-B-WRA-3



IIHR-B-WRA-4

Exotic Fruits (Dragon fruit and Apple ber): Dragon fruit exhibited its potential in the region, however prevalence of high temperature during April – May

affected its growth and yield potential. Two types of dragon fruit; white fleshed (*Hylocereus undatus*) and red fleshed (*Hylocereus monacanthus*) were been evaluated for their bearing habit and fruit quality. Flower appeared in four flushes between mid-Junes to mid-September. About 10-12 fruits were produced per plant during the fruiting period and from each hill 40-50 fruits were harvested. Fruit weight varied from 180-600g and pulp content from 65 - 70%. TSS varied from 12 - 14 °B and acidity 0.16- 0.20%. Stem rot was the major disease in dragon fruit. Apple ber (*Z.mauritiana*) was evaluated considering its precocity in bearing and yield potential. In two year old plants the number of fruits varied from 290-840 and fruit weight ranged between 45-65g. The size of fruit and yield may increase with the regulation of fruit number and age of plants. The average yield from one year old plant varied between 15-18 kg. The pulp content, TSS, acidity and TSS ratio were 93.5, 13.1, 0.32 and 41.8, respectively. The vitamin C content ranged from 62 – 65 mg/100g.



Dragon Fruit

Moringa and leafy vegetables: Eighty one moringa germplasm accessions were evaluated for leaf nutritional quality and growth and other desirable characters. The Fe content in the leaf samples ranged between 142 and 303.7 ppm, whereas Zn content varied from 24 to 100 ppm.

Amaranthus: Two hundred sixty seven accessions were evaluated for their morphological traits and yield



IIHR-B-AM-32



IIHR-B-AM-65

potential. In addition, twenty six species of edible leafy vegetables other than amaranthus were evaluated for

their green yield. Among them the important species are; *Talinum portulacifolium*, *Marsilea polycarpa*, *Commelina benghalensis*, *Alternanthera sessilis*, *Portulaca oleracea*, *Rivea hypocrateriformis*, *Glinus oppositifolius*, *Ipomoea aquatic* etc. The green yield of different edible leafy vegetables was as high as 1870 g/m² in 4 cuttings.



Talinum portulacifolium



Rivea hypocrateriformis

Beans: On the basis of pod and seed traits, nine accessions of dolichos bean and ten accessions of field bean were found promising and IC numbers (Dolichos bean: IC 0624256-0624264, Field bean: IC 0624265-0624274) were obtained from ICAR-NBPGR, New Delhi. Pod yield in these lines ranged from 230-950 g/plant in 150 days. Seven accessions of field bean were evaluated for green pods. Green pod yield ranged from 90-180 gm/plant in 120 days. Three accessions of pole type French bean (Raikia bean) evaluated for pod yield and quality traits. Pods were stringless, flat type with bold seeded and delight taste, yield ranged from 150-200 g/plant.

At CHES, Chettalli

Germplasm Collection

Underutilized Fruits: Twenty accessions of Avocado, 8 of Malabar tamarind, 3 of Mangosteen, 6 of *kokum*, 4 of Dragon fruit and 2 each of Passion fruit, Karonda, and Macadamia nut were collected through exploration in Kerala, Tamil Nadu, Maharashtra and Karnataka.

Vegetables: Forty five collections were made in beans, brinjal, chilli, leafy vegetables and tuber crops from Kodagu (Madikeri, Somwarpet and Virajpet) and Dakshina Kannada regions of Karnataka.

Germplasm Conservation and Domestication

Gourds: Forty accessions of teasel gourd (*Momordica subangulata* subsp. *renigera*), two of ivy gourd (*Coccinia grandis*), one of sweetgourd (*Momordica cochinchinensis*) were shifted from ICAR-IIHR, Bengaluru to CHES (ICAR-IIHR), Chettalli and conserved in simulated *in situ* condition.

Germplasm Evaluation for Yield and Quality

Underutilized Fruits: Among the 17 avocado accessions evaluated, maximum number of fruits per tree was recorded in CHESPA-III-1 (750). The accessions *viz.*

CHESPA-III-1, PA-XIII-1, CHESPA-X-3, CHESPA-VII-1, and CHESPA-VII-4 were selected based on the fruit yield and quality for further evaluation. In Rambutan, maximum number of fruits/tree was recorded in CHES R-8 (1281) followed by CHES R-28 (1177). Fruit weight varied from 16.92 g (CHRS R-XVII-3) to 56.34 g (CHES R-XVIII-5). Among the new collections, CHESR-III-11, CHESR-IX-10, CHES-XI-11, CHESR-X-9, CHESR-XV-7, CHESR-XVIII-5 were found to be better with respect to fruit weight and yield. Sixteen mangosteen accessions evaluated, maximum number of fruits (56) with higher average fruit weight (119 g) and TSS (16.1 °Brix) was recorded in CHESGM-II-3. Evaluation of 45 accessions of *Garcinia indica* have shown that number of fruits ranged from 152 (CHES GI-V-4) to 3276 (CHESGI-VIII-5) per tree. Maximum fruit weight and TSS was recorded in CHESGI-V-8 (75 g & 16.4° Brix respectively). Among all the accessions, GI-V-8, GI-V-4, GI-VII-4, GI-VIII-5 were found promising with respect to yield and quality parameters.

Vegetable crops: Improved IIHR vegetable varieties were evaluated in Kodagu and promising varieties have been identified for commercial cultivation in the area. They are Arka Meghana (32.5 t/ac) in Chilli, Arka Anand (54.2 t/ha) in Brinjal, Arka Suguna (19.7 t/ha) in Amaranthus, Arka Sharath (18.5 t/ha) in French bean and Arka Amogh (18.0 t/ha) in Dolichos bean. Among various high value exotic vegetable crops evaluated in open field, lettuce, broccoli, red cabbage, Chinese cabbage and zucchini performed well under humid tropical region of Kodagu.



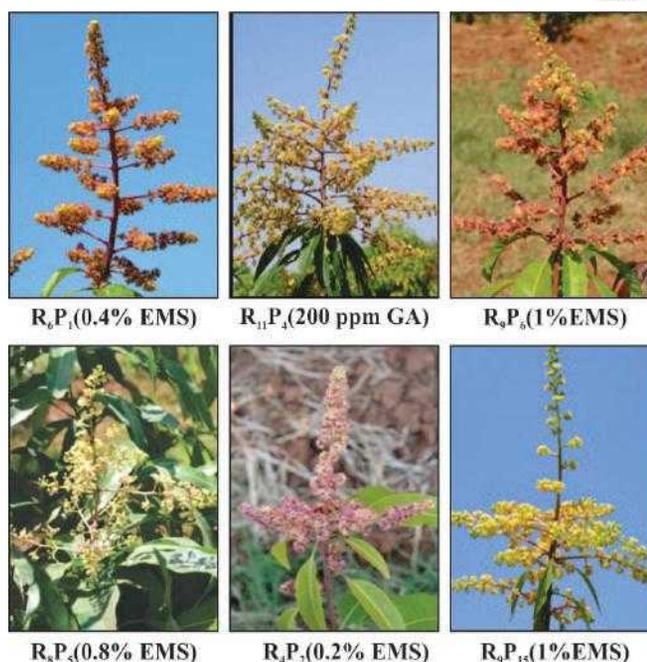
Chinese cabbage

3.2. Crop improvement

3.2.1. Fruit Crops

Mango

Breeding for yield: A total of 5720 hermaphrodite flowers from 1175 panicles of Vellaikolumban were crossed with 6 monoembryony and one polyembryony. The average fruit set was 7.22% at pea stage and fruit retention is yet to be worked out. Huge variability was observed with regard to plant height, canopy, leaf shape, leaf size, inflorescence colour and size in variety Arka Puneet with the use of chemical mutagens such as EMS (0.2 to 1%) and GA₃ (100 to 500ppm).



Putative mutants of Arka Puneet

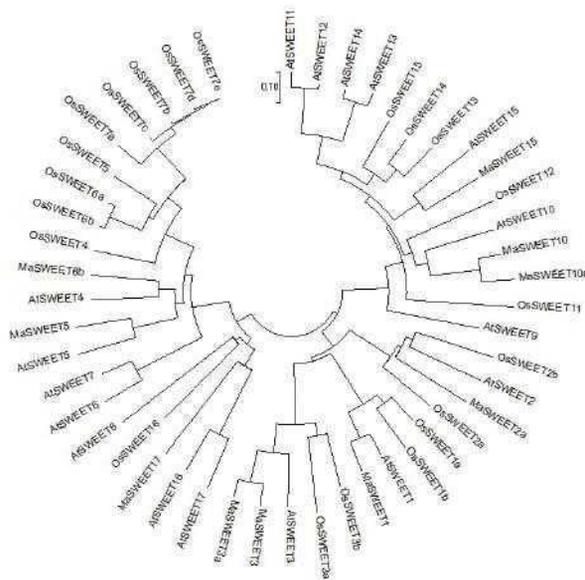
Anther and pollen characterization using scanning electron microscope showed a distinct variation among the progenies. The precocity in flowering was observed in R9P15, R9P6, R4P2, R6P, R8P5, R12P8, R11P4 and R11P1 progenies. SSR markers MiIIHR_31, MiIIHR_26, MiIIHR_34, MiIIHR_36, MiIIHR_23, MiIIHR_17, MiIIHR_18, MiIIHR_30(8 nos) were used to distinguish the origin of seedlings. No plants showed similar banding pattern with their respective mother plant. Percentage of seedlings per seed from cultured embryo was higher in *in vitro* conditions compared to those grown under greenhouse conditions. The first or early seedling to emerge per seed was found to be taller and vigorous than late emerging seedlings.

Mango polyembryony DNA was isolated and PCR analysis was done for 533 OP progenies of Nekkare and Vellaikolumban. Panel of 11 SSR primers developed for Mango (LMMA 12, LMMA 9, LMMA 10, Mliihr 11, Mliihr 18, Mliihr 15, Mliihr 23, Mliihr 24, Mliihr26, MISHRS 29,) were used for genotyping and identification of zygotic/nucellar seedlings. All the progenies can be identified by the based on their specific allele size of the SSR marker which is specific to the genotype.

Screening for biotic resistance: Out of 7 polyembryonic varieties screened for resistance to *Verticillium* wilt, EC95862 was found to be resistant to wilt.

Gene Identification: Ten SWEET (Sugars Will Eventually be Exported Transporters) genes were identified in cv Alphonso at fruit ripening stage from annotated mango scaffold data. Gene specific primers were designed and

q-PCR analysis was done at four ripening stages namely, mature green, semi-ripe, half ripe and full ripe mango, cv. Alphonso.



Phylogenetic analysis of identified mango SWEET genes

Papaya

Screening for PRSV tolerance: Based on the combined tolerance to PRSV and desirable fruit quality, the intergeneric progeny S 12-2 has been advanced for next generation. The fruit weight of the selected progeny ranged from 880 to 910 g, pulp thickness from 2.9 to 3.5 cm, TSS from 9.0 to 10.2 °B, with yellow orange (24 A) pulp.

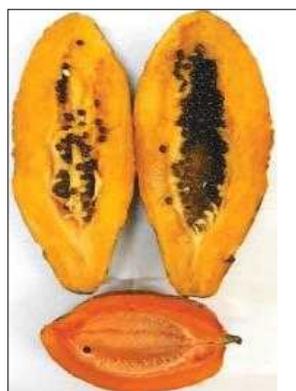
A total of 180 F₁ intergeneric progenies involving ArkaPrabhath, Surya and Red lady as female parents with *V.cauliflora*, *V.parviflora* and *V.cundinamarcensis* as male parents were challenge inoculated and field planted for further evaluation. Twenty progenies from F₂ intergeneric crosses (Arka Prabhath X *V.cundinamarcensis*) and 36 progenies of BC₁ crosses (Arka Prabhath x *V. parviflora*) were field planted after challenge inoculation for evaluation of morphological and fruit traits.

Screening of papaya 'Arka Surya' plants by MS-RAPD markers: Twelve biological samples from DNA-methylation-modifier treatments on papaya cv. Arka Surya zygotic-embryos, and plants issued thereof analyzed for variation in methylation status by methylation-sensitive restriction fragment analysis using six RAPD primers on DNA samples digested with methylation-sensitive and methylation-insensitive isoschizomers of the enzyme MspI (M) vs. HpaI (H); and, TfiI (T) vs. PfiI (P). The DNA methylation status varied among individuals showing, that, DNA methylation-modification was successfully induced.

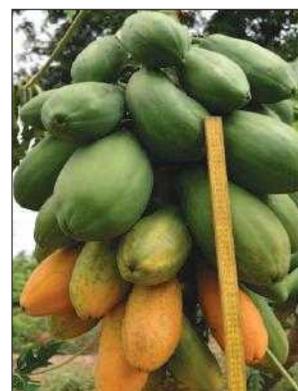
Gamma mutagenesis: M₁ populations (50-500 Gy treatments and control) of gamma mutagenesis induced

lines were evaluated for quantitative parameters including plant height at fruiting, trunk circumferences, canopy spread (N-S), canopy spread (E-W), number of leaves at first flowering, number of nodes to first flowering, height to first flowering and yield. And qualitative parameters such as date of first flowering, sex, type of leaves, branching pattern and initial PRSV infection were recorded. Pearson χ^2 analysis with continuity correction, likelihood ratio, Fisher's exact test (containing no. of valid cases) was used to analyze the populations. Significant differences were recorded in several traits. A yellow pulped variant was derived in ArkaPrabhath background. PCR analysis of 14 cloned genes was performed.

Papaya cv. Arka Prabhath wet seed treated (50 and 35 Gy) and dry seed treated (400Gy) were expressed more in dwarfness and fruit variability (size, shape, weight, fruit cavity, fruit filling and colour of the pulp). Yield per plant was noticed more in lower dosage 35Gy and early harvest also in the same treatment. Arka prabhath cultivar mutated population showed more variability when comparatively Arka Surya.



Fruit of a yellow pulp variant of ArkaPrabhath



Dwarf variant induced by mutation breeding

Guava

Breeding for yield and quality: Two hybrids viz., H-1314 and H 12-5 of the combination Purple local X Allahabad Safeda were proposed for VTIC approval. H 13-14 has been isolated for medium to big sized round fruits (180 to 220 g) with smooth shiny surface, white pulp, firm with thick outer pulp (1.2 to 1.4 cm), medium seed softness (9.0-12 kg/ cm²) with a TSS of 10.0-12.0°B suitable for both table and processing. The plants are of semi-vigorous with prolific bearing. H 12-5 has been isolated for red pulp with medium sized, round fruits (180-220 g) with smooth shiny surface, having medium soft seeds (9.5 to 12.0 kg/ cm²) with good TSS (10.0 to 12.0°B), keeping quality and suitable for both table and processing. The plants are of semi-vigorous with prolific bearing. Screening of guava hybrids / species for fruit fly (*Bactocera correcta*, and *Bactocera dorsalis*) the

per cent infestation ranged from 8.28 (Arka Kiran) to 37.68 (H 5-9) and 22.2 (Arka kiran) to 64.08 (H 8-30) respectively.



H 13-14



H 12-5

Micropropagation of Guava cv Arka Kiran – a pink pulped variety : Initiation and establishment of healthy *in vitro* cultures of guava cv Arka Kiran was successfully accomplished after controlling the problem of phenolic exudation through use of antioxidants and PVP. Sprouting of guava cv ArkaKiran explants to the extent of 36-45% was obtained with the incorporation of putrescine in the culture medium with season playing a major role in the initiation and establishment of cultures.



Initiation of fresh sprouts in *in vitro* cultures of guava cv Arka Kiran

Grapes

***In vitro* culture:** One-month old single node cuttings of Dogridge cultured in MS based media, recorded early bud burst ($3.00 \text{ days} \pm 1.00$), less contamination, longer shoots (5.34 ± 1.85) and early root emergence (48 ± 5.64). Single node cuttings were exposed to 10 Gy, 15Gy, 20 Gy, 25 Gy and 30 Gy gamma ray irradiation. 50% lethal dose was found in 10 Gy which was on par with 15 Gy.



Dogridge rootstock single node cuttings established in MS basal media

Endophytic bacteria: NGS mediated 16S rRNA metagene taxonomic profiling on Field shoots of Flame Seedless showed predominantly Proteobacteria phylum succeeded by Actinobacteria, Firmicutes, Bacteroidetes and 15 other phyla including several candidate phyla (135 families, 179 genera). Callus stocks displayed broad bacterial diversity (16 phyla; 96 families; 141 genera) bearing resemblance to field tissues with Proteobacterial dominance, enrichment of Actinobacteria and Firmicutes, disappearance of some field-associated phyla and detection of a few additional taxonomic groups over field community. Similar results were documented during 16S V3-V4 amplicon taxonomic profiling on Thompson Seedless field shoot-tip and callus tissues. Video-microscopy on tissue homogenates corroborated enormous endophytic bacteria.

Sapota

Breeding for yield and quality: 36 seedling progenies and 42 hybrid progenies of Cricket Ball x PKM-1, PKM-1 x Kalipatti and PKM-1 X Cricket Ball were evaluated for fruit quality parameters during the year. Among seedling progenies seedling-6 produced larger fruits (210g) where as seedling-116 and seedling-40 had highest TSS and total sugar content (25.60°B; 22.22%) respectively. Seedling-63 continued to show dwarf stature with 2.90M height as compared to other progenies which had 6.80M height. In hybrid progenies 3-1-18 (CB x PKM-1) had highest fruit weight of 175.80g, hybrid 3-7-12 and 3-3-16 had highest TSS and Sugar content (25.4°B; 30.30%) respectively. Hybrid progeny of PKM-1 X CB 3-16-5 had lowest height.

Pomegranate

Trait evaluation: 36 elite pomegranate lines identified from single plant selection were evaluated for characters such as disease tolerance, large fruited attractive fruits with bold arils and high TSS or suitability to anardhana along with check varieties like Bhagwa and Wonderful. Based on the fruit quality parameters evaluated individual fruit weight ranged from 77 to 200g. TSS ranged from 14 to 17 B. The aril colour ranged from light pink to red colour. The gamma irradiated mutants of Baghwashowed varied aril length ranging from 7.6 to 9.6 mm and aril width from 3.8 to 6.9 mm. TSS ranged from 9 to 15 °B among the progenies.

Annona

Breeding for Elite line: A pre-breeding line (19/26) identified for its self-fruitfulness was crossed with eight different varieties of *Annona squamosa* (Balanagar, APK-1, Mammoth, Red Sitaphal, Barbados, Washington

07005 and Raidurg). The crossed seeds from different combinations have been extracted and being maintained in the nursery for planting in the ensuing season



Profuse fruiting of Annona pre-breeding line 19/26

Pummelo

Breeding for quality: The biochemical analysis of fruit pulp of 25 pummelo accessions revealed that the accession-3 recorded maximum content of ascorbic acid (78mg/100g), accession-14 recorded maximum content of TSS(15.06°Brix), accession-21 towards reducing and total sugars(10.33g/100g) and Accession- 22 has less acidity (0.79%). The volatile profiling in juice of selected pummelo accessions revealed more than 50 compounds through GCMS. Among them, the sesquiterpenes levels were found to be high. In flavanoid profiling 12 compounds were identified in juice of selected pummelo accessions. Among the flavanoids, Noringenin is a bitter principle in pummelo was found to be less in 20-1 and 19-1 which are being used in the breeding programme.

Banana

Linkage analysis: Out of 288 SSR markers screened for parental polymorphism, 138 markers were found to be polymorphic among the parents *M. acuminata* “Calcutta-4” and *M. acuminata* “Kadali”. Ninety four F₁ progenies from a cross between two contrasting genotypes were

employed. 62 markers were mapped on 11 Linkage groups at LOD score of 3, spanning 1512.3 cM. The current study would help to serve a strong foundation for fine mapping of genes and their utilization in *Musa* breeding programs for Fusarium wilt disease tolerance.

Genetic transformation: Banana cv Rasthali was transformed with four antiapoptosis gene constructs for *Fusarium* wilt resistance and acclimatized in glass house. The root challenge bioassay of PCR and RT-PCR confirmed transformants is in progress.

3.2.2 Vegetable Crops

Tomato

Identification of source of resistance to Tomato Leaf Curl Bangalore Virus (ToLCBV): Nineteen lines received from USDA were screened for ToLCBV resistance through whitefly transmission and nine accessions viz; *Solanum pimpenellifolium* LA 0397, LA 1416 & LA 1589, *S. arcanum* LA 2157, *S. lycopersicum* LA 1243, LA 0177 & LA 2003 *S. chilense* LA 1963 and *S. comeliomulleri* were found resistant to ToLCV.

Identification of sources of resistance to South American tomato moth (*Tuta absoluta*): Twenty one genotypes including six wild accessions of tomato were screened for resistance to *Tuta absoluta* under polyhouse conditions. *Solanum lycopersicum* LA1257 and *Solanum comeliomulleri* LA1274 were found relatively resistant to *Tuta absoluta* based on mean per cent damage. *In-vitro* studies further confirmed the promising wild accessions particularly *Solanum arcanum* LA2157, *Solanum pennellii* LA 1940 and *Solanum comeliomulleri* LA1292 as good source of resistance against *Tuta absoluta*.

Confirmation of resistance to Tomato Leaf Curl New Delhi Virus (ToLNDV): Ten entries were screened against *Tomato Leaf Curl New Delhi Virus (ToLNDV)* at ICAR-IIVR, Varanasi and ICAR-IARI, New Delhi. The response of the IIHR lines is provided in the following table:

Table : Confirmation of ToLNDV resistance in Tomato lines of IIHR at IIVR & IARI

S. No.	IIHR lines	Entry name	Ty gene	% Disease Index	
				IIVR	IARI
1	IIHR-2101	<i>S.habrochaites</i> LA-1777	Ty2+Ty3	-	MR
2	IIHR-2892	4-3-3-3	Ty2 (Ty3/-)	S (90%)	R
3	IIHR-2901	CLN3070J	Ty2	10.0	R
4	IIHR-2611	TV 55	UK Ty	HR (2.43%)	R
6	IIHR 2896	CLN3552B	Ty1+Ty2	HR (0%)	HR
7	IIHR-2902	CLN3241H27	TY2+Ty3	-	HR

8	IIHR-2921	Abhinav	Ty1		MR
9	IIHR-2809	<i>S. peruvianum</i>	UK Ty	R	MR
10	IIHR-2922	Laxmi	-	-	S

Development of F₁ hybrids for commercial segments:

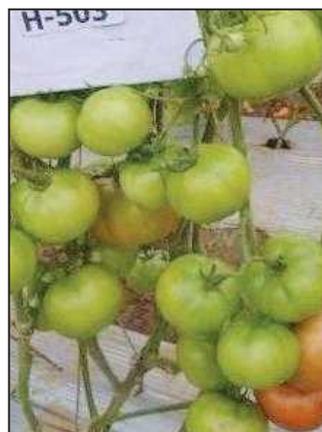
Three F₁ hybrids viz; H-502 (Laxmi segment), H-504 (Shivam segment) and H-505 (FM hybrid) were developed by stacking Ty genes (Ty2+Ty3). All the hybrids were on par with commercial hybrids in yield but had more firm and large fruits with high level of resistance to ToLCV on artificial screening when compared to commercial hybrids.



H-505 developed for Fresh Market



H-502 developed in acidic segment;



Indeterminate F₁ hybrids (H-503 & PH-1025) for polyhouse cultivation

Development F₁ hybrids for yield and fruit quality attributes in tomato:

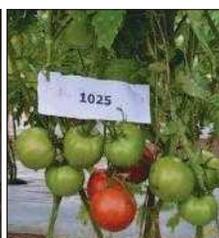
Out of 55 hybrids developed for Fresh market, six semi-determinate F₁ hybrids viz; H-387, H-391, H-392, H-397 and H-423 were developed for open cultivation and H-391 was also found suitable for processing. Five indeterminate F₁ hybrids viz; PH-1021, PH-6321, PH-1025, H-501 and H-506 were bred for polyhouse cultivation. All the above hybrids were found promising for yield (>75tons/ha) and fruit quality attributes.



H-397: High yielding F₁ hybrid under CRPH



H-391: High yielding F₁ hybrid suitable for processing



Indeterminate F₁ hybrids PH-6321, PH-1025, PH-1021 suitable for polyhouse cultivation

Incorporation of high temperature & drought tolerance in tomato:

A total of 124 F₇ plants derived from the cross involving large fruited HT line (CLN 3125A) and drought tolerant line (RF₄A) were raised for further advancement. Five IPS yielding higher than both the parents were selected for replicated yield trials. SH-1 an Inter-specific (15 SB SB x *Solanumhabrochaites* LA-1777) was confirmed as drought tolerant root stock in tomato.



RILs advanced for HT & DT Shivam as Scion Inter-specific root stock (SH-1)

Genetic transformation: PjVP1 a vacuolarpyrophosphatase gene from a hardy shrub, *Prosopis* was expressed in tomato for enhancing the root growth and improved drought and salinity tolerance. The T₃ tomato lines, PjT3-C1-13a and PjT3-A3-3a had 31 to 43% higher root mass and 56-63 % higher root length than the non-transgenic control plants.

Marker assisted selection: Pyramiding of Ty-2, Ty-3, Ph-2 and Ph-3 genes was done to develop combined resistance against tomato leaf curl virus and late blight disease in tomato. Introgression of Ph-2 and Ph-3 markers in ArkaRakshak hybrid parents to develop additional resistance against late blight disease in high yielding hybrid ArkaRakshak was carried out. Quantification of Bangalore virus titer and accumulation of viral genomic

unit in resistance lines and susceptible lines was done using RT-PCR assay. Genotyping of tomato parental lines and their progenies is under process using KASP™ assay.

Chilli: Large scale seed production of released varieties/ F₁ hybrids: Nucleus seed production of Arka Lohit, Arka Suphal, Arka Abhir, Arka Mohini, Arka Gaurav, Arka Basant & parental seeds of Arka Meghana, Arka Harita, Arka Sweta and Arka Khyati was taken up. Large scale seed production of CGMS based chilli F₁ hybrids viz., Arka Meghana, Arka Harita, Arka Sweta & Arka Khyati; and chilli varieties Arka Lohit and Arka Suphal was done through Seed Village Concept and seed production plots were monitored twice both at flowering and fruit harvesting stages.



Seed Village Concept

Evolving high yielding varieties/ hybrids of chilli with tolerance to moisture stress: Using IHR 4517 (a line having combined resistance to low and high moisture stress), fourteen F₁ combinations were developed and evaluated for yield and fruit quality attributes during the period. Among the F₁ hybrids evaluated, IHR4517 X ArkaSuphal performed superior, followed by IHR 4517 X EC 378688 and IHR 4517 X EC 378632.

Evaluation of advanced breeding lines for combined resistance to thrips and viruses (CMV & ChiVMV) in chilli: Advanced breeding lines were evaluated during the period for thrips, CMV and ChiVMV tolerance in the field conditions. Further, in order to identify the range of host-associated volatile cues that thrips can detect and also to understand the role of olfaction in modulating thrips behaviour, a preliminary biochemical profiling in thrips resistant (TR) vs thrips susceptible (TS) lines of chilli was done through LCMS & GCMS and the phenolic acids profiling showed variation in ferulic acid and salicylic acid among the two lines. The Apigenin and naringenin,

flavonoids also varied among the two lines.

Evaluation of advanced breeding lines for heat tolerance in bell peppers: CHT 3-1a, CHT 3-1b, CHT 3-2, Arka Gaurav, Arka Mohini, California Wonder Selection and SolanBharpur were evaluated for yield and fruit quality. Utilizing the promising lines, seed multiplication of F₁ hybrids was taken up during the period.



CHT 3-1



CHT 3-2

Evaluation of advanced breeding lines for powdery mildew resistance in bell peppers: During the period eleven CPMR lines were evaluated for yield, fruit quality and resistance to powdery mildew. Among the lines evaluated CPMR 15 and CPMR 47 were found superior.

Water Stress adaptation through grafting: The physiological response of grafted bell-pepper to water stress was evaluated under field conditions. Bell-pepper (CHT3-2) was grafted on Arka Mohini (AM), Arka Gaurav (AG) and Bullet Chilli (BC). The grafted plants maintained higher leaf turgidity as indicated by less reduction in RWC and water potential. Among the grafts, CHT3-2/AM maintained highest RWC (71-79%). The grafted plants maintained higher root length, volume, fresh weight and dry weight upon 10 days of water stress period compared to self-grafted plant; the highest parameters was noticed in CHT3-2/AM and CHT3-2/AG. Under stress CHT3-2/AM grafts showed higher photosynthetic rate, fluorescence efficiency, better electron transport and higher activities of antioxidant enzymes compared to non-grafted plants. The recovery of photosynthesis and its characteristics was also better in grafts compared to self-grafted plants.

Grafting studies in hybrid capsicum: Green bell pepper hybrid Indra was grafted on to four chilli selections/ varieties that are resistant to nematodes. The graft success was 70%, polyhouse grown grafted green bell pepper

hybrid Indra on chilli root gave higher yield (46.8-50.6 t/ha) compared to non grafted Indra hybrid (42.6 t/ha).

Maintenance of chilli male sterile (CGMS) lines and restorer lines of F₁ hybrids: Nine sets of cytoplasmic-genic male sterile lines *viz.*, MS1, MS2, MS3, MS4, EC 771551/2, EC 771553/4, EC 771549/ 50, CCA 4261 and CCA 4916 with varied fruit types were maintained during the period along with corresponding maintainer lines. Further, the male parents (R lines) of Arka Meghana, Arka Harita, Arka Sweta and Arka Khyati were maintained. Further, in order to search for new sterile cytoplasm, fifteen sets of new primers were designed and procured during the period.

Advancing and evaluation of introgressed pre-breeding lines for anthracnose fruit rot resistance: Intraspecific crosses were attempted with various accessions of *C. baccatum* & seeds collected. F₂ seeds of PBC 80 & Belly type were collected. F₁ progeny along with parents were evaluated for *C. truncatum* & *C. gloeosporioides* resistance.



Various accessions of Capsicum baccatum

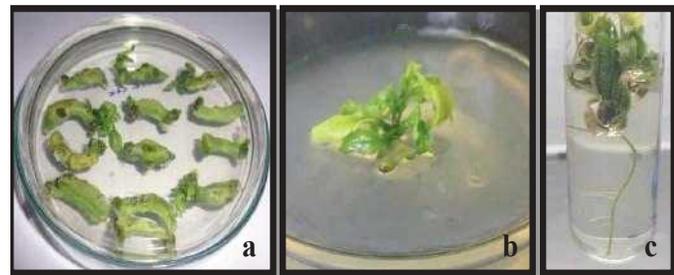
Molecular analyses for anthracnose fruit rot resistance genes: The parental polymorphism (contrast for resistance) assessed by using 327 SSRs and also through GBS and a total number of 3250 SNPs and 40 SSRs showing polymorphism were identified. The polymorphic SNPs identified are located across the genome, spreading across 12 chromosomes. 400 F₂ and BC populations DNA was isolated for further molecular mapping. Randomly selected DNA samples of 98 F₂ populations along with parents was out sourced for GBS studies

Breeding for biotic stress resistance: IHR4582 & Arka Mohini derived populations were evaluated for tospovirus resistance and found the resistance is not simply inherited. Colonization index at collar level of 385 F₂ populations of Anugraha X KTPL 19 derived, could differentiate resistant genotypes more clearly as the chilli

plants are symptomless carriers to bacterial wilt incidence. The results showed that bacterial wilt resistance in chilli is polygenically controlled trait. Among the lines evaluated, two chilli lines *viz.*, EC769375 and EC769430 showed tolerance to *Bemisia tabaci*. Out of chilli germplasm lines challenge inoculated, three lines are found highly resistant to ChiLCV. Using the contrast parents F₂ and back cross populations are being developed. F₂ populations of RxR lines are being developed for allelism studies. Ty and RGA markers were validated in the contrast parents.

Registration of Extant Varieties with PPV&FRA: Four Extant varieties *viz.*, Arka Lohit, Arka Suphal, Arka Meghana and Arka Harita were registered with PPV&FRA and received registration certificates during the period.

Genetic Transformation: Chilli cv G4 was transformed with dsRNACMV construct for cucumber mosaic virus resistance through Agrobacterium mediated transformation. The putative transformants were selected on kanamycin 100mg/L. The rooting was observed in 2mg/L IBA after 45 days inoculation.



Development of transformants over expressing dsRNACMV construct (a) Regeneration of cotyledon explants (b) Elongation (c) Rooting of putative transformants

Okra:

Screening of okra advance lines for yield, quality and resistance to YVMV and ELCV diseases: Out of 25 advance lines evaluated in hot spot area of Guntur, A.P, Improved Arka Anamika recorded the highest fruit yield of 20.95 t/ha with 11.91 % incidence of YVMV at 90 days after sowing followed by IIHR-299-12-14 (20 t/ha) with 6.33 % incidences of YVMV. The lowest yield recorded from 9.20 t/ha (IIHR-362-1-3) with 70 % incidence of YVMV. Eight lines were found free from YVMV and ELCV. The selected lines fruits appeared dark green smooth with 5 ribs and good keeping quality

Evaluation of GMS based okra F₁ hybrids for yield, quality and resistance to YVMV disease: Eight okra F₁ hybrids (GMS based) were evaluated during summer season at hotspot area (Vangalapalyam) of Guntur. Among them GMS-OKMSH-3 found superior for high fruit yield (21.80t/ha) with medium length and girth and also resistance to YVMV (4.5 % incidence) under natural

field condition This is followed by OKMSH-7 (21.31 t/ha yield) and tolerance to YVMV. The fruits of OKMSH-3 appeared dark green, smooth, thin, free from hairs and 5 ribs early maturing type followed by OKMSH-7.

Identification and release of promising GMS based F₁ hybrid Arka Nikita for yield , quality and tolerant to YVMV at Institute level by VTIC: Arka Nikita, a newly released okra variety is early flowering (33-36 days) and flower appears at 4th node, takes 49-50 days for first picking of fruits, dark green, medium long, tender, smooth fruits and 5 ribs, plant green stem, one side petal base color purple, 3-4 narrow angle branches, yielding 21-24 t/ha in 115-120 days of duration suitable for both *Kharif* and Summer season. Rich in Iodine: 33.31 μg/kg, mucilaginous substance: 1.08 % (FW), edible fiber : 8.85 % (DW), Potassium :3.7 % , Zn : 43.34 ppm. It is first commercial genetic male sterile based F₁ hybrids from India and world.



Arka Nikita GMS based F₁ hybrids & VTIC visit to demo plot

Initial evaluation of new F₁ hybrid for yield, quality and resistant to YVMV: Nine hybrids with 2 commercial checks were evaluated during summer at Guntur for nine characters in an Observational Row Trial (ORT). Among them, two hybrids namely GMS-4XIIHR-385-2 (19.87 t/ha) and GMS-4XIIHR386-7-2 (18.24 t/ha) found superior for yield, quality and both are resistant to YVMV (<10 % incidences).

Screening okra for resistance to biotic stress: A total of 130 accessions including (Arka Anamika) were screened against jassids, among them, two accessions (IC-O394158 , IC-506045) had less incidence of jassids (0-5.0 jassids/leaves), nine accessions recorded the highest incidence (77.4 to 94.4 jassids/ leaf). IIHR- 402

was found to be resistant; seven were moderately resistant Arka Nikita 1685, Anamika, 311, 359, 362 and 368 and rest were susceptible to root knot nematode (*Meloidogyne incognita*). Two lines viz., IC -329394-1 and IC-140985-2 were found to be resistant to powdery mildew disease. Whereas, Arka Anamika was found to be susceptible to PM (30 % incidence).



IC -329394-1



IC-140985-2

Watermelon:

Evaluation of icebox watermelon lines/hybrids for yield and quality traits: Nine recurrent selection families of watermelon with orange flesh have been evaluated. Two of these, line no 36 (TSS 11%) and Line-39 (TSS 11.7%) were found promising

Screening of watermelon for resistance to WBNV under natural epiphytotic conditions: 283 RIL and BIL families of interspecific cross of watermelon were screened for resistance to WBNV under natural epiphytotic conditions during summer, 2017. Among them BIL-53, RIL-174, RIL-175, RIL-180, RIL-185, RIL-197, RIL-284, RIL-306 and RIL-337 were found promising.



Reaction of watermelon resistant (Right) & Susceptible (Left) to WBNV

Genetics of resistance to WBNV: Six generation mean analysis was conducted to understand the genetics of resistance to WBNV in the cross involving resistant (BIL-53) and susceptible icebox (IIHR-140-152) parents. The results revealed that additive component was significant and negative in direction contributing towards resistance. The results of segregation in F₂ and back cross progenies

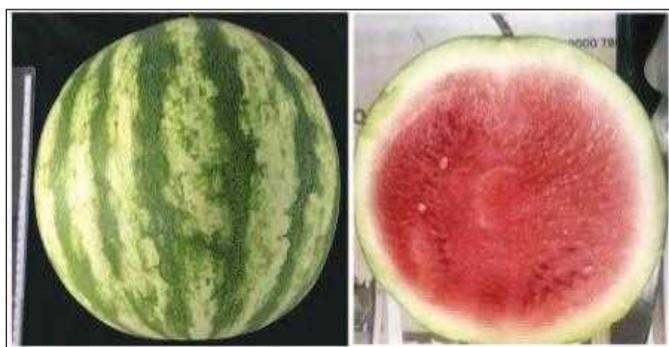
suggest that resistance is governed by a major dominant gene along with other background minor genes. QTL analysis was performed for WBNV resistance in the cross BIL-53 x IIHR-140. A major QTL with 11.7% PVE at 3.02 LOD was identified.

Artificial screening of watermelon germplasm for *Fusarium* resistance: A total of 340 germplasm accessions of watermelon have been screened for two isolates of *Fusarium oxysporum* f sp. *niveum*. While all the commercial hybrids were susceptible to both the isolates, 19 germplasm accessions were identified to possess resistance to both isolates. These are being tested as root stocks. Most promising were IIHR-9 and EC-759804 which were resistant to both isolates.



*Reaction of susceptible (left) and resistant (right) genotypes of watermelon to *Fusarium oxysporum* f sp. *niveum**

Seedless Watermelon: Micropropagated triploid watermelon was grown in the open field in the Demonstration Block and in the polyhouse. The plants showed 80-90% field establishment. The polyhouse plants showed good growth and flowering. It warrants controlled pollination for good fruit set and yields. Plants in the open field showed vulnerability to Watermelon Bud Necrosis Virus (WBNV). Triploid watermelon appeared better suited for protected cultivation under polyhouse conditions. The fruits weighed 4-6 Kg with a TSS of 9-10%.



Micropropagated triploid seedless watermelon in polyhouse

Muskmelon:

Evaluation of muskmelon inbreds for yield and quality traits: A total of 73 inbred lines of muskmelon have been evaluated for yield and quality traits during summer, 2017. Among them, IIHR 2016-10 (12.7 % TSS; 1.1 kg), IIHR 2016-24 (TSS:12.14%; 0.7 kg) and IIHR 2016-45 (TSS:13.47%; 0.45 kg) were found promising. A total of 60 inbred lines in orange, green and white fleshed backgrounds of muskmelon selected from summer 2017 have been evaluated and promising lines were forwarded during Rabi, 2017-18. Among them, Sel-7, Sel-37, Sel-48 and Sel-22 have been found promising.

Ridge gourd

Advancing the segregating populations: Out of eighty four families belonging to F_7 generation, 193 IPS belonging to all four pedigree populations have been advanced based on the selection criteria. Among 193 selected IPs, 5 IPs were very dark green fruited, 78 IPs were dark green fruited and the remaining IPs were green fruited. Whereas with respect to fruit length, 90 IPs were long fruited, 98 IP were medium fruited and remaining were short fruited. Among the selected IPs, 15 IPs belonging to 11 families were found to be resistant (score 0) to powdery mildew under field conditions. With respect to ToLCND Virus resistance (0-5scale), 34 IPs belonging to 29 families showed moderate resistance (score 1) and 4 IPs belonging to 4 families were found to be highly susceptible (score 4).

Advancing ToLCND virus resistant inbred lines during summer: Forty-four advanced resistant inbred lines and two susceptible lines were screened against ToLCND virus under field conditions during summer season. Scoring has been done on 0-5 scale at 15 days interval after the incidence was observed and vulnerability index (VI) has been worked out. Based on the average VI, 21 advanced inbred lines were found to be resistant (VI<25.0) and two lines were highly susceptible (VI=80.0). Out of the 21 resistant advanced inbred lines, RV-9-1-9 and RV-2-4-12 had very low VI (<15.0). Self-seeds of all the resistant lines were collected for further evaluation.

Advancing combined resistant selections for Downy mildew and ToLCND: Twenty-one combined resistant advanced breeding lines belonging to BC1F5, BC2 F5 and BC2 F6 families were screened against downy mildew as well as ToLCND virus during late *kharif*. Out of these 21 families, one family viz., BC2 F6 [(23-8-10 x 7-5-1) 7-5-1]-24-2-1-7-6 (VI=0.0 and PDI=5.6) showed combined resistance to both ToLCND virus and downy mildew diseases. Five other families belonging to BC1F5 and BC2 F6 generations were found to be resistant to ToLCND virus (VI ranged from 0.0 to 15.0) and

moderately resistant to downy mildew (PDI ranged from 13.9-17.8). Selfed seeds of all these lines were collected for further evaluation.



Ridge gourd advanced breeding line, BC2 F6-24-2-1-7-6 with combined resistance to downy mildew + ToLCND virus

Expression of male sterility and restoration of fertility in F₁ hybrids:

Out of the eight ms x mf crosses evaluated, one cross, 12MS x IIHR-37 had 100% male sterile plants, indicating the cytoplasmic inheritance of male sterility in ridge gourd. Six other crosses viz., 12MS x IIHR -10-1, 12MS x IIHR -30, 12MS x IIHR -70, 12MS x IIHR -72-1, 12MS x IIHR -73 and 12MS x IIHR -72-2 had 100% male fertile plants indicating that these monoecious lines could be possible restorer lines. One more cross, 12MS x IIHR -72-2 had segregating population for sterility/fertility indicating that the fertility restorer genes might be in heterozygous condition in these inbred lines which can be used to develop either maintainer lines or restorer lines after progeny evaluation and back crossing.

Analysis of F₂ populations of five MS x MF crosses for male sterility and restoration of fertility:

F₁, BC₁ and F₂ populations of five msx mf crosses were evaluated for segregation of fertility and sterility. All the F₁ plants of three ms x mf crosses and two of their corresponding back cross populations were male fertile. As the F₂ population segregated into two classes in all the crosses, monohybrid ratio, 3:1 was tested for significance using chi-square test. The chi-square value for the 3:1 (fertile: sterile) single dominant gene action exhibited a good fit to the expected ratio (80-90% probability) in only one F₂ population of the cross, 12MSxIIHR-12. This again confirmed the presence of cytoplasmic genic male sterility (CGMS) in ridge gourd with single dominant gene restoring male fertility in either homozygous or heterozygous condition in the presence of sterile cytoplasm. In rest of the crosses the fertility restorer genes might be segregating.

Advancing the male sterile back cross populations:

Ten male sterile back crosses (BC₂ generation) were advanced to develop male sterile lines in different genetic backgrounds (long, medium long and short fruit length). Out of these 10 back crosses, seven produced 100% male sterile plants with rudimentary male flowers, two back crosses produced intermediate flowers which had small sized male flowers with less pollen and one back cross had healthy male flowers with good amount of pollen. Hence, selected plants having fruit type similar to their

respective male fertile parents from the seven male sterile back cross populations were again back crossed with their respective male fertile monoecious parents to develop male sterile lines in that genetic back grounds. Back crossed seeds and the selfed seeds of the parents were collected for further development.

Bitter gourd

Evaluation of bitter gourd inbred lines during summer:

Eighteen bitter gourd inbred lines were evaluated in replicated yield trial during summer for yield and yield components and viral disease incidence. IIHR-12-6-2 was the earliest inbred to produce female flowers at 9.87 node and IIHR-147-12-1 produced first female flower within 47.27 days. Maximum fruit length was recorded in IIHR-134-1-3 (15.64 cm). Maximum fruits/plant was recorded by IIHR-147-12-1(17.63) whose fruit length was minimum (6.7 cm). Out of these 18 inbreds, IIHR-14-2-6 recorded maximum yield of 10.32 t/ha followed by NDBT-9-5-1 (7.31 t/ha). All the inbreds were susceptible or highly susceptible to CABM virus (62-97.5 PDI) whereas five lines were resistant to leaf curl virus (<10 VI) under field conditions.

Advancing the breeding lines during summer:

From the 78 F₃ families of bitter gourd, 173 IPs were advanced based on node (9-22nd node) and days taken (32-45 days) for first female flower appearance, fruit length (7-22.2 cm), fruit girth (9.75-14.3 cm), fruit number (1-21), fruit weight (26-150 g), fruit color, (green, dark green, very dark green), ridge type (continuous, discontinuous), tubercle (prominent, non-prominent). With respect to cucurbit aphid born virus incidence, 11 IPs belonging to 9 F₃ families were found to be less susceptible (scale 1) under field condition. As per the leaf curl virus scoring done before CABM virus incidence, all the selected IPs were less susceptible (score 0-2).



Fruits of selected F₃ generation IPs in Bitter gourd

Advancing the breeding lines during kharif: From the 148 F₄ families evaluated, 349 IPs were advanced based on fruit length (6.7-28.1cm), fruit color, (green, dark green, very dark green), ridge type (continuous, discontinuous), presence of white tip (present, absent), tubercle (less, medium, many), downy mildew disease index (0.2-0.92) and leaf curl virus incidence (0-5 scale). There was severe incidence of downy mildew but, leaf curl incidence was very less during kharif. Out of 349 selected IPs, only six IPs showed less downy mildew incidence (0.2 DI). With regard to the leaf curl virus incidence, only few IPs had severe incidence and rest had very less incidence. Self seeds of all the selected IPs were collected for further evaluation.

Evaluation of Bitter gourd F1 crosses made between Gynoecious and Monoecious plants: Nine Gynoecious x monoecious crosses along with their monoecious parents were raised to observe the sex expression. All the F1 plants of all nine crosses were monoecious indicating the recessive nature of the gynoecy. Flower and fruit characters of these crosses and parents were recorded. With respect to fruit characters, there was not much difference between Gynoecious hybrids and parents except that the hybrids had male flower at later nodes (7.34th node) than the parents (6th node). Even the fruit characters like fruit length, fruit girth and fruit weight were also almost similar in both Gynoecious hybrids and the respective male parents.

Inheritance of Gynoecy: Monoecious parents, back crosses and F2 populations of three Gynoecious x Monoecious crosses have been raised to find out the inheritance of gynoecy in bitter gourd during kharif season. All the plants of parents and back crosses were monoecious indicating the recessive gene nature of gynoecy. This was also confirmed by the segregation of F2 population into 2 classes viz., monoecious and gynoecious in 3:1 ratio which further indicate the single recessive gene inheritance of gynoecy in bitter gourd.

Transferring Gynoecy into different genetic backgrounds: In order to transfer the gynoecy in to different genetic back grounds depending on various fruit traits viz., fruit color (green/ dark green/ very dark green), fruit length (long/ medium long), fruit ridge type (continuous/ discontinuous), number of tubercles (less/ many), tubercular prominence (prominent/ non-prominent), white tip (present/ absent); three-way crosses have been developed in 24 cross combinations. All these crossed seeds along with the selfed parent seeds were collected for further evaluation.

Transferring powdery mildew resistance into different genetic backgrounds: In order to transfer the powdery mildew resistance in to different genetic back grounds with respect to fruit color (green/ light green) and ridge type (continuous/ discontinuous ridges), hybridization was done between 21 powdery mildew susceptible inbred lines and two resistant inbred lines, IIHR-144-1 and IIHR-144-1-7 and a moderately resistant line, NDBT-9-5-2-7. Seeds from these 21 crosses were collected for further evaluation.

Screening of SSR markers to study parental polymorphism between powdery mildew resistant and susceptible lines: A total of 295 SSR markers (genomic SSRs) from bitter gourd (previously reported by Yuan Ji *et al.*, 2012; Guo *et al.*, 2012; Wang and Xiang, 2013; Saxena *et al.*, 2015) were used to study the parental polymorphism between highly susceptible and resistant genotype of bitter gourd for powdery mildew disease to identify lined markers. The SSR primers were synthesized by Bioserve, Hyderabad, India. Out of the 295 SSRs, 275 primers were amplified in our bitter gourd lines of which, 23 primers viz., McSSR 3, 5, 15, 26, 27, 29, 57, 68, 107, 112, 114, 117, 129, 147, 150, 135, JY002, JY007, JY010, C4, C7, A2, A47 showed clear polymorphism between susceptible line (Arka Harit) and resistant line (IIHR-1444-1) and rest of the primers were monomorphic.

Bottle gourd

Screening of bottle gourd inbreds and varieties against GSB: Sixteen inbred lines and a local susceptible check were screened against Gummy stem blight during Rabi season. Disease incidence on leaves and stem was recorded at regular intervals after the incidence was noticed. Leaf blight and stem blight index was calculated of all the lines. Out these, two lines viz., IIHR-95-3 (PDI-40) and IIHR-M4-2 (PDI-24) were least affected (leaf and stem blight) and two other lines, IIHR-112-1 (PDI-92) and Local (PDI-79) were highly susceptible to GSB.

Radish

Evaluation for yield, physical quality and pungency in radish (normal season): In radish, Accession No 30, 41 and 31 was superior for leaf weight which recorded 30 g, 25 g and 20 g respectively. Accessions No 5 and 23 were superior for pod type having long pods of 15 cm and higher pod number (60). 5 accessions (Acc No 17, 18, 27, 37 and 40) were selected for high anthocyanin. Highest root diameter of 12 cm was observed in Acc no 17 and Acc 32. Root weight was highest in Acc No 30 (250 g) followed by Acc No 31 (200 g) and Acc No 41

(200 g) Root length was highest in Acc no 28 (28 cm), Accno 30 (25 cm) Acc. no 31 (20 cm) and Acc. no 41 (16 cm). Acc no 20, 31 and 41 were found to have less pungency in radish.

French bean

Evaluation of pole type advanced breeding lines (F₆) for resistance to rust: Forty pole type breeding lines of the crosses involving IIHRPB-2, 3, 4, 7 (pole type) and IC-525236 & Arka Anoop (rust resistant) and IIHR 231 (dark green and pencil podded) were evaluated. Two IPS lines IIHR Sel 1 and IIHR Sel 2 were made based on dark green, string less pods with rust resistance. PDI for rust ranged from 3.5 to 72.5. The nutritional profiling of disease resistant French bean breeding lines was carried out. 2015/FBB VAR 1 showed highest total phenol and antioxidant values



IIHR Sel-IPS 2 resistant line along with rust susceptible check

Evaluation of selected breeding lines for biotic and abiotic stress: Five advance breeding lines of the cross Arka Anoop and stemfly tolerant IC 525235, IC 525239 were evaluated. Breeding line (IC 525235 X AA)-09-3 BS-1 showed lowest incidence of stemfly with green pod yield of 16 t/ha. Nine advance breeding lines of the cross IC-525239 (stemfly tolerant) and IC 525224 (HT tolerant) were evaluated. Breeding line (IC 525224 X IC 525239) -10-1-6-1 showed good pod set and pod yield of 13.5 t/ha. However, Arka Arjun gave the maximum pod yield of 14.3 t/ha. Hybridization between Arka Arjun, Jade 5058 (MYMV resistant parents) and Allama, IIHRPB 7, IPS-1 (pole type lines with good pod quality) were attempted.

Cowpea

Evolving cowpea variety resistant to rust: Five advance breeding lines of the Cross VS-389, Pusa Komal, Arka Suman and Arka Samrudhi were evaluated. IIHR-16 (VS 389 x Pusa Komal) 09-1-



VS 389 x Pusa Komal

5-2-4 is early (50 days) and the pods were borne above the canopy and yielded 18t/ha. Pods were light green, stringless and thin podded. Rust disease has not appeared.

Further, hybridization of rust resistant lines with Kashi Kanchan to improve the pod quality is under progress.

Garden Pea

Identification of new and diverse sources of resistance to rust (*Uromyces viciae-fabae*) in garden pea : Out of 130 germplasm lines (including 12 released varieties of IIHR) were screened for rust resistance, two genotypes (IIHR 13-11 and IIHR 13-18) were found resistant and nine genotypes were moderately resistant (MR) and remaining 119 genotypes (including 12 released varieties of IIHR) were susceptible under field conditions. The rust resistant germplasm will further be tested for resistance under artificial challenging and will be used for resistance breeding program.



Susceptible and resistant lines of Garden pea to rust disease under field conditions

Validation of molecular markers for powdery mildew resistant genes, er1 and er2 in garden pea: Twelve varieties of garden pea developed by ICAR-IIHR were validated for powdery mildew resistant genes *er1* and *er2* by using linked SSR markers A5 (Loridon *et al.*, 2005, Lakshmanareddy *et al.*, 2015) and ScX17_1400 (Katoch *et al.*, 2009), respectively. The results indicated that, both *er1* and *er2* genes were present in seven varieties namely, Arka Sampurna, Arka Ajit, Arka Nirmal, Arka Priya, Arka Pramod, Arka Uttam and Arka Karthik. Only *er1* present in Arka Apoorva and *er2* present in Arka Mayur, Arka Chaitra and Arka Harini. However, presence of *er2* has to be further validated.

Dolichos

Evaluation of breeding lines of bush type dolichos for pod yield and quality:

Fifty breeding lines of bush type Dolichos were evaluated for yield and pod quality and seven lines were selected for next generation.



Brinjal

Evaluation of F_4 progenies for yield and resistance to bacterial wilt in bottle brinjal fruit type:

A total of ten crosses in each of IIHR 586 x Arka Nidhi, IIHR-104 x Arka Neelkanth and IIHR-104 x Arka Keshav were evaluated for resistance to bacterial wilt of which one individual plant selection IIHR-586 X Arka Nidhi-1-5 was promising for yield potential of 2.50 to 2.75 kg/pt with fruits deep purple to black, glossy and oblong in shape with average fruit weight of 300-350 g and having high level of resistance to bacterial wilt.



Individual plant selection: IIHR-104 X Arka Neelakant-4-3 was promising for higher yield potential of 2.35 kg/pt with average fruit weight of 200 g with deep purple to black colour and oval to oblong in shape and having high level of resistance to bacterial wilt whereas check black star completely succumb to wilt. IIHR-104 X Arka Keshav-2-5 was promising for higher yield potential of 2.30 kg/pt with average fruit weight of 290 g with high level of resistance to bacterial wilt

Performance of Manjarigota advanced breeding lines of brinjal for yield: Two advanced breeding lines evaluated namely: IIHR-438-2 X IIHR-571-1-2 and IIHR-438-2 X IIHR571-1-4 having potential yield 2.34 kg/pt and 2.16 kg /plant and average fruit weight 70-80 g and 90-100 g respectively. Flowers are purple with green fleshy calyx and fruits are borne in clusters which are attractive dark purple colour with white stripes, glossy, and oval in shape and have excellent cooking and keeping quality.

Performance of Manjarigota advanced breeding lines of brinjal for yield and fruit quality (Spiny fruit type): IIHR- 438-2 X IIHR-575-2-1 performed better with yield potential of 2.53 kg/plant and average fruit weight of 67 to 86 g. IIHR-438-2 X IIHR575-2-2 recorded potential yield 2.31 kg /pt with average fruit weight 74 g. Flowers were purple with fleshy green thorny calyx and fruits borne in clusters having purple colour with white stripes, glossy and oval to round in shape and has excellent cooking and keeping quality.

Performance of advanced breeding lines for resistance to bacterial wilt: A total of 12 advanced breeding lines derived from a cross between IIHR438-2 X 2BMG -1 were evaluated for yield and resistance to bacterial wilt, of which one IPS namely IIHR438-2 X 2BMG-1-1 was promising with potential yield of 2.53 kg/pt and resistance

to bacterial wilt with tall plant and spreading growth habit having dark green stem & foliage with purple flowers and fleshy green calyx, fruits borne in clusters, light purple in colour with white stripes and glossy oval in shape with average fruit weight 93 g.



IIHR438 - 2 X 2BMG-1-1

Restoration of fertility in interspecific F_1 hybrid between *Solanum melongena* and *Solanum macrocarpon*: Fertility of *S. macrocarpon* X *S. melongena* has been restored . 152 $BC_1 F_2$ seeds of interspecific hybrid (*S. macrocarpon* X *S. melongena*) were obtained successfully.

Screening of interspecific hybrid progenies (F_6) for shoot and fruit borer infestation :

Among 12 F_6 advanced breeding BFSB resistant families, screening of interspecific hybrid progenies (F_6) for shoot and fruit borer infestation under open field and artificial challenging resulted in selection of 39 highly resistant plants (0-10% BFSB infestation) and 53 resistant plants (<20% infestation). Among 12 F_6 advanced breeding BFSB resistant families, screening of interspecific hybrid progenies (F_6) for shoot and fruit borer infestation under artificial challenging of *Leucinodes* moths in nethouses, resulted in selection of 21 single plants (0-10% BFSB infestation) and 38 resistant plants (<20% infestation). Biochemical studies on total phenols, PPO, peroxidase and solasodine confirmed the resistance in the selected resistant plants from artificial challenging in nethouses.

Evaluation and identification of superior resistant lines in F_6 for yield and quality: Among 12 F_6 advanced breeding BFSB resistant families evaluated for yield and quality, 15 superior lines which are high yielding (3 kg/ plant), having more number of fruits per plant > 45 fruits and possessing good fruit quality (higher protein, ascorbic acid, lesser acidity and pH and higher TSS (%)) have been selected and advanced for further screening and evaluation

Genotyping of F_2 population: Bacterial wilt resistance CAR1-1 and IIHR-7 were used as the resistant parents.

Rampur local, IIHR-586 and Arka Kushmakar (IIHR-108) were used as the susceptible parents. F_2 population of CARI-1 X Rampur local, and IIHR-7 X Arka Kushmakar (IIHR-108) crosses were developed. About 400 SSRs were screened to identify the SSRs giving polymorphism between parents. The resistant SSR marker (SSR 46) as linked to bacterial wilt resistance loci and validated in F_2 populations.

Genetic transformation: Evaluation of four selected and promising Bt brinjal lines, 2HA1-1, 2HA1-2, 2HA1-3 and 2HA1-4 along with non-transgenic control line under contained transgenic glasshouse for resistance phenotyping: All the five lines were evaluated by resistance phenotyping in collaboration with entomologist. Differential resistance responses were recorded. Three separate and independent challenges were undertaken. On a comprehensive scale, 2HA1-3 and 2HA1-4 super selected lines were found to be promising.

Bell pepper

Bell pepper AVT-II Varietal trial: Four entries of bell pepper were evaluated under AVT-II varietal trial with 2 checks (Pusa Deepti & Nishat) and 2015/CAPVAR-2 was found best performing in IIHR, Bangalore which is at par with the checks in yield performance.

Bell pepper AVT-II Hybrid trial: Evaluated 5 entries of bell pepper under AVT-II hybrid trial with 2 checks (Pusa Deepti & Nishat) and 2015/CAPHYB-3 was found best in IIHR, Bangalore which gave significantly higher yield than both the checks.

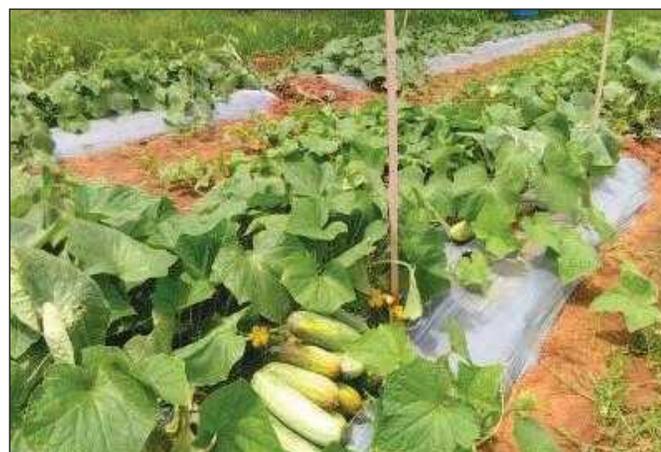
French Bean:

Resistance to MYMV in French bean: Among forty SSR markers screened parental polymorphism with Eight French bean genotypes, two were found polymorphic between contrasting parents.

Cucumber:

Evaluation of advance lines of cucumber for yield, quality and resistance to Downy mildew disease: Thirteen advance lines including susceptible check Swarna Agethi, were evaluated in RBD with three replications during Rabi season. Among them IC-613488-1-S4 found promising for highest fruit yield of 15.76 t/ha with Percent Disease Index (PDI) 8.46 followed by IC-541391-16 (yield 15.20 t/ha) with 20 PDI. However, Swarna Agethi (Check) recorded 9.23 t/ha with 63.22 PDI, which is significantly different from the rest of the lines. It has taken 36.5 days for first female flower opening, average

fruit weight is 232.64 g, fruit are cylindrical, long, light green fruit, medium diameter and free from bitter taste.



IC-613488-1-S4

Development of gynoecious and parthenocarpic cucumber: Four gynoecious lines namely IIHR-434, IIHR-435, IIHR-436, IIHR-437-11 lines were successfully developed by consecutively selfing with plant-to-row selection. Among them IIHR-437-11 was recorded for higher yield (8 kg/ plant) and early flowering (3rd node & 36.3 days for female flower opening). The gynoecious lines were maintained by spraying GA_3 at 1.3 mM for 5% staminate flower induction. The concentration varies with cucumber genotypes and environmental condition.



Gynoecious (a) & monoecious (b) plant in F_4 cucumber inbred line IIHR-437-11.

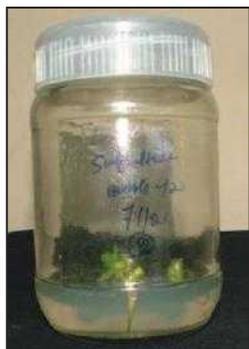
Development of Inter-specific hybridin cucumber: The cross between cv. Swarna Agethi (*Cucumis sativus*) and (*Cucumis hystrix*) were attempted, F_1 's are sterile and tried for embryo rescue with 3 different nutrient media, BAP 1mg/L resulted in 59% germination with 3% success rate. The embryo rescued plants were kept for hardening and hardened plants transferred in the field for further evaluation



F₁ (20 days old)



Immature embryo



Embryo rescued plant



Hardened plant

Development and evaluation of F₁ hybrid in slicing cucumber:

Fifteen F₁ hybrids were developed and evaluated in an ORT along with commercial check. Among them two slicing cucumber F₁ hybrid namely IC 447388 X IC 613488 and IC 447388 X IC 331628 were found for high yield (6.5 kg/ plant) and (5.8 kg /pl) with long cylindrical, green fruit and resistant to downy mildew (<12 PDI) Whereas, commercial check Chitra had (4.5 kg yield per plant) with 24 PDI downy mildew disease.



IC 447388 X IC 613488(6.5 kg/pl)

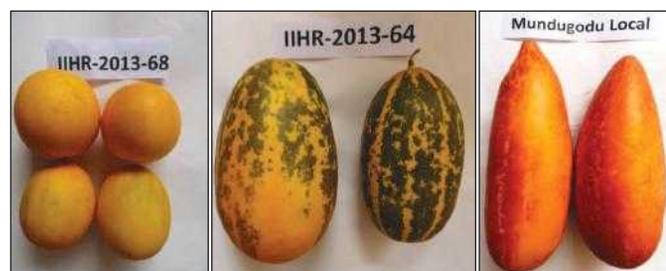


IC 447388 X IC 331628 (5.8 kg/pl)

Out of 20 sets of SSR primers linked to downy mildew resistance screened, four primers showed parental polymorphism (SSR16110, CSWTA05, SSR21747 and SSR16882). BC₁F₁ progenies were advanced to BC₂F₁ and seeds were collected. Foreground selection was done in BC₂F₁ (125 plants) using SSR markers

Evaluation of *Cucumis melo* var. Conomon: Among three advance lines evaluated, IIHR-2013-64 found to highest yield of 34.53 t/ha followed by IIHR-2013-68 (26.17 t/ha which is significantly different from rest of the line. However, Check Mudigodu Local had recorded 24.83 t/ha. IIHR -64 fruits are oblong, yellow skin with greenish specks with lining . It has 8 fruits per plant and 120 days keeping quality after harvest. IIHR-68 had round fruit smooth, golden yellow colour with 110 days keeping quality after harvest.

Validation of SSR markers (SSR-02021 and SSR-18718) linked to gynoecious trait in advanced gynoecious cucumber lines. The 185 SSR markers were screened to identify the makers linked to downy mildew resistant gene. Among them 28 makers showed a polymorphism for resistant gene at parental level. These SSR markers are using for bulk segregant analysis (BSA) in F₂ population of Swarna Agethi (susceptible) X IIHR-438 (Resistant).



IIHR-2013-68 IIHR-2013-64 Mudigodu Local Check

Best performing advance lines of *C. melo*. Var. Conomon

Breeding onion hybrids for purple blotch disease:

Thirty F₁ crosses of onion were evaluated to purple blotch disease resistance. Three hybrids namely PBR MS 439 x PBRC440 (32 t/ha, PDI 9.00) and PBRMLT MS 96 x MLTC (30 t/ha, PDI 9.55) & PBR MS 317 X PBRC340 were found resistant to purple blotch disease and gave high bulb yield with qualities. The percent heterosis in case of the first hybrid over the best parent was 30.00% & 20% over standard check. Twenty advanced lines evaluated for combined resistance to Purple blotch, Basal rot and white rot during *Kharif* season. Three advanced lines namely PBR-405-564, PBR-407-207 and PBR-372-203 showed combined resistances to Purple blotch, Basal rot and White rot diseases under field condition.



F₁ hybrid resistant to purple blotch – PBR 439 A x PBR C440

Breeding onion varieties for resilient to soil moisture stress: Forty two advance lines (F₈) were evaluated for soil moisture stress resilience. Three lines namely MST 690-50, MST810 and MST689 were found to show resilience for soil moisture stress under 20 days of stress induction at both field & lab condition

with variation of bulb yield of 30-35 t/ha. Stress was imposed by withholding water for twenty five days in field, after 30 days of transplanting under rain shelter and 8 days of stress in poly house condition in pots with the same age of the seedlings.



Resilient line- MST 810 (Developed bulbs) (Resilient line)



Satara Local (Under developed) (Susceptible line)

Breeding for processing (dehydration): Arka Yojith, white onion variety developed for dehydration was identified by VTIC. Arka Yojith has high TSS 15-20°B, dry matter 18-20%, pungency 14µm/g, drying ratio 3.55:1, bulb yield 30 t/ha. Onion varieties developed for processing Arka Yojith (dehydration), Arka Kalyan, Arka Lalima and Arka Kirthiman (Paste) were promoted in the processors and exporters meet organized by APEDA at the Institute

Breeding onion varieties for export: Breeding F₁ hybrids of yellow, rose and multiplier onion for export, the male sterile lines developed under different backgrounds were back crossed (BC3 F₁), Rose onion, Rose MS807 X Rose MF131; yellow onion YLMS91 X YLMF63 and in multipliers MLTMS59 X MLTMS62 with identified maintainer lines to develop the isogenic lines. Back crossed progenies showed stability for sterility.



MS -299-Rose onion



YLMS-269-Yellow onion

Carrot

Development of stable high carotene male sterile lines:

In development of male sterile lines (A) line, fifteen advanced male sterile lines were evaluated in carrot. Two best performing pure male sterile lines namely MS 80-301 had root length 12.00 cm, root weight 100g, root diameter 3.8 cm, TSS 10%, deep orange root with self colour core, smooth surface and carotene Content 18 mg/ 100g. MS 82-10 had root length 14 cm, root weight 70g, TSS 12%, deep orange root with self colour core, smooth surface and carotene content 15.50 mg/100g. In development of maintainer (B) line, MS 80-301 X MF 79-301 had root length 12 cm, root weight 750 g, root diameter 3.55 cm, TSS 10.50%, deep orange root with self colour core, smooth surface. MS 82-10 x MF 81-10 had root length 15 cm, root weight 60 g, root diameter 3.00 cm, TSS 10%, deep orange root with self colour core, smooth surface.

Development of molecular markers for male sterility:

Cytoplasmic male sterility (CMS) is found to operate in the carrot. One hundred seventy one carrot lines were screened, individual phenotype and genotype was recorded. cmt 4 set of primers associated with *atp6-u1* gene clearly amplify in fertile line, but not in sterile line. mtSSR16 showed clear polymorphism between A lines and B lines.



Phenotypically sterile



Phenotypically fertile

Development of stable high carotene male sterile lines:

Twenty two high carotene advance lines were evaluated. Three lines with high carotene content were selected namely HC-66-39 (18.00 mg%), HC-68-43 (16.32 mg %), HC-69-43 (15.00 mg%) were found to have good quality characters. Twenty four carrot carotenoid biosynthesis pathway genes were investigated. The three main PSY1 variations differed from each other by 1-2 amino acids positions at 168-175 positions. PSY1 allelic variations observed at 7 genomic regions, whereas in PSY2 gene, deletions were observed at three genomic regions i.e. 137- 139, 504-509, 677, 688 nucleotide regions. Phytoene desaturase enzyme (PDS) deletions was observed from 308-325 gene genomic area in both red and orange carrot ζ-Carotene desaturase 2 (ZDS2) more numbers of SNP and deletions are observed in black and red carrots compared to orange carrot at 710, 714, 756-759. In carotenoid isomerase enzyme (CRTISO) few

variations observed in all three colour carrots red, orange & black, Lycopene β -cyclase (LCYB) a long stretch of deletions from 365-424 observed in black as compared to red and orange carrot. Lycopene ϵ -cyclase (LCYE) more no. of structural variations are observed in all carrot colour lines. Carotenoid cleavage dioxygenase 3 (CCD 3) was also most similar with black, red and orange with respect to sequence. 9-cis-Epoxy-carotenoid dioxygenase I (NCED1), more variations observed in black and orange compared to red carrot. 9-cis-Epoxy-carotenoid dioxygenase 3 NCED3 sequence retrieval was very narrow and variation identified.

3.2.3 Flower and ornamental crops

Tuberose

Evaluation of advance breeding lines: Advance breeding lines Hybrid 1x 6-1, Shringar OP, IIHR-4, clonal selection of Arka Nirantara were evaluated for growth, flowering and yield parameters. The hybrid IIHR-4 with double type florets, medium-tall spikes with spike length (65.0 cm), rachis length (26.0 cm), numbers of flowers (50.0) and floret diameter (5.2 cm) was found promising as cut flower.

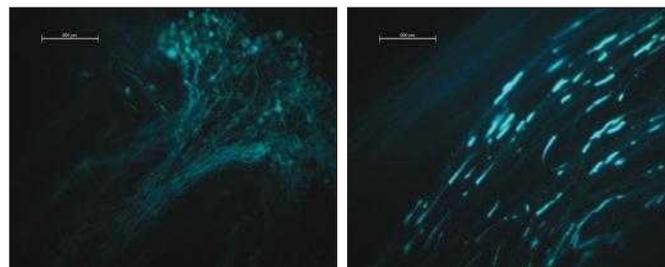


IIHR-4

Evaluation of intervarietal hybrids and half-sibs for growth, flowering and yield: Among seventeen hybrids and eight half-sibs evaluated, two hybrids IIHR 15-2-13, IIHR 15-3-2 and two half-sibs IIHR 15-22-HS-1 and IIHR 15-19-HS-1 with green tinge on flower bud were found to be promising. The pre-breeding line of tuberose IIHR 15-3-10 with reflexed petal and green tinge on flower bud were developed by crossing Variegated x Arka Suvasini. The flowers with reflexed flower petals are less prone to petal breakage.

Cross incompatibility studies in selected accessions: Direct and reciprocal crosses were carried out involving Mexican Single, Arka Shringar, Arka Prajwal, Arka

Nirantara, Arka Sugandhi, Variegated, Suarna Rekha and Phule Rajani to study the cross incompatibility. Among the different crosses, 21 cross combinations produced seed set. Seed set was not observed when Arka Prajwal was used as female parent though pollen germination and pollen tube penetration was found in the stigma, stylar and ovary.



Pollen tube penetration in stigma and stylar region

Presence of callose plugging in pollen tube at stylar region

Gladiolus

Hybridization with cryopreserved pollen: Hybridization was carried out in five different cross combinations using 24 years 11 months old cryopreserved pollen of Arka Poonum and Arka Shobha. In one cross combination 4 seeds and in another cross combination 107 seeds were obtained.



Seed set in cross Arka Aayush x Arka Shobha using cryopreserved pollen

Evaluation of promising hybrid selections: The promising hybrid selections i.e. in orange-red group (IIHRG-3), in yellow group (IIHRG-4), in red-purple group (IIHRG-6) in purple-violet group (IIHRG-12) were multiplied and are at pre-release stage. Following promising hybrid selections were selected on the basis of qualitative traits.



Arka Amar x IIHRG-12

Arka Aayush x Pink Friendship

IIHRG-12 x Arka Amar

Arka Amar x IIHRG-12



IIHRG-12 x Arka Amar

IIHRG-12 x Arka Amar

Arka Amar x IIHRG-12

IIHRG-12 x Arka Amar

Breeding for biotic resistance: Twelve genotypes were screened against blight and grouped based on scoring as moderately susceptible to highly susceptible. The genotypes Arka Poonum, Arka Gold and IIHRG-12 were found to be moderately susceptible for blight. In two genotypes, the color breaking or variegation in the gladiolus cv. Dhanvantri was attributed to presence of Ornithogalum mosaic virus belonging to potyvirus. Out of six genotypes screened against thrips damage, Arka Darshan was found resistant to thrips followed by Arka Tilak and Arka Gold.

Rose

Breeding for cut flower: Among the four advanced breeding lines screened, IIHRR 13-3-1, IIHRR 7-7 reported good stalk length (>60 cm), large bud size and slow unfurling of petals with an yield of 130 and 125 flowers/m², respectively. IIHRR 13-3-1 and IIHRR 7-7 were found to be on par with commercial varieties. IIHRR 7-7 was also found to be performing well in open field cultivation producing quality flowers.

Bud sticks of advanced breeding lines IIHR IIHRR7-7, IIHRR 7-8, IIHRR7-1, IIHRR13-3-1, IIHRR204 and IIHRR3-18-2 were subjected to gamma irradiation at 30 to 90 Grays. Based on the survival percentage, 60 Grays was considered to be LD-50 dosage. Irradiated buds were cultured in tissue culture to minimise diplontic competition and to encourage the growth of mutated cells. Twenty-five new progeny plants were evaluated in field for their flower quality. IIHRR 7-8 and IIHRR 7-9 were scored for cut flower features and multiplied for further evaluation.

Breeding for loose flower: IIHRR 11-2 was identified as 'Arka Savi' by VTIC of IIHR for commercial production of loose flower. The hybrid 'Arka Savi' developed by hybridisation using gametophytic selection. It is a spray category of rose belonging to floribunda group. Flowers are Purple Pink in colour (RHS colour chart Red purple group 66-A) and flowers are produced in bunches. It is identified for its floriferous nature with high yield. Potential yield of flowers expected is 30 tons/acre/year. It has long shelf life of 5-6 days.



Arka Savi Plant



Arka Savi Flowers

Breeding for flavour and food colour: Utilization of rose anthocyanin as natural food colour is indeed an advantage with rose bioresource, where both colour and aroma can be utilized for generating value-added products. IIHRP-7 is rich in total anthocyanin content (1.5 g /100 g dry weight of petals), total phenol (110 mg /100 g 100 g of dry petals), FRAP (191.34 mg/ 100 gm dry petals) and DPPH (153.49 mg/ 100 gm dry petals) content indicated the added advantage of antioxidant values of IIHRP-7. With perfect combination of color, flavour and antioxidant property, IIHRP-7 can be a good candidate for developing value added products.



IIHRP-7 Flower



IIHR 2-28-1

Breeding for landscape: Scoring of the progenies for their visual appeal round the year as well as ease of cultivation has resulted in selection of ten best genotypes (IIHR 2-28-1, IIHRR 4-15-12, IIHRR 4-15-15, IIHRR 4-15, IIHRR 11-3, IIHRR 13-24, IIHRR 9-13, IIHRR 5-6 and IIHRR 4-4-2) that can be of significant value for their utility in landscape. Among the selected genotypes, IIHR 4-4-2 is a climber types which is one of the preferred plant form in landscape architecture.

Resistance breeding biotic stress: IIHRR4-15-12 is scored as moderately resistant genotype for black spot. IIHRR13-4 recorded powdery mildew resistance has been used in crossing program and results suggested its potential as pollen parent than as seed parent considering percentage of seed setting. The moderately resistant variety for thrips infestation, Berries N Cream have been established for further genetic studies and introgression of desired characters.

Carnation

Evaluation of hybrids for cut flower: Hybrid selection IIHR CH13 has attractive peach colour frilled and petals recorded 62.0 cm stalk length, flower diameter of 7.8 cm and bud length of 5.6 cm. IIHR CH15 was multiplied through terminal cuttings and planted for further evaluation.

Gerbera

Breeding for quality: One hundred and five hybrids were multiplied through tissue culture. A total of 41 hybrids were evaluated for five economical characters and 8 hybrids were short listed for further trials. Two hybrids

(IIHR 10-3 and IIHR 15-7) were evaluated for three years and are on par with the commercial check in stalk length, stalk diameter, flower diameter and number of flowers.

IIHR 10-3 is a promising line developed through hybridization (half-sib) between IIHR10 and mixed pollen of 10 varieties followed by selection. It produces double type flowers with yellow purple colour group, 24A. It performs well under polyhouse with 50% shadenet and on par with commercial varieties. Floral traits of the line are flower diameter (10.91 cm), flower stalk length (60.38 cm), flower stalk diameter (6.62 mm) and 2.96 numbers of flower/month. It is suitable for cut flower and flower arrangement. Since it has black center it is a novelty in the market.

IIHR 15-7 was developed through hybridization (half-sib) between IIHR15 and mixed pollen of 10 varieties followed by selection. It has double type with white colour group, 24A. It performs well under polyhouse with 50% shadenet and on par with commercial varieties. It produces 2.96 numbers of flower/ month, flowers with a diameter longer flower stalks (60.38 cm) and greater flower stalk diameter (6.62 mm). It is suitable for cut flower and flower arrangement. Since white is preferred after red, this variety may get a premium price in the market.



IIHR 10-3

IIHR 15-7

Chrysanthemum

Breeding for day neutral trait and pot culture:

Twenty-three crosses were made with 'Yellow' coloured genotypes in order to develop day neutral varieties for open condition. Six half-sib lines were evaluated with Arka Pink Star as check for pot culture and IIHR4-8 found promising for 4th consecutive year. A total of 105 half-sib lines were evaluated for open conditions. Half-sib line IIHR2-13, IIHR2-16 and IIHR5-9 were found early flowering and have attractive flower.

China aster

Breeding for cut flower and bedding: Twelve pure lines evaluated with check. Line 13-1-1, 13-1-2, 13-1-5 and 13-3-1 were found promising for long stalk, attractive flower

colour and extended vase life. Individual plant selections viz., IIHRJ3, IIHRJ3-2 and IIHRG-13 were also promising and unique for flower colour, long flower stalk and vase life. Lines L8, L9, L18, KS3, and KS5 were found promising for bedding purpose with spreading growth habit. A total of 140 individual plants were selected from F₂ population derived from 20 crosses.

Evaluation for shelf life and vase life: Vase life of 23 genotypes with fully opened flowers was evaluated under ambient condition (temperature 24-28 °C and relative humidity 50-62%) in distilled water. Maximum vase life of cut flowers was recorded in line IIHRKS1 (12.3 days) followed by IIHRC5 (11.6 days) and IIHRCC31A (11.6 days).

Genetic studies: Heterosis (%) over commercial check Arka Kamini among 49 hybrids was estimated. The F₁ hybrids viz., 15-38 (-34%), 15-11 (-30%) and 15-28 (-28%) recorded significant negative heterosis for days to flowering, however, F₁ hybrids 15-15 (71%), 15-20 (64%) and 15-7 (57%) recorded significantly higher positive heterosis for number of flowers/ plant, F₁ hybrids 15-16 (88%), 15-20 (80%) and 15-21 (78%) for weight of flowers/ plant.

Components of variability, heritability and genetic advance among 49 F₁ hybrids and 28 lines were analyzed. High genotypic coefficient of variation (>20%) was observed for plant spread, leaves/ plant, branches/ plant, flowers/ branch, weight and florets per flower head; high heritability (>60%) was observed for all the traits; high genetic advance over mean (>20%) was observed for all traits except flower head diameter.

Crossandra

Breeding for quality and novelty: Hybridization with various combination was carried out using three IIHR released varieties and local line. The performance of hybrids evaluated was on par with the released varieties. One mutant with medium flower size compared to the large size in Arka Ambara was identified. The medium flower size with high yield is preferred over large size flowers. The shelf life of mutant is better (3.4 days) over the parent (3.1 days).

Anthurium

Breeding for high quality cut flower: The hybrids derived from *Anthurium ornatum* and *A. andreanum* showed fragrance, which is a novelty and at present not available in the Indian market have been multiplied and evaluated for their suitability for commercial cultivation through somatic embryogenesis pathway.



Ex vitro leaf segment cultured in half MMS medium



Leaf segment forming embryogenic calli



in vitro plant derived from embryos



plants after hardening

Somatic embryogenesis in leaf of Anthurium crossed lines (A1P and A2W)

Marigold

Male sterile lines for development of hybrids: Petaloid, apetaloid and gynomonocious male sterile lines are being maintained and evaluated. Male sterile line IIHR 2-2(S) and IIHR 2-3(S) were found to be most promising for hybrid development considering their general combining ability (GCA) for flower yield and related characters. The genotypes with two separate cytoplasm (S and N) have been identified.

Production of natural dye and phytochemicals: 'Arka Agni' rich in carotenoid (1384 mg/ 100gm of dry petals), IIHR 2-3 rich in zeaxanthin (1.75 mg/ 100g of dry petals) have potential to be used in production of natural dye. Arka Agni is also rich in lutein content (1140 mg/ 100 g of dry petals) and have the commercial potential to be used by Pharmaceutical companies. IIHR 2-2(S) with carotenoid content of 1049.68mg/ 100 gm dry petals and having good general combining ability (GCA) for phytochemicals is being used in different cross combination for production of hybrids.

3.2.4. Medicinal Crops

Mucuna sp.

Breeding for high yield and L - Dopa content

Elite lines identified by VTIC: Four elite lines of velvet bean (*Mucuna pruriens* var. *utilis*) viz., Arka Shubra, Arka Charaka, Arka Shukla and Arka Daksha were identified for release by VTIC based on their consistent superior performance over four years.

Arka Shubra (IIHR PS 2) is a pedigree selection from cross IIHR MP 10-1/IIHR MP 11-5. It is a white seeded line with high seed yield (4.5 to 5.5 t/ha under support, 2.25 to 2.75 t/ha under surface cultivation), high L-Dopa content & yield (5.43%; 269.67 kg/ha) with non-irritant trichomes on pods, produces white flowers on medium long rachis and matures in 180-190 days.

Arka Charaka (IIHR PS 6) is a pedigree selection from cross IIHR MP 10-1/IIHR MP 4-6. It is a black shiny seeded line with high seed yield (4.0 to 4.25 t/ha under support, 2.0 to 2.25 t/ha under surface cultivation), high L-Dopa content & yield (4.80%; 200 kg/ha) and non-irritant trichomes on pods. It bears purple flowers on medium long rachis and matures in 155-165 days.

Arka Shukla (IIHR Sel 3) is a pureline selection with white medium bold size seeds. It gives a seed yield of 3.0 to 3.5 t/ha under support, 2.0 t/ha under surface cultivation with an L-Dopa content & yield of 3.86%. It produces purple flowers on short rachis and pods with non-irritant trichomes and matures in 155-165 days.

Arka Daksha (IIHR Sel 8) is a pureline selection with bold black seeds with brown mottling and yields (3.5 to 4 t/ha under support and 1.8 to 2.2 t/ha without support) with L- Dopa content (3.72%) and L-Dopa yield (150.39 kg/ha). It bears purple flowers on short rachis and matures in 150 to 160 days.



Arka Shubra Arka Charaka Arka Shukla Arka Daksha

Performance of high L-Dopa selections: High L- Dopa selections developed from crosses between lines with itchy trichomes/non-itchy lines were evaluated for four years. IIHR 13-4 recorded high L- Dopa content (5.8 to 6.0%) with non-itchy trichomes on pods with a seed yield of 4 to 4.5 t/ha. IIHR 12-7 and 13-6 recorded high L- Dopa yield/plant (5.8 to 6% L- Dopa with seed yield of 320 to 350 g/plant).

Evaluation of lines with novel seed coat colours: Novel seed coat colour variants isolated from segregating

population were evaluated for seed yield and L - Dopa content for four years. The selections IIHR SC3 (195B), IIHR SC6 (201A), IIHR SC5 (N199B), IIHR SC1 (dark red) and IIHR SC7 (N200) were found promising. Seed yield ranged from 260 to 350 g/ plant and L - Dopa content varied between 4.60 to 5.75%. These lines with unique seed coat colours are suitable for commercial cultivation and can help in maintaining the genetic purity.

Coleus forskohlii

Breeding for root yield and forskolin: Among good tuberous rooted hybrids evaluated, Hy08-129 and Hy08-53 and CF 75 recorded dry root yield/ plant (65 g, 62 g and 59 g, respectively) with a total forskolin content of 1.00, 1.55 and 1.76%, respectively which were at par with check K8 (62 g and 1.51%).

Forskolin production in cultures of *Coleus forskohlii* transformed with *Agrobacterium rhizogenes*

A. rhizogenes (AR532) strain 1 enhanced hairy root production atleast by 1.5x times compared to the other strain (AR2364). Incorporation of abiotic elicitors in the media such as NaCl and CaCl₂ resulted in drastic decline in hairy root production. Likewise, increasing the incubating temperature by 5°C drastically reduced hairy root production by 6-10X. Among all the treatments tried for enhancing hairy root production, AR1 strain had the greatest influence on enhanced (1.8X) forskolin content.

Kalmegh

Breeding for yield and quality: Ten promising selections along with two checks (Anand Kalmegh and CIM Megha) evaluated. AP 32-1, 27-2 and 52-1 recorded significant higher dry biomass yield 35 to 40 g per plant. AP 40-16 recorded highest leaf andrographolide content (> 6.12%) followed by AP 52-1(5.49%). Total andrographolide yield per plant was highest in AP 18-3 (96.41 mg) followed by AP 27-2 (79.54 mg) AP 40-16 (77.97 mg) and AP 32-1(75.17 mg).

Genetical studies: Combining *gca* and *per se*, IIHR AP 18-7 was the best parent for eight characters. The higher magnitude for specific combining ability variance for all the characters studied implied the preponderance of non-additive gene action. The correlation and path analysis revealed that total andrographolide yield per plant is highly related to leaf area index, number of leaves at harvest per plant, leaf dry weight per plant, stem dry weight per plant, leaf andrographolide yield per plant and stem andrographolide yield per plant.

Centella

Polyploidy was attempted in the shoot tips, roots and

in vitro cultures of *Centella asiatica* variety Prabhavi using colchicine. Treated plant (IIHR-CA-28) was found superior to the control with respect to all quantitative and biomass characters. The dry biomass yield of treated plant was higher (357.04 kg/ha) than the control (303.63 kg/ha). Treated plants also showed a high nutrient content with respect to minerals and proteins as compared to the control variety.

Betelvine

Phytochemical evaluation: In order to discover new drugs which actively inhibit the oral pathogens, the methanolic leaf extracts of five cultivars namely Godi Bangla, Desavari, Swarna Kapoori, Meetha Pan and Halisahar Sanchi were tested against oral pathogenic bacterial strains of *Streptococcus* genus namely *Streptococcus pyogenes*, *S. pneumonia*, *S. salivarius*, *S. sanguinis* and *S. mutans*. Four out of five leaf extracts showed highest inhibition of *S. Mutans* with an MIC of 312.5 µg/100µl. Among the five cultivars tested, leaf extracts of cv. Swarna Kapoori exhibited higher antimicrobial activity against *S. pyogenes*, *S. sanguinis* and *S. mutans* followed by cv. Meetha Pan against *S. salivarius* and *S. mutans* at MIC value of 312.5 µg/100µl. Among the cultivars tested, only cv. Halisahar Sanchi recorded significant inhibition of *S. pneumonia*. (MIC 625 µg/100µl).

3.3. Crop production

3.3.1. Fruit Crops

Mango

Rootstock studies: Fruit yield and fruit quality of Totapuri mango as influenced by eight rootstocks studied during the eleventh orchard year indicated that the vigorous rootstocks were Olour (128.7 kg/ tree) and Turpentine (103.0 kg/ tree) which gave higher fruit yield/ tree, while the least vigorous rootstocks were Nekkare (43.0 kg/ tree) and Vellaikulamban (35.0 kg/ tree) which yielded less although fruit quality remained unaffected. Pooled analysis for the eleventh year indicated the superiority of Olour as rootstock for Totapuri.

Evaluation of polyembryonic rootstocks: Ten polyembryonic rootstocks of mango were assessed for zygotic and nucellar seedlings. It was found that emergence of zygotic seedlings ranged from 25% in Kensington to 100% in Peach. These rootstocks were found susceptible to chloride toxicity above 3 dS/m. There was no significant difference in uptake of primary, secondary and micronutrients, and nutrient concentration among genotypes. The trial is being monitored at different growth intervals.

Soil volume wetting: Field experiments on 18 years old mango (variety Raspuri) for second year to standardize optimum soil volume wetting, indicated that spacing of 6 m x 6 m had significantly higher soil moisture (12.8%), with higher soil volume wetting (70%) compared to 30% (7.7%). Although the fruit yield of mango was higher with 70% soil volume wetting (33.7 kg/plant, 41.27 kg/ha.mm); water use efficiency was higher at 30% (57.58 kg/ha.mm).

Effect of pollen and stigma metabolites on bearing: In order to understand the variations in fruit set of different mango varieties, profiling of sugars, amino acids, hormones and polyamines was carried out. The low fruit setting variety Alphonso recorded lower spermine, salicylic acid and amino acids in the stigma compared to other varieties, pollens also recorded lower spermidine, amino acids and IAA in Alphonso compared to other varieties at anthesis.

Induction of flowering by novel formulation: Alphonso mango trees sprayed with an environmentally safe formulation developed under NICRA project at ICAR-IIHR showed increase in flowering. The contents of starch, total and soluble sugars in leaves and bark and GA_3 : ABA ratio in leaves indicated that the treatment promoted mobilization of carbohydrate reserves and altered the hormonal balance (GA:ABA) in favor of flower induction.

Evaluation of training system under high density planting: The efficacy of training system assessed in mango at CHES, Bhubaneswar for mango var. Arka Neelachal Kesari for the second year showed minimum light interception (55.7), tree volume, leaf area index (2.96), better light distribution inside the canopy and maximum intensity of productive shoots (66.4) under 'Y-shaped trellis system' (YSTS). Maximum number of fruits (84.6) and fruit yield (15.7 kg/ plant) was recorded under YSTS followed by 'vertical trellis system' (VTS) (13.8 kg/plant). Low incidence of mango hopper and mealy bug was also recorded under both the training systems. Long term suitability of training systems is under investigation.



Maximizing mango yield under HDPS

Canopy management and irregularity in flowering: To harness the potential of HDPS to tackle the issue of canopy management and irregularity in flowering, studies were conducted at CHES, Bhubaneswar, to maximize mango yield by regulating 'plant canopy architecture', by the 3 Ps – practicing, 'pruning' and using 'paclobutrazol'. A combination of three primary branches (in different directions) and 2-3 secondary branches/primary was found suitable for mango planted at 3 m x 4 m spacing, whereas a combination of four primary branches (in different directions) and 2-3 secondary branches/primary was found optimal for 5 m x 5 m spacing. Along with this combination of branches, trunk height (80–90 cm), length of primary (40–50 cm) and secondary branches (30–35 cm), angular distance of primary branches (45° from horizontal axis) were also optimized for developing an ideal canopy which acts as an important framework for harnessing solar energy efficiently and ensuring high yield. Under the planting density of 3 m x 4 m, the height and spread of plants were restricted to 2 m, while plant height and spread of 3.5 m were regulated under 5 m x 5 m spacing. The optimized canopy height and spread were regulated by annual pruning carried out during June–July (after fruit harvest). In order to ensure regularity in flowering optimized dose of paclobutrazol (PBZ) was applied (0.25 g a.i./ m canopy spread). The results indicated that the 3 Ps significantly enhanced yield and fruit quality of mango. Despite the high cost of cultivation, the benefit–cost ratio was substantially high (>2.3).



Plant architecture under HDPS

Annual pruning under HDPS

Fruit yield under HDPS

Delay in mango flowering: In the eastern coastal tropical region of CHES, Bhubaneswar, flowering in different mango varieties begins in November and continues till January. Flowering in Arka Neelachal Kesari, an extra early variety, usually occurs in the second fortnight of November, but this year it was delayed by 7-8 weeks. Similarly flowering in Amrapali was also delayed by 4-5 weeks from its usual time (mid-January). Other varieties of mango like Banganapalli, Dashehri, Langra, Mallika, Suvarnarekha and Totapuri, exhibited similar pattern of flowering. The delay in flowering may be attributed to prevalence of low temperature ($T_{min} < 15^\circ C$) for relatively longer period during December (22 days) and January (30 days) in comparison to previous years. It was also observed that the intensity of hermaphrodite flower in Arka Neelachal Kesari was reduced by about half (6.8%) which in turn affected the fruit set.

Physiological disorders in mango: Jelly seed was recorded as the most common physiological disorder in important mango varieties like Arka Neelachal Kesari, Amrapali and Dashehri, while spongy tissue was common in Alphonso and Kesar. The intensity of jelly seed was as high as 26-45% at different fruit maturity stages. It was also observed that the jelly seed incidence was associated with the accumulation of heat unit. In Arka Neelachal Kesari, an extra early variety, jelly seed usually developed when heat unit exceeded 800 degree days and fruit was at advanced ripening stage. Also, the intensity of disorders increased with the fruit maturation. Harvesting of fruit at early maturity stage i.e. when pulp colour turns light yellow, minimises the incidence of disorders significantly. The intensity of spongy tissue in Alphonso was as high as 60-70%, while the incidence of soft nose was observed in Mallika and Amrapali (10-15%).



Jelly seed in Arka Neelachal Kesari

Spongy tissue in Alphonso

Soft nose in Mallika

Pineapple - a viable intercrop in mango: Suitability of pineapple as an intercrop in bearing low density mango plantation (100 plants/ ha) was assessed at CHES, Bhubaneswar. About 50% area between two rows of mango plants were utilized for cultivation of the pineapple variety Queen which was planted in double row system with a spacing of 60 x 70 x 90 cm. About 12000-13000 of pineapple were planted in the mango orchard, on raised bed (20 cm), using plastic mulch (60-100 micron) and drip irrigation. With the use of flower inducer (ethephon in acidic pH) at different time intervals, year round production of pineapple was achieved with a fruiting intensity of 85-90%. The duration between ethrel application and fruit maturity was about 5 months. The average fruit weight was 0.8–1.2 kg, TSS 15-18 °B and TSS/acid ratio – 14-21. Best quality fruits were obtained from January–May. The economic analysis indicated that by covering 50% area of mango plantation under pineapple cultivation one can earn 1.8-2.0 lakh/ ha from fruits and about 1.00–1.20 lakh from sucker and slips. There was a subsequent increase in income in next two years as the cost of cultivation was reduced substantially. Considering the high B:C ratio (2.5) and market potential, pineapple can be considered a profitable intercrop for low density mango plantation.



Pineapple - Mango Intercrop

Guava

Rainfed production: Enriched coir pith (10 cm height) and polythene mulching in the basins conserved significantly higher soil moisture *in situ* (55% and 33% on a pooled mean basis during different periods of the year, respectively) compared to no mulching. Polythene mulching with raised soil around the root zone resulted in 39.8% higher fruit yield over control, in three years pooled mean basis - 12.30 t/ ha at sixth year of guava planting. Application of enriched coir pith recorded overall yield advantage of 31.8 %. Fruit size was relatively higher with the placement of coconut husk (208 g) and polythene mulching (183 g). Rainfed guava can yield up to 82% of irrigated condition production and is economically viable with higher B:C ratio (4.16).

Branch bending for crop regulation: Under the hot, humid climate of CHES, Bhubaneswar, branch bending during both summer and winter, contained the shoot growth and improved flushing, flowering and crop yield over control. January branch bending resulted in the maximum number of shoots (27.5 shoots/ m of branch length) and flowering intensity (54.18%) for *Ambe Bahar* and enhanced the rainy season crop yield (37.84 kg/ plant), whereas, branch bending during May was very effective in enhancing *Mrig Bahar* (42.56%), thereby shifting the main crop during winters. With a crop yield of 31.16 kg/ plant during winters, May branch bending not only recorded 83.44% improvement in winter season crop, but also improved the fruit quality in terms of TSS and vitamin C content (10.66°B and 194.56 mg/ 100g of pulp) over parameters in control (5.16 kg/ plant yield, 9.23 °B TSS of pulp and 173.58 mg/ 100 g vitamin C content).

Grapes

Rootstock studies: To overcome the problem of delayed graft compatibility in Red Globe grapes grafted on Dogridge rootstock, different treatments were given to Red Globe scions before grafting. The treatments were scion treatment with 100 ppm benzyl amino purine (BAP), 100 ppm Kinetin, preconditioning of scions for 5 days on vines, etiolation of scions for 5 days on vines, scion

preconditioning + BAP @100 ppm, scion preconditioning + Kinetin @100 ppm, scion preconditioning + etiolation on vines along with control. The preconditioned scions treated with 100 ppm BAP had higher graft success of 75% compared to control (45%). The growth of plants after 90 days of grafting, and the effect of different scion treatments on graft success as supported by anatomical studies are shown in figure below. This technology will help growers to achieve uniform plant growth in the first year itself so that other cultural operations like training and pruning can be taken up uniformly in subsequent years.



Shoot growth at 90 days after grafting in Red Globe scions

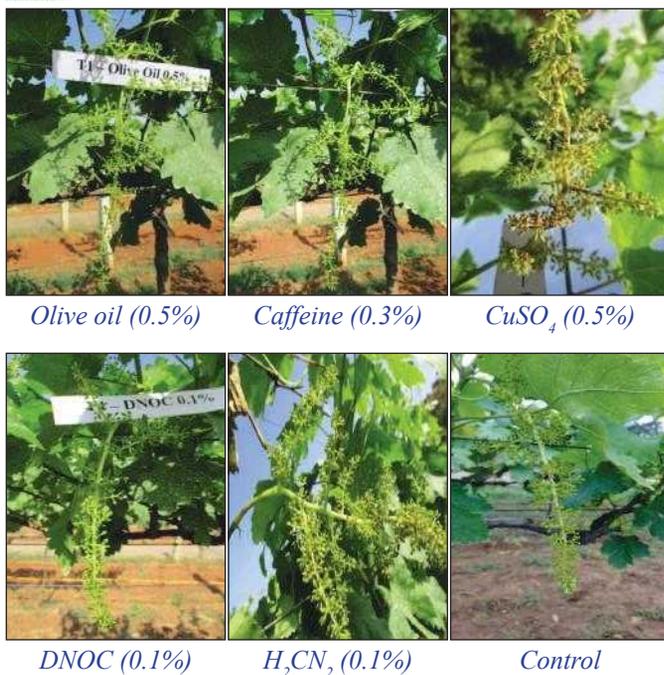
Canopy management: In a third year study on influence of canopy management practices on bunch and berry quality parameters of Red Globe and Crimson Seedless grapes, eight treatments consisting of berry thinning, bunch covering, ethrel application and basal leaf removal in different combinations were imposed during November–December 2017. In both the varieties, consistent results were obtained during the third year wherein, the treatment combination of berry thinning at 8-10 mm stage + ethrel application + basal leaf removal (T5 and T6) at veraison stage produced good quality bunch with respect to TSS, anthocyanin content, berry diameter and berry length, and the bunches were less compact compared to untreated control or among vines of other treatments without berry thinning. The average bunch weight of 1130 g was recorded in Red Globe with treatment T6 while it was 702 g in Crimson Seedless in T5. The cluster compactness was less in the treatment T5, T6 and T7 (1.5 to 1.7 berries/ cm rachis) against control which recorded 2.78 berries/ cm rachis indicating very compact clusters. In Crimson Seedless, maximum anthocyanin was recorded in T5 and T6 while it was least in T4; in Red Globe grapes maximum anthocyanin was recorded in T3 and T6 while it was least in T1 and T8.



Effect of canopy management practices on bunch and berry quality of Crimson Seedless (left) and Red Globe (right) grapes

Effect of GA₃: In a second year experiment to standardize concentration of GA₃ for rachis elongation in Crimson Seedless grapes, pre-bloom spray of GA₃@ 2.5 ppm produced less compact bunches (1.15 berry/cm length of rachis) with higher average bunch weight (548.12 g), berry weight (5.13 g); and TSS (18.52 °B). Although higher concentrations of GA₃ (5 and 7.5 ppm) could elongate rachis initially, after a few days, there was severe coiling of bunches resulting in irregular bunch shape. At higher concentration of GA₃ (7.5 ppm), the rachis of the cluster was flattened with abnormal size, unlike the control treatment without GA₃ spray, which produced very compact clusters (2 berries/ cm rachis) with less average bunch weight (418 g), berry weight (3.89 g) and berry diameter (16.41 mm).

Effect of flower thinning agents: In the second year experiment on application of flower thinning chemicals in Red Globe to improve the bunch and berry quality parameters, different chemicals viz., 0.5 % olive oil (T1), 0.3% caffeine (T2), 0.1 % hydrogen cyanamide (T3), 0.1 % dinitro-*ortho*-cresolate (T4), 0.5% copper sulphate (T5) were sprayed during full bloom stage and compared with manual berry thinning at 8-10 mm stage (T6) and untreated control (T7). Similar to the first year results, clusters treated at 50% bloom stage with olive oil showed less bunch compactness (0.80 berries/ cm of rachis length). Caffeine at 50% bloom recorded the maximum values for some of the berry parameters viz., bunch weight (1215.46 g), and berry diameter (28.27 mm). Anthocyanin concentration was highest in olive oil treated bunches (306.54 mg/ 100 g) followed by caffeine (270.05 mg/ 100 g). Spraying CuSO₄ and hydrogen cyanamide resulted in severe scorching of rachis. Total phenol content was maximum in bunches treated with DNOC (226.90 mg/ 100 g) followed by CuSO₄ treated bunches (213.29 mg/ 100 g) and control (214.23 mg/ 100 g). Manual berry thinning could produce quality bunches with respect to reduced cluster compactness (0.98 berries/ cm rachis) and berry characters although low anthocyanin concentration (157.15 mg/100 g). Also, labor cost involved in manual thinning may not be economical compared to chemical thinning.



Effect of chemicals on flower thinning in Red Globe grapes after 10 days of application

Pomegranate

Tissue cultured plants: A comparison of different properties on growth, yield and quality of pomegranate cv. Bagwa higher number of hermaphrodite flowers (261.60), fruit weight (192.70 g), fruit length (6.54 cm), fruit width (6.80 cm), fruit volume (167.55 ml), number of fruits/plant (169.00) and percentage of fruit set (63.41%) with highest yield (32.88) kg/ plant was obtained from tissue cultured plants as compared to grafted and air layered plants (least yield) for the third year. As in the previous two years, the plant height and canopy spread was least in plants grafted on Dharu rootstock compared to air layers and tissue cultured plants. The tissue culture plants were more vigorous in terms of plant height and canopy spread. Where in cv. Bagwa, the highest number of hermaphrodite flowers (264.66), fruit yield (27.10 kg/tree and 18.86 t/ha) and fruit number/ tree (154) were obtained with spraying of uracil @50 ppm.

Fig

Rootstock Studies: The initial vigor of Deanna, Excel and Conadria scions during the first year after grafting was higher in Brown Turkey (Yercaud collection) than in Poona rootstock.

Annona

Rootstock studies: Variations in growth and gas exchange characteristics in one year old Arka Sahan grafted on *Annona atemoya*, *A. cherimola*, *A. glabra*, *A. muricata*, *A. reticulata*, *A. squamosa* ('Balanagar'), *A. squamosa* (Washington) and Arka Sahan hybrid, revealed higher

tree height in Arka Sahan grafted on *A. muricata* (90.34 cm) and lower in Arka Sahan grafted on *A. glabra* (73.33 cm). The diameter of rootstock and graft union was higher in *A. glabra* L. rootstock, but lower in *A. squamosa* cv. Balanagar. Photosynthesis Rate (A) was maximum in Arka Sahan grafted on *A. reticulata* ($6.36 \mu\text{mol m}^{-2} \text{s}^{-1}$), while it was lowest in Arka Sahan grafted on *A. glabra* ($5.31 \mu\text{mol m}^{-2} \text{s}^{-1}$). Changes in stomatal conductance and transpiration rates were nonsignificant.

Canopy Management: Observations on intensities and time of pruning imposed in Arka Sahan annona trees for crop regulation indicated significant favorable influence of early intense pruning on earliness of cropping and fruit quality. The recommendation resulting from the four year study period (2014-2017) for canopy management of Arka Sahan trees is that pruning all the previous season's shoots to half their length during first week of November is best for higher fruit yield and quality through synchronization of its flowering with sufficient leaf area development to support fruit growth with that of Balanagar variety, the pollen source for assisted pollination, as well as for keeping tree size manageable for easy hand pollination and other orchard operations. The treatment also resulted in early fruit harvest during July and such fruits had higher TSS and smaller seeds.



Initial sprouting of new shoots from shoots pruned to 50% length in Arka Sahan



Canopy development in pruned trees of Arka Sahan (left of the field board) compared to unpruned trees (right of the field board)

Variation in pollen and stigma metabolites :

To understand the reasons for low fruit setting in Arka Sahan, metabolites were assessed in pollen and stigma and compared with cv. Balanagar (*A. Squamosa*). Stigma of *A. Squamosa* contained higher putrescine and spermidine; all other metabolites were higher in the stigma of Arka Sahan. Pollen of Arka Sahan had higher sugars, amino acids and hormone profiles but polyamines and salicylic acid were higher in *A. squamosa*.

Papaya

Partial root zone drying irrigation: Field experiments on partial root zone drying irrigation in papaya indicated that for the same level of evaporation replenishment, shifting of irrigation recorded lower fruit cavity index (0.25) compared to fixed laterals (0.34). Although, irrigating the plant on only one side with single emitter resulted in significantly higher TSS (11.70%) in papaya, significantly higher water productivity (9.27 kg/ m³) was obtained by scheduling the irrigation at 40% evaporation replenishment through shifting of laterals at fortnightly intervals with substantial saving of water (1118 m³/ ha).



Harvested papaya crop from PRD irrigation trial

Optimizing productivity under salinity and drought stress: Arka Prabhat and CO-4 cultivars of papaya are more tolerant to salinity and drought stress. Root anatomy under drought stress in 4 papaya varieties (Arka Surya, Arka Prabhat, Red Lady and CO-4) showed distinct contraction in vascular system as evident from reductions in xylem bundle thickness and cortex cross sectional area. The cortex and xylem bundle thickness were high in CO-4 and low in Arka Surya and Red Lady. Cultivars CO-4 and Arka Prabhat showed upregulation of 17, 26 and 55 kDa proteins and downregulation of 130 kDa protein under stress.

Effects of salinity (2.94 dsm) in 71 days old seedlings of four papaya species namely *Vasconcellea cauliflora*, *V. cundinamarcensis*, *V. goudotiana* and *Carica papaya* showed significant reduction in stem diameter, photosynthesis rate, stomatal conductance, leaf water

potential and shoot dry mass compared to control. *Carica papaya* under stress performed comparatively better with higher values over other species.

Pre-treatment with plant growth promoting bacteria (*Bacillus amyloliquefaciens*-P72 strain 10⁷ cfu/g), in papaya cvs Arka Surya and CO-4 was effective in ameliorating the effect of drought stress and improved the fruit quality in papaya plants.

3.3.2. Vegetable Crops

Tomato

Water productivity and nutrient management: An experiment on phenophase based nutrient scheduling through drip fertigation was conducted during *khari* 2017. The fertilizer dose was 150:120:150 kg NPK/ ha. The maximum fruit yield was 83.6 t/ ha with application of NPK at 20:30:20, 30:30:20, 30:20:30 and 20:20:30 ratio at vegetative, flowering and fruit development, harvesting and late harvesting stages respectively, followed by 30:30:20, 30:30:20, 20:20:30 and 20:20:30 (82.3 t/ ha). Soil application of nutrients resulted in lower yield (57.5 t/ ha) and yield attributing characters compared to other treatments. The fertigation treatments increased yield by 8.86 to 39.58% over soil application and fertilizer use efficiency was in the range of 165–211 kg/ kg as compared to soil application (151 kg/ kg).

Chilli and Bell pepper

Water productivity and nutrient management: A fertigation trial was conducted with ten treatments in chilli with three hybrids i.e. Arka Meghana, Arka Harita and Arka Khyati. Bi-weekly application of 100% RDF of NPK (125:100:125 kg/ ha) through water soluble fertilizers resulted in maximum yield of 31.00, 29.88 and 28.15 tons/ ha followed by weekly application of the same amount of nutrients i.e. 30.48, 28.54 and 23.95 tons/ ha, which gave 23, 40 and 43% higher yields than the soil application treatments in Arka Meghana, Arka Harita and Arka Khyati respectively.

Brinjal

Water productivity and nutrient management: Bi-weekly application of 100% RDF of NPK (150:125:150 kg/ ha) through water soluble fertilizers resulted in higher yield followed by weekly application of the same amount of nutrients (51.34 t/ ha) in hybrid Arka Anand (51.72 t/ ha) and Arka Harshita (41.89 t/ ha). In comparison, lowest yield was observed following soil application of nutrients in both the cultivars. There were significant differences among the treatments for the soil available N (172.0-182.3 kg/ ha) and P (66.0-75.0 kg/ ha) after harvest.

Organic farming: The experiment was conducted with four levels (25, 50, 75 and 100%) of nitrogen substitution through Farm Yard Manure (i to iv), (v) only recommended FYM application i.e. five organic treatments (i-v) , and three inorganic treatments viz., (vi) Conventional practice (recommended FYM @25 t/ ha + recommended NPK fertilizers), (vii) only recommended NPK fertilizers and (viii) Conventional practice + pesticides used upto flowering stage of crop. Integrated nutrient management treatment(viii) produced significantly higher yield (31.14 t/ ha) than 25% recommended and N substituted with FYM (21.74 and 20.29 t/ ha). This treatment also recorded minimum brinjal shoot and fruit borer damage (14.03%) as compared to organic treatments (16.53-19.27%).

Onion

Tolerance to water logging: The experiment was conducted during *kharij* 2017. Water logging treatment affected onion bulb yield at bulb formation stage (16.80 t/ ha) than bulb formation (18.50 t/ ha) and post-bulb formation stages (18.0 t/ ha) in red sandy loam soils. Control treatment (no water logging) recorded a yield of 20.10 t/ ha in red sandy loam soil conditions. The average soil moisture varied from 23.4-33.9% during different stages at 30 cm depth.

Muskmelon

Precision farming: Muskmelon hybrid Kohinoor grown during February to April recorded significantly higher growth characters and yield (30.2 t/ ha) under precision farming practices which included drip irrigation, polyethylene mulching, fertigation and foliar nutrition system against normal practice (14.3 t/ ha). All practices without fertigation reduced yield significantly (25.5 t/ ha), likewise, all practices without mulching also reduced the yield significantly (19.6 t/ ha).

English cucumber

Organic farming: The effect of five organic module treatments on growth and yield of English cucumber (MultistarRz) under naturally ventilated poly house was studied. Application of FYM @50 t/ ha basal + Jeevamrutha + Panchagavya + AMC recorded an yield of 68 t/ ha in 90 days.

Fertigation studies: English cucumber grown in naturally ventilated poly house during December to April with a fertigation rate of 135-90-135 kg NPK/ ha recorded a yield of 102.6 t/ ha which was optimum compared to higher level of fertilizers.

Bitter gourd

Water productivity and nutrient management: In a fertigation trial, bi-weekly application of 100% RDF of

NPK (100:80:100 kg/ ha) through water soluble fertilizers resulted in significantly higher yield (24.36 t/ ha) than most treatments except the treatment which received the same amount of nutrients at weekly basis through fertigation in F_1 (21.75 t/ ha). Soil application of nutrients recorded lowest yield compared to all the treatments (14.19 t/ ha).

Bottle gourd

Organic farming: The experiment was conducted with the same 8 treatments as with organic farming of brinjal described above. Integrated nutrient management treatment (viii) markedly increased plant growth parameters such as vine length (283.73 cm), fruits per plant (5.46) and fruit weight (848.0 g). It also resulted in significantly higher yield (49.14 t/ ha) than treatment (vi) (29.05 and 29.67 t/ ha); only chemical treatment, however, produced the lowest yield of 38.42 t/ ha.

Garden Pea

Organic farming: An organic farming experiment was conducted on Garden pea (Arka Priya) with 8 treatments as in organic farming of brinjal. INM (viii) with 100% RDF recorded higher ten pod weight and 100 seed weight followed by safe production methods and 100% N through FYM. Similarly, 100% RDF through INM resulted in higher yield 10.51 t/ ha followed by safe production methods (9.02 t/ ha); 100% N substituted by FYM resulted in 7.35 t/ ha, which was 31% less than the INM treatment.

High temperature stress: In the phenotyping studies on high temperature stress tolerance in pea genotypes it was observed that high temperature stress affected photosystem II (PSII) efficiency with a reduction in the range of 7-23%. Among the genotypes, Arka Sampoorna and Oregon Sugar maintained higher PSII efficiency. High Electron Transport Rate (ETR) was also observed in Oregon Sugar, Arka Sampoorna, Arka Chaitra and IIHR 544. The metabolites, phenolics and flavonoids were high in flower buds of genotypes, Arka Tapas, Arka Priya, Arka Sampoorna and Arka Uttam. High amino acid contents were observed in tolerant genotypes, Oregon sugar, Arka Chaitra, Arka Priya and Arka Uttam.

Dolichos (Bush Type)

Organic farming: This experiment conducted on var. Arka Amogh, with eight treatments: four levels of Nitrogen (25, 50, 75 and 100%) were supplemented with FYM, three inorganic treatments viz., Integrated Nutrient Management with 100% RDF (25:60:50 kg N:P₂O₅:K₂O/ ha and 25 tons of FYM , Only recommended NPK (100%) without FYM and Safe Production wherein, no chemicals were used from the day of flowering for plant protection measures and only organic source was used.

Here substituting 100% recommended N through FYM recorded an yield of 12.21 t/ ha followed by 75% N through FYM (9.79 t/ ha). INM treatment produced significantly higher yield (15.37 t/ ha) than other treatments but on par with Safe vegetable production methods (15.14 t/ ha). Only chemical treatment produced the lowest yield of 9.54 t/ ha. Yield reduction in 100% recommended N through FYM was ~20% compared to INM.

Dolichos (Pole Type)

Organic farming: In a similar experiment, as in organic farming of Dolichos (Bush Type) with the same treatments, but on variety Arka Vistar revealed that INM treatment (FYM, 100% RDF (6:12:12 g/ plant) through inorganic fertilizers and PP chemicals) produced significantly higher yield (22.06 t/ ha) compared to other treatments except Safe vegetable production methods, which recorded (20.64 t/ ha). Only chemical treatment produced the lowest yield of 12.55 t/ ha. Application of 100% recommended N through FYM recorded yield of 13.65 t/ ha, followed by 75% N through FYM (12.75 t/ ha); N (100%) substituted through FYM recorded 39% less yield compared to INM with 100% RDF.

3.3.3. Ornamental crops

Chrysanthemum

Irrigation and nutrient scheduling: In var. Aishwarya scheduling the irrigation at 0.8 ER in combination with 33.3:33.3:33.3% NPK at @75:112.5:75 Kg NPK/ ha/ year (75% RDF) during all the three phenophases i.e. vegetative, bud and flowering phase produced the maximum flower yield/ha (22.50 t) and maximum water use efficiency (74.99 kg/ ha-mm). The physiological parameters i.e. photosynthesis rate (11.25 $\mu\text{mol m}^{-2} \text{s}^{-1}$), transpiration rate (5.31 $\text{mmol m}^{-2} \text{s}^{-1}$) and stomatal conductance (0.21 $\text{mol m}^{-2} \text{s}^{-1}$) were recorded for this treatment combination. Analysis of initial chemical and physical properties of the soil revealed that the soils were nearly neutral in reaction (pH 6.74), non-saline in nature (EC 0.26 dSm^{-1}), high in organic carbon status (8.7 g kg^{-1}), medium in available N (280 kg ha^{-1}), high in available P (39.5 kg ha^{-1}) and K (368 kg ha^{-1}). Exchangeable Ca (4.97 $\text{cmol (p}^+) \text{kg}^{-1}$) and Mg (1.69 $\text{cmol (p}^+) \text{kg}^{-1}$), DTPA Fe (12.63 mg kg^{-1}), Mn (14.6 mg kg^{-1}), Cu (2.94 mg kg^{-1}) and Zn (2.28 mg kg^{-1}) were also optimum in the soil having bulk density (1.32 mg m^{-3}), particle density (2.65 mg m^{-3}) and pore space (49.8 %). Plant nutrient uptake (kg ha^{-1}) for this irrigation and nutrient combination were - N (77.67), P (15.13), K (78.13), Ca (39.57), Mg (12.53), S (9.22), Fe (1.09), Mn (0.45), Cu (0.08), Zn (0.12). Shelf life of 4.3 days was obtained with flowers grown under this irrigation and fertilizer regime in 150 gauge polyethylene package under room condition (temperature 24-28 °C, RH 56-68%).

Gerbera

Cultivars Balance, Stanza and Arka Ashwa were efficient in nutrient use based on growth, nutrient accumulation and flower yield parameters (245-274 flower stalks/ m^2 / yr). In var. Julia scheduling the irrigation at 0.8 ER during vegetative and flowering phase in combination with 40:25:25% NPK at vegetative phase, 60:75:75% NPK at flowering phase @11.25:7.5:22.5 g NPK/ m^2 / month (75% RDF) produced the maximum number of flower stalks/ m^2 / year (226.33) and also maximum water use efficiency (2162.08 no./ ha-mm). The physiological parameters i.e. photosynthesis rate (6.92 $\mu\text{mol m}^{-2} \text{s}^{-1}$) transpiration rate (4.61 $\text{mmol m}^{-2} \text{s}^{-1}$) and stomatal conductance (0.24 $\text{mol m}^{-2} \text{s}^{-1}$) were recorded for this treatment combination. Flowers grown under this irrigation and fertilizer regime had vase life of 7.6 days under room condition in distilled water (temperature 24-28 °C, RH 56-68%).

Rose

Nutrient requirement: Nutrient requirement was quantified under polyhouse and open conditions based on biomass and nutrient removal pattern resulting in reduction of P dose by 37-69% over present recommendation of 32 g P_2O_5 / m^2 . In polyhouse, flower stalk production rate (14-17/ m^2 / month) of cut flower rose cultivars (Arka Swadesh, Arka Ivory and Arka Pride) was higher than average reported yields at different nutrient levels (40:10:50, 50:15:60 and 60:20:70 g NPK/ m^2). About 70% of the flower stalks in all cultivars registered grade A and B stalk length of above 45 cm. Preliminary results indicated that the number of flower stalks was slightly more at increased intra-row spacing to 20 cm (61 flower stalks/ m^2). Among the varieties, Arka Swadesh registered maximum number of flower stalks (67.5 flower stalks/ m^2). The growth and yield was better at lower doses of nutrients (64-67 flower stalks/ m^2) than at higher level (57 flower stalks/ m^2).

In open condition, both cut flower (Arka Swadesh) and loose flower (Arka Parimala) cultivars recorded better growth and yield parameters during the initial 4-month period after planting. The performance of cut flower to two irrigation levels (0.75 and 1.0 Ep) and three nutrition levels was positive in terms of flower stalk yield (29-33/ m^2 / month) and length. Irrespective of treatments, seasonal variability in flower diameter was noticed both in polyhouse and open field with lesser diameter of 2-3 cm during summer months than in winter. In rose, nutrient use efficiency in cut flower cultivars was quantified as 32% for N, 16% for P and 30% for K in polyhouse condition.

Tolerance to salinity and high pH: For identification of rose root stocks tolerant to salinity and high pH, initially a field survey was conducted in major rose growing regions



Rose cultivars with long flower stalks in polyhouse and open field

of Rajasthan and Uttar Pradesh, where soil and water had salinity and high pH problems. Some rose accessions performed well even when soil pH was as high as 8.29 and water salinity up to 2.72; chloride contents of 20 meq/ l was recorded, while bicarbonate varied from 3.8 to 10.9 meq/ l. The major rose varieties viz. Pushkar, Chaitri, Ganganagari of Rajasthan and Calcutta, Goriah and Jungli rose varieties from Uttar Pradesh have been collected and planted at IIHR for multiplication.

Gladiolus

Nutrient removal: Significant variations in above ground biomass of leaf and flower stalks (45-62% of total), below ground biomass of corms/ cormels (38-55%) and nutrient accumulation pattern was recorded in different genotypes. Phosphorus removal ranged from 2.8 to 5.45 kg/ ha. Potassium removal was significantly higher in cultivars like Arka Kumkum (114 kg/ ha) and Arka Aayush (107 kg/ ha) than other genotypes (37-80 kg/ ha). Overall, the P requirement for flower crops like rose, gerbera and gladiolus was less compared to the present recommendation.

Tuberose Pot culture: The media combination of Arka Fermented Cocopeat + Soil + Sand + FYM (1:1:1:1) v/v was the best potting media for the production of

maximum number of spikes/ plant, rachis length, floret length, number of florets/ spike, number of florets open at a time and longevity of spikes on the plant.



3.3.4 Medicinal Crops

Mandukaparni

Two varieties of mandukaparni (Arka Divya and Arka Prabhavi) were evaluated under open and 50% shade with graded doses of nitrogen through FYM and RDF. Arka Divya produced maximum fresh herbage yield (cumulative of four harvests taken at 60 days interval) of 21,777 kg/ ha with application of recommended FYM (5 ton/ ha) + RDF (100:60:60 NPK kg/ ha), followed by treatment with recommended FYM (5 t/ ha) + 125% of recommended N through FYM with fresh herbage yield of 20,776 kg/ ha when grown under open condition. The same treatment also produced maximum fresh herbage yield of 13,830 kg/ ha under 50% shade. However, there was 36.5% reduction in herbage yield in the best treatment viz., recommended FYM (5 ton/ ha) + RDF (100:60:60 NPK kg/ ha) under 50% shade.

Kalmegh

Water stress: Physiological and biochemical responses under low water stress imposed for different durations (3, 6, 9 and 12 days) was studied in kalmegh. Photosynthesis rate, stomatal conductance, transpiration rate, relative water content, chlorophyll content, and quantum yield of photosystems I and II (PSI and PSII) decreased in response to drought stress. MDA and proline showed significant increases at different durations of stress; however the increases in antioxidants were more pronounced in plants exposed to more than three days of stress period than at early stage.

Brahmi

Shade and manure requirements: The data of two harvests showed significantly higher growth parameters such as plant height, number of primary and secondary branches, plant spread and yield parameters (fresh and dry herbage) under 35% shade net compared to 50%

shade net and open conditions. Among different nutrient combinations, 100% N equivalent through FYM recorded highest fresh and dry herb yield (11.4 and 1.27 t/ ha) which was on par with inorganic nutrients.



Brahmi under shade and open conditions

3.3.5. Soil Health Management

Fruits

Nutrient management module under high density planting system in guava: A nutrient management module is being developed for Arka Kiran variety under high density planting. Vegetative growth characters of guava were marginally influenced at the early stage by planting densities. On an average, plant growth increased by 11.4% and stem girth increased by 8.54% in 3 m x 2.5 m planting density, compared to 2 m x 1.5 m planting density. Six months after planting, pruning was done. The 3rd pair of recently matured leaves in the month of August collected from different plots were analyzed for leaf nutrient concentrations: optimum levels for N (2.29-2.81%), P (0.167-0.213%), K (1.2-1.6%), Ca (1.78-2.4%), Fe (150.3-181.1 ppm) and Mn (66.1-81.7 ppm), and below optimum levels for Mg (0.195-0.219%), S (0.102-0.142%), Zn (16.5-19.8 ppm) and Cu (5.0-6.7 ppm) were noticed; Boron concentrations in leaf varied from 18.0-22.3 ppm, indicating that the leaf B concentration of guava is slightly lower than the optimum range (20-25 ppm) in few of the plots.

Soil chemical and microbial characteristics were analyzed from the experimental plots before imposing nutrient management modules and uniform pruning treatments. There were no significant differences in pH (7.1-7.6), EC (0.18-0.26 dSm⁻¹), organic carbon (5.8-6.3 g/ kg), available N (205.6-231.3 kg/ ha), available P (20.5-29.2 kg/ ha), available K (165-200.5 kg/ ha), Exch. Ca (2.48-2.95 cmol + kg⁻¹), Exch. Mg (0.73-0.91 cmol p + kg⁻¹), DTPA-Fe (8.15-9.56 mg/ kg), DTPA-Mn (5.75-7.15 mg/ kg), DTPA-Zn (0.54-0.67 mg/ kg), DTPA-Cu (0.36-0.49 mg/ kg) and hot water soluble boron (0.37-0.46 mg/ kg) among the different plots. The microbial

population in soil also did not vary considerably among the plots. On an average, the populations of bacteria, fungi, actinomycetes, Azotobacter and P-solubilizers in different plots varied from 1.6 x 10⁶ to 3.1 x 10⁶ cfu g⁻¹ soil; 4.1 x 10³ to 7.1 cfu g⁻¹ soil; 4.2 x 10⁴ to 7.1 x 10⁴ cfu g⁻¹ soil; 5.8 x 10³ to 8.5 x 10³ cfu g⁻¹ soil and 0.1 x 10³ to 0.4 x 10³ cfu g⁻¹ soil, respectively. Shoot borer, soft green scale, mealy bugs and ash weevil were the major pests observed during the period under report. Higher incidence of pests were observed in 2 m x 1.5 m planting density compared to 3 m x 2.5 m planting density.

Sources of potassium and their application methods on grapes:

A third year study on the influence of different sources of potassium and their method of application on growth, yield and fruit quality parameters in grape variety Sharad Seedless, was conducted with eight different treatment combinations, imposed on 14 years old vines. The treatments were 100% potassium (SOP) through soil application (T1); 60% fertigation (SOP) + 40% soil application (SOP) (T2); 60% fertigation (K₂NO₃) + 40% soil application (SOP) (T3); 60% fertigation (19 all) + 40% soil application (SOP) T4; 40% fertigation (SOP) + 60% soil application (SOP) (T5); 40% fertigation (K₂NO₃) + 60% soil application (SOP) (T6); 40% fertigation (19 all) + 60% soil application (SOP) T7 and 100% fertigation (SOP) (T8). After back pruning, highest sprouting percent was in 100% fertigation treatment. The incidence of Downy mildew was highest in T8 (84.2%) and least in T5 (35%) as deduced by sporangia count. At forward pruning, significant difference was recorded in percent fruitful canes and number of bunches among treatments with maximum in T5 and T8 and least in T6. Powdery mildew infection in bunches was highest in T1 (26.9%) and T6 (25.3%), and least in T5 and T2 (14.2-15.0%). Defence mechanism of treatments which showed higher and less incidence of diseases were studied through activity of peroxidase, catalase and PPO enzymes. Petiole nutrient content showed no significant difference after both the pruning except for calcium and manganese. Maximum yield was recorded in T7 (10.84 t/ ha), followed by T5 and T6 (8.5 t/ ha), and lowest yield was recorded in T8 treatment.

Integrated nutrient management: In Arka Sahan annona, highest fruit yield was obtained for 75% RDF + Bio-fertilizer Consortium in 10 kg FYM per plant both under fertigation and rainfed situations with all parameters including fruit quality remaining unaffected, suggesting the possibility of 25% replacement of chemical fertilizers with the Bio-fertilizer Consortium.

Conventional and Specialty fertilizers in fruit crops: Effect of conventional and specialty fertilizers in

fertigation showed that specialty fertilizers significantly improved growth of banana and papaya in terms of height and girth and yield in terms of bunch weight and individual finger weight in banana, and fruit weight in papaya. Distribution of NPK at different soil depths showed that soil NPK increased up to 20-40 cm depth in the treatments where specialty fertilizers were given through fertigation, due to increased solubility of water soluble fertilizers and consequent leaching to lower depths wherein majority of root growth of banana occurred. In banana, B:C ratio of using conventional fertilizers in fertigation to supply NPK was 2.99, whereas it was 3.43 when NPK was supplied through specialty fertilizers. In papaya, B:C ratio was 4.22 and 3.90 when RDF of NPK was supplied completely by water soluble fertilizers. In papaya use of specialty fertilizers rather than conventional fertilizers in drip was remunerative. In banana, the highest nitrogen use efficiency (3.14 g/ kg) and potassium use efficiency (5.23 g/ kg) were recorded when only N and K were given through water soluble fertilizers in fertigation. The highest phosphorus use efficiency (0.36 g/ kg) was recorded when all the three nutrients NPK were given through water soluble fertilizers.

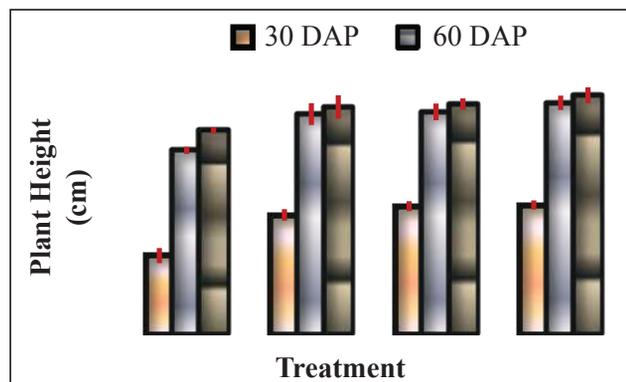
Vegetables

Foliar application of silicon in chilli: The highest K (3.59%), Ca (2.46%), Mg (0.74%), B (71.96 mg/kg) and Zn (49 mg/ kg), silicon (1.68%) contents were recorded in plants with zinc sulphate at 1.25 g/ l) and 4 ml/ l potassium silicate spray. The uptake of N, K, Zn and B was substantially higher in plants sprayed with potassium silicate compared to control. Enhanced K/Ca and Ca/Mg ratios in leaf and shoot tissues were observed. Foliar treatment with ZnSO₄ with potassium silicate was the most effective in providing resistance to powdery mildew. Leaf spots (*Cercospora capsici*) and die back symptoms (*Collectotrichum capsici*) were not observed in chilli plants even after 75 days after planting.

Chlorophyll content increased on application of ZnSO₄ with silicon sprays. The studies clearly indicate that Zn with silicon aids in the production and detoxification of oxygen radicals, limiting damage to plant cells. Higher enzyme activity of SOD and CAT was recorded by Zn with Si spray on leaves of chilli. Increased amount of Si aided accumulation of phenolic compounds, enhanced Zn uptake, and accumulation of Si on leaf surface may strengthen cell walls by lignin biosynthesis as evident by the increased activity of peroxidase enzymes.

Combined application of micronutrients and silicon on biomass production, yield, pest and disease incidence in Chilli (cv. Arka Meghana): The experiment was

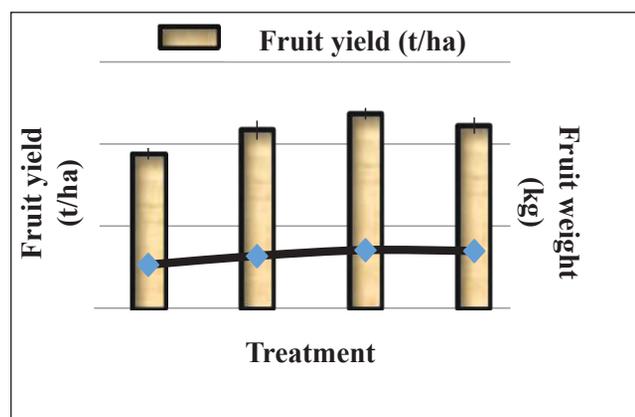
conducted on sandy clay loam soil (Typic Haplustepts), with pH 6.84, organic carbon 11.50 g/ kg, available N: 268 kg/ ha, available P₂O₅: 37 kg/ ha, available K₂O: 299 kg/ ha. The silicon content in soil extracted with CaCl₂ 0.01mol/l was 14.3 mg/ kg. The treatments were imposed by foliar application of zinc, boron with silicon (T1-Control; T2-0.125% Zn + 0.05% B + 2 ml/ lt potassium silicate; T3-0.125% Zn + 0.05% B + 4 ml/ lt potassium silicate; T4-0.125% Zn + 0.05% B+4 ml/ lt potassium silicate) after 15 DAP.



Chilli plant height as influenced by K₂SiO₃



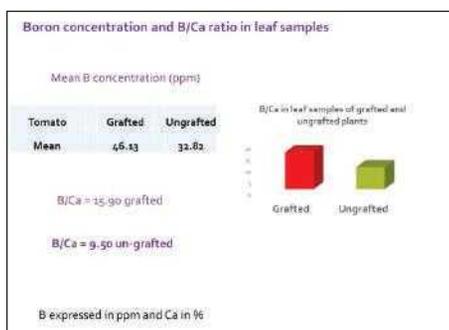
Zn and Silicon foliar application with micronutrients



The foliar application of silicon (as potassium silicate) irrespective of levels, significantly increased plant height and biomass production compared to control, significantly higher fruit yield was recorded by foliar application of potassium silicate irrespective of zinc levels compared to control. The highest fruit yield per plot (20.14 kg) was recorded in the treatment with foliar spray of potassium silicate at 6 ml/ l which was on par with the treatment supplemented with potassium silicate at 4 and 2 ml/ l (18.70 kg and 19.80 kg respectively).

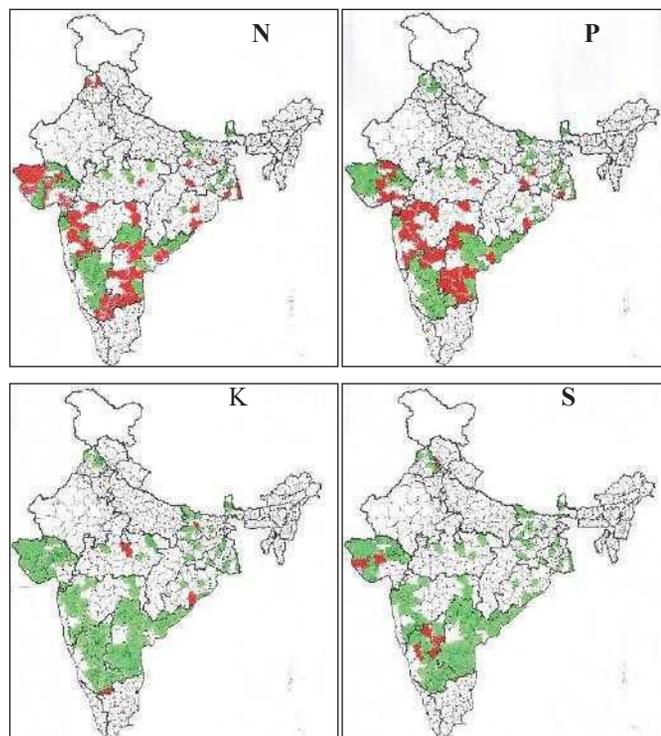
Rootstock-scion interaction effect on nutrient uptake and utilization efficiency in tomato and brinjal:

The influence of grafting in tomato on nutrient concentration and growth attributes was studied. At pre-flowering stage, the dry weight of grafted plants increased by nearly 66% compared to ungrafted plant. Minerals constituted 8.69% of dry weight in grafted and 6.98% in ungrafted plants. At harvest, there was an increase of 20% in dry matter accumulation of grafted plants compared to ungrafted plants. Bulk of the nitrogen in ungrafted plants were in the roots, nearly 2.5 times higher in roots of ungrafted plants compare to the grafted plants. The concentration of the critical elements like K and Ca was higher initially in leaf in ungrafted plants, however at harvest, the concentration of as many as seven elements in leaf, decreased by nearly 30% compared to pre-flowering stage. The fruits of grafted plants had higher concentration of N, K, Ca and Zn compared to the ungrafted plants. The nutrients in 18 Solanaceous species was quantified to assess if a particular accession had higher affinity for a given nutrient and if it could be used as a root stock in future studies: Ca concentration showed wide variation ranging from 0.94-6.53%, of the micronutrients Fe and B showed maximum variation in their concentration - Fe concentration ranged from 191-699 ppm, while B ranged from 1.15-8.92 ppm. The B/Ca ratio, one of the factors governing BER in tomato, ranged from 0.41-4.66 for different accessions. The nutrient acquisition and uptake was monitored in tomato plants grafted on brinjal root stocks: the roots had higher accumulation of Ca, grafting tomato on brinjal resulted in greater accumulation of K, Ca and Zn and less of Fe in stem, whereas the leaves were more efficient in acquisition of K and Ca.

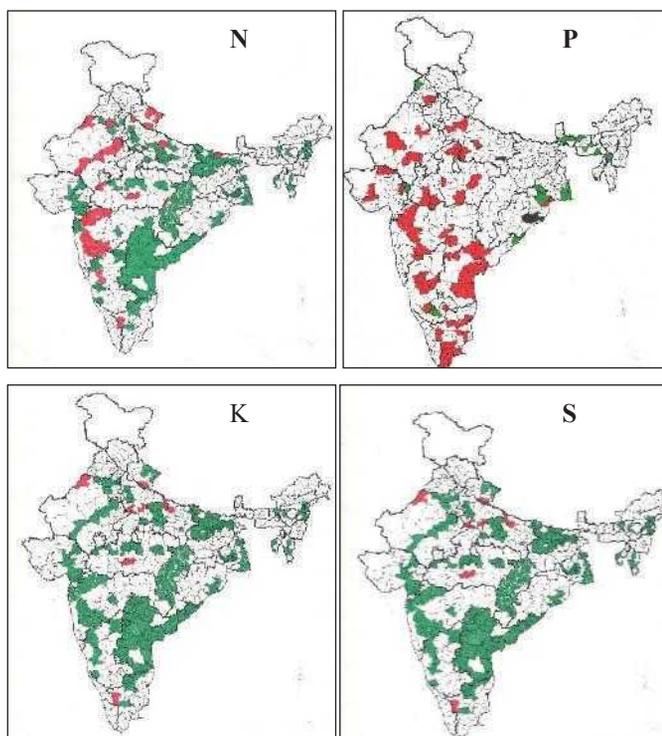


Crop specific N, P, K and S delineation maps of India for tomato, chilli, cabbage and cauliflower:

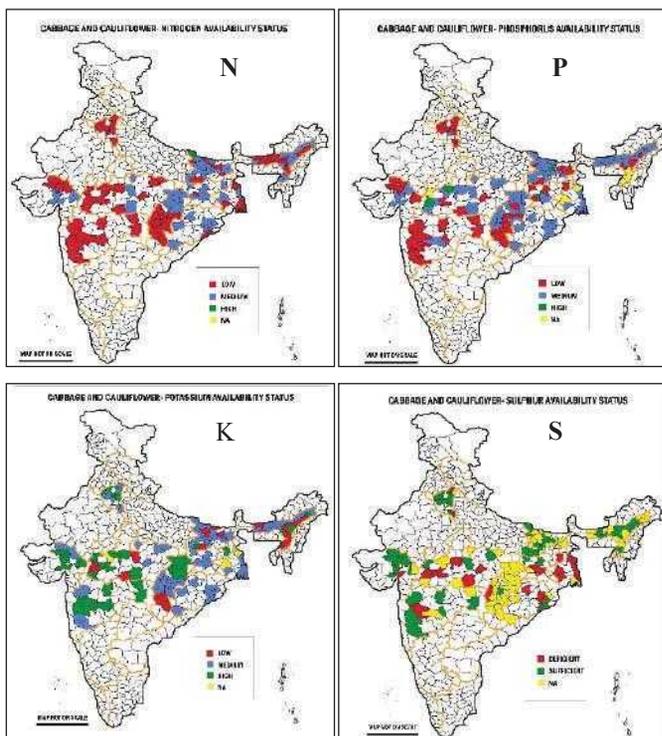
Data pertaining to nitrogen, phosphorus, potassium and sulphur status of soils of leading tomato, chilli, cabbage and cauliflower growing districts of Indian states was collected, and categorized into sufficiency and deficiency levels based on the critical values. Nutrient delineation maps for N, P, K and S for these crops were prepared.



Micronutrient delineation maps of for tomato



Micronutrient delineation maps of for chilli



Micronutrient delineation maps of for cabbage and cauliflower

Conventional and Specialty fertilizers in vegetable crops:

Specialty fertilizers in fertigation have not shown any significant effect on tomato growth. Height of tomato was maximum when N and K were provided through specialty fertilizers, followed by the treatment where N and K were given through conventional fertilizers and P as conventional fertilizers in basal application. Girth of tomato was highest when conventional fertilizers were used to supply N and K through fertigation. Tomato yield was highest when 75% of N and K were provided through conventional fertilizers in drip fertigation and P applied as basal. Specialty fertilizers have shown no benefits in tomato yield. In tomato, use of conventional fertilizers in drip to supply NPK was more profitable than use of water soluble fertilizers in drip. A B:C ratio of 4.70 was obtained when conventional fertilizers were used to supply 75% RDF of NPK in drip and B:C ratio of 3.77 was obtained when 75% RDF of NPK was given through water soluble fertilizers in drip. Nitrogen use efficiency was maximum (3.87 g/ kg) in tomato, with the use of water soluble fertilizers in fertigation. In cauliflower performance of water soluble fertilizers was on par or significantly higher compared to that of conventional fertilizers in terms of flower head weight and diameter. The N and K contents were more in 15-30 cm layer than 0-15 cm layer. Phosphorus content was more in 0-15 cm layer in all the treatments except in the treatment where 100% RDF of NPK was given through completely water soluble fertilizers. In cauliflower the highest nitrogen use efficiency (12.6 g/ kg) and potassium use efficiency (15.8 g/ kg) were recorded with water soluble fertilizers and

highest B:C ratio (2.66) was obtained with conventional fertilizers

Anhydrobiotic drying of efficient plant growth promoting rhizobacterial (PGPR) strains: To produce bioencapsulated seeds of okra, chilli and onion, anhydrobiotic drying of efficient PGPR strains, viz., *Pseudomonas* sp. - CP3, *P. taiwanensis* - AMC3, *Bacillus aryabhatai* - AMC2, *B. amyloliquefaciens* - P-72, *B. licheniformis* - CP2, *B. invictae* - CB16, *B. endophyticus* - FLCB11, *B. simplex* - FLCB 5, *Citricoccus zhacaiensis* - B4 was attempted. These strains were initially confirmed for their ability to grow in the presence of graded levels of PEG 8000, and all the strains survived at PEG concentrations of up to 25%, besides expressing plant growth promotion traits such as growth hormone production, phosphate solubilization and ammonia production. All the isolates promoted tomato seedling growth when the root and shoot parameters were recorded at 21 days after sowing. The elite isolates were then subjected to osmo-conditioning with either 25% PEG or NaCl and subjected to stable drying by lyophilization using different lyoprotectants such as skim milk, casein and trehalose. When cells were lyophilized with skim milk as a lyoprotectant, the unprimed cells had cell lyophilization efficiencies ranging from 0.83-0.92, cells lyophilized with 25% NaCl had cell survival efficiencies ranging from 0.83-0.93 while cells lyophilized with 25% PEG had cell survival efficiencies ranging from 0.91-0.98.

Soilless cultivation of chilli and coriander on Arka Fermented Cocopeat:

The production technology for soilless cultivation of chilli hybrid Arka Meghana and coriander var. Arka Isha on Arka Fermented Cocopeat under open as well as protected conditions was standardized. In chilli, nutrient scheduling of 176 ppm N-NO₃, 29 ppm P and 200 ppm K per plant recorded maximum stem diameter, number of branches and plant spread under open field conditions. Plant spread in EW direction was found to be slightly higher than in NS direction. However, the maximum plant height of 74.6 cm was recorded with 194 ppm N-NO₃, 32 ppm P and 228 ppm K nutrient scheduling. The highest number of fruits (248.2) and yield per plant (1.43 kg) was recorded with scheduling of 176 ppm N-NO₃, 29 ppm P and 200 ppm K per plant. The best nutrient scheduling under open conditions registered maximum growth and chilli yield in polyhouse conditions. Open field system of soilless cultivation outperformed polyhouse system in almost all the parameters. Maximum plant height of 91.8 cm was recorded with polyhouse system of soilless cultivation. In grow bag system of soilless cultivation, chilli raised on Arka Fermented Cocopeat registered maximum stem diameter (17.7 mm), number of branches (8.17), plant

spread (71.7 cm), number of fruits (232), fruit length (11.8 cm), fruit girth (10.3 mm), average fruit weight (5.68 g) and yield (1.29 kg/ plant) compared to soil (1.02 kg/ plant). However, soil recorded maximum plant height (78.8 cm) than Arka Fermented Cocopeat (72.0 cm). Soilless cultivation of coriander var. Arka Isha on Arka Fermented Cocopeat under open as well as in protected conditions revealed that the highest leaf yield of 4.79 t/ ha by pulling at 40 DAS was recorded with scheduling of 132 ppm N, 21 ppm P and 150 ppm K.



Soilless cultivation of chilli and coriander under open conditions

Plant growth promoting Actinobacteria from temperate regions: Soil samples were collected from pomegranate orchards in temperate regions of Jammu and Kashmir, Uttarakhand and Himachal Pradesh to explore Plant growth promoting Actinobacteria from temperate regions. Actinobacteria were isolated on different media like Actinomycetes Isolation agar, ISP-2 medium (International *Streptomyces* Project), Modified Nutrient agar and Kenknight and Munaier's medium. More than 80 different morphotypes of Actinobacteria were isolated and screened for biocontrol potential against *Xanthomonas axonopodis* pv. *punicea*, of which 20 isolates showed inhibition zones ranging from 0.80-2.50 cm under dual culture technique; 30 isolates also exhibited phosphate and zinc solubilizing ability on respective media. These isolates have to be further tested under *in vivo* conditions.

Ornamentals

Tuberose

Nutrient absorption studies: Uptake of macro (N, P, K, Ca, Mg and S) and micro (Fe, Mn, Cu and Zn) nutrients by 27 genotypes were studied. The highest N uptake was recorded in Bidhan Rajani-1 (2.14 g/ plant) and Arka Prajwal (2.08 g/ plant) and phosphorous uptake was high in Arka Prajwal (0.53 g/ plant) and Bidhan Rajani-1 (0.45 g/ plant). High potassium uptake was observed in IIHR-12 (2.58 g/ plant) and Bidhan Rajani-1 (2.26 g/ plant). The highest uptake of secondary (Ca, Mg and S) and micronutrients were also recorded in Bidhan Rajani-1 and Arka Prajwal. Six genotypes Bidhan Rajani-1, Arka Prajwal, Bidhan Rajani-2, Arka Vaibhav, IIHR-12 and IIHR-4 were superior in most of the mineral nutrient uptake.

In var. Arka Prajwal for the first year ratoon crop, scheduling irrigation at 0.8 ER at vegetative, 1.0 ER at flowering phase and 0.6 ER at dormancy phase in combination with nutrient scheduling at 30:25:25% NPK at vegetative phase, 30:40:40% NPK at flowering phase, 10:10:10% NPK at dormancy phase, 30:25:25% NPK at ratoon vegetative phase, 35:25:25% NPK at ratoon flowering phase, @200:200:200 kg NPK/ ha/ year resulted in 17% increase in yield of flowers and 28% increase in yield of cut flowers over the conventional practice. The water use efficiency of this treatment was 44.86 kg/ ha-mm for loose flowers and 805.39 nos./ ha-mm for cut flower production. The fertilizer use efficiency was estimated to be 58.16 kg/ kg for this treatment.

Marigold

Irrigation, fertigation and mulching schedules in marigold var. Arka Agni: Highest yield was recorded in fertigation with water soluble fertilizers @100% RDF and polyethylene mulching (13.08 t/ ha) followed by fertigation with water soluble fertilizers @75% RDF and polyethylene mulching (11.10 t/ ha). At all growing stages, N, P and K removal by plant (kg/ ha) was significantly affected by irrigation (I), fertigation and mulching (S) and their interaction (IxS). Among irrigation treatments, 1.0 ER resulted in highest N, P and K removal by plants at harvest followed by 0.8 ER and the lowest in 0.6 ER. Among fertigation and mulching treatments nutrient uptake by plant was maximum in fertigation with WSF @100% RDF and mulching followed by fertigation with WSF @75% RDF and mulching. Total nutrient removal was in the order of $K > Ca > N > Mg \geq P > S > Fe > B > Mn > Zn > Cu$. On an average, 13.6 kg N, 3.85 kg P and 18.7 kg K is required to produce one tonne of marigold (N:P:K ratio = 3.5:1:4.9).

Identification of pollutant absorbent ornamental shrubs/ trees: Air pollution tolerance index (APTI) was analyzed for 46 different tree species from Lal Bagh, Bengaluru. Highest APTI value was recorded for *Ceiba pentandra* (9.81), followed by *Terminalia myriocarpa* (9.75) and *Calliandra brevepes* (9.60). The species *Ceiba pentandra* and *T. myriocarpa* also recorded highest relative water content, chlorophyll and moderately high ascorbic acid content.

Mushroom : Substrate containing 33% corn cob waste could be utilized for *Pleurotus eryngi* cultivation. *Pleurotus tuber-regium* was found to be a rich source of protein, fiber and contained very low fat .

3.4. Crop protection

3.4.1. Fruit Crops

Mango

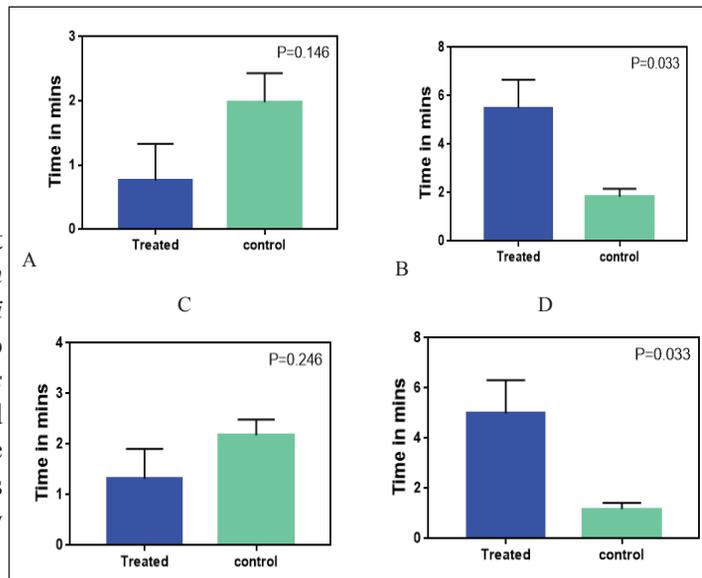
Management of leafhoppers and thrips: Different formulations of entomopathogens *viz.*, *Metarhizium anisopliae*, *Beauveria bassiana* and *Verticillium lecanii* were evaluated for their efficacy against mango leafhoppers (*Idioscopus* spp.) and thrips (*Scirtothrips dorsalis*) on *Totapuri* variety of mango. An IIHR developed oil formulation of *M. anisopliae* (0.5ml/L) which gave 85.2 % reduction in hopper and 74% reduction in thrips population was the most effective treatment consistently for three years.

Distribution of mango fruit borer, *Citripestis eutraptera*: The distribution of invasive fruit borer, *Citripestis eutraptera* on mango was studied in collaboration with centres of AICRP on Fruits and distribution map was prepared. The borer, which was earlier reported to be confined to Andaman and Nicobar islands has spread to several mango belts in the country since its first report in 2013 in the mainland. The incidence in different regions was in the range of 1-5% and was found to be spreading faster. The borer infestation was recorded from Chittoor (Andhra Pradesh), Bengaluru, Kolar, Shivamogga (Karnataka), Vengurle (Maharashtra), Paria (Gujarat), Bhubaneswar (Odisha) and Malda (West Bengal). In the Sub-Himalayan region of Pantnagar, the incidence was relatively high (15-20%) on varieties Alphonso, Dashehari, and Chausa. Across the regions, Alphonso was the most affected variety, though incidence was recorded on other varieties like Totapuri, Langra, Banganapalli, Mallika and Amrapali.



Symptoms of mango fruit borer damage

Niche partition in tephritid fruit flies: Studies were conducted to understand how two fruit fly species *viz.*, *Bactrocera dorsalis* and *B. correcta* coexist while using the same niche (guava fruit) for oviposition. Olfactometer bioassays with egg associated microbial cultures revealed that *B. dorsalis* was significantly more attracted to microbial volatiles collected from *B. dorsalis* eggs but not to microbial volatiles of *B. correcta* eggs. Whereas microbial volatiles collected from *B. correcta* eggs were more attractive to *B. correcta* but not *B.dorsalis*; However both *B. dorsalis* and *B. correcta* were attracted to the volatiles from control fruits.



Response of gravid females of *B. dorsalis* (A,D) and *B. correcta* (B,C) to microbial cultures isolated from the eggs of *B. correcta* (A,B) and *B. dorsalis* (C,D) in four arm olfactometer bioassays

Red ants repel fruit fly oviposition: Olfactory bioassays revealed that females of *Bactrocera dorsalis* avoided the treatment arm containing the body volatile of red weaver ant, *Oecophylla* suggesting repulsion behaviour, which was not observed in males. GC- EAD results showed that female *B.dorsalis* was responding to the cues *viz.*, undecane, tridecane that are present in the body volatiles of red ant, *Oecophylla* .

Wilt management: Among 10 fungicides evaluated to manage the wilt pathogen, *Verticillium dahliae* in mango, under *in vitro* conditions, benomyl at 200 ppm, thiobendazole and carbendazim at 1000 ppm were the most effective while other fungicides were effective at 2000 ppm.

Anthracnose management : At CHES, Bhubaneswar, 1-16% occurrence of anthracnose on green fruits was recorded. *Colletotrichum* species associated with

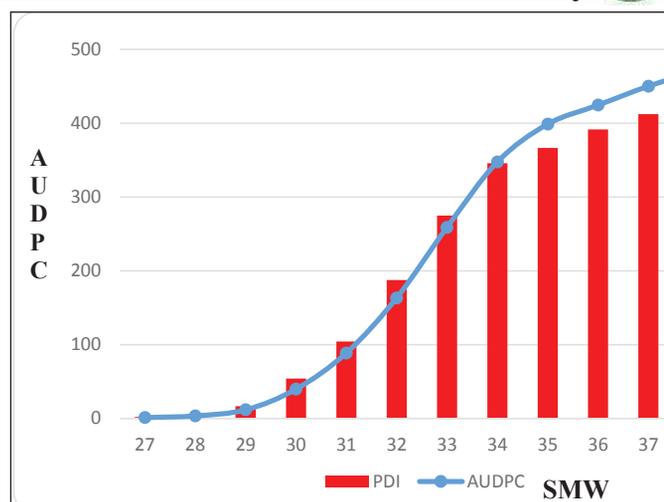
pre as well as post-harvest anthracnose rot of mango were isolated, their pathogenicity was evaluated and confirmed. Multilocus gene sequence analysis revealed that *C. siamense* was responsible for both pre as well as post-harvest anthracnose rot. Among the five treatments evaluated for the management of anthracnose, first spray with hexaconazole (0.05%) at pea stage followed by prepacked mixture of Tebuconazole+ Trifloxystrobin (0.1%) after 15 days and 3rd spray at 30 days prior to harvest again with hexaconazole (0.05%) with followed by post harvest hot water dip treatment (52°C for 10 min) resulted in 77.49 per cent reduction in disease severity compared to unsprayed control.

Citrus

Rootstock screening against *Phytophthora nicotianae* and *Phytophthora palmivora*: At CHES Chettalli, 12 rootstocks viz. Volkamer, Calamondin, Pomeroy, CRH-12, Soh-nairange, Tasi, Alemow, Citrumello, X-639, Rangpur lime, Hystrix and NRCC-3 obtained from CCRI, Nagpur were evaluated against *P. palmivora* and *P. nicotianae*. The rootstocks were inoculated by detached leaf method, seedling inoculation and root inoculation., Alemow rootstock was found resistant against both species of *Phytophthora* with low disease severity, while Soh-nairange recorded low disease severity against *P. palmivora*. Susceptible rootstocks were Volkamer, Calamondin and Pomeroy.

Grapes

Epidemiology and prediction model for yellow rust: Grape rust severity (PDI) varied from 22.00 to 84.00 in different 'Bangalore Blue' vine yards of various age groups in Bangalore District. Epidemiology of the disease revealed that the initial symptoms were noticed 80 days after pruning. There was a constant enhancement in apparent infection rate (r) from 0.11 in 27th SMW (2017) to 4.6 unit/day during 33th SMW (2017). Basic infection rate (R) increased from 0.22 unit/day during 27th SMW (2017) to 0.788 unit/day during 30th SMW (2017) and further decreased to 0.22 unit /day in the 38th SMW. The correlation coefficient (r) between mean disease severity indices and the weather parameters has indicated that severity of rust disease was positively correlated with maximum temperature ($r = 0.68^{**}$) and relative humidity during evening 14.00 h ($r = 0.68^{**}$), rainfall ($r = 0.57^{**}$) and number of rainy days ($r = 0.57^{**}$). In the case of high severity about 89.8% variability in per cent disease incidence followed the equation of $Y = -39.02 + 0.148 \text{ Max. temp.} + 1.164 \text{ Min. temp.} + 3.16 \text{ Rainfall}$ where $Y = \text{Percent disease Index (PDI)}$. This model would be highly useful in predicting the disease severity.



Progression of Yellow rust in grapes var. Bangalore Blue

Pesticide residues: Residue study of Forchlorfenuron on grapes was carried out as per good agricultural practices (GAP) after spray application at the recommended and double the recommended doses of 2 and 4 ppm twice at 10 day intervals. Residue analysis of grapes was carried out at regular intervals up to harvest (60 days). The residues of forchlorfenuron on the grapes were 0.246 and 0.438 mg/kg. At harvest, grapes were free from residues. The residues on grapes degraded with the half-life of 8 and 8.9 days from both the treatments and pre-harvest interval calculated based on the supervised field study and maximum residue limit (MRL) of 0.01 mg/kg was 36.3 and 46.8 days for standard and double dose treatments, respectively.

In case of Fosetyl-Al, tested at two doses of 2 and 4 g/L applied twice at 10 day intervals, the initial residues on the grapes (6.628 and 9.682 mg/kg) persisted beyond 30 days. Residues degraded with half-life of 5.4 and 7.4 days from the two treatments respectively. The pre-harvest interval calculated based on the supervised field study and maximum residue limit (MRL) of 100 mg/kg was 1 day for both standard and double dose treatments.

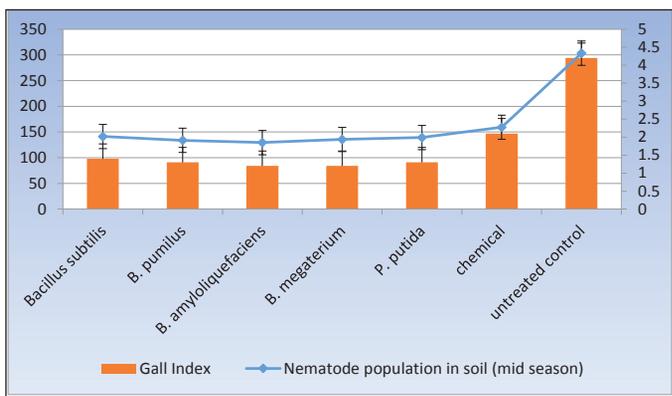
Method validation for analysis of residues: Method validation was carried out for analysis of fosetyl-Al, forchlorfenuron, and chlormequat chloride on grapes. The QuEChERS method was modified and used for sample preparation resulting in recoveries were in the range of 60-82 percent.

Pomegranate

Antennal transcriptomics of fruit piercing moth: Antennal transcriptome analysis was done for fruit piercing moth (FPM), *Eudocima materna*. A total of 286 olfactory related genes could be identified in the transcriptome. In addition, chemosensory receptors, sensory neuron receptors and ionotropic receptors were also identified. Further analysis and validation needs to be

done to understand the OBPs specificity and expression with respect to semiochemicals. A cladogram constructed for the pheromone binding proteins from FPM and other related moths showed its evolutionary relatedness to *Helicoverpa armigera*, *Spodoptera litura* and *Conogethes punciferalis*.

Biomangement of nematodes: Soil application of FYM enriched with biocontrol bacteria viz., *Bacillus amyloliquefaciens* or *B. megaterium* at 5 kg/plant before planting and further application of neem cake enriched with bioagents at 200 g/plant at six month intervals reduced population of *Meloidogyne incognita* by 55.8 - 57.3% in soil and by 71.42% in roots of pomegranate (cv. Bhagwa).



Effect of bacterial bioagents on root knot nematodes in pomegranate

Studies on wilt pathogen in cv. Bhagwa: Ceratoplatinin, a protein of low molecular weight (10-15 kDa) secreted by pomegranate wilt pathogen, *Ceratocystis fimbriata* was isolated and partially purified. Its efficacy was tested through bioassay using detached leaf and stem. Four methods of inoculation with toxin were tested, viz. applying a drop of toxin (10 µl) on leaf surface as point inoculation, spreading 10 µl of toxin on the leaf, point inoculation on the stem twig and dipping the stem twig in the toxin suspension for one minute. Phytotoxicity (browning of leaf and stem) was observed 24 h after application while necrosis or wilting in twig or stem started four days after inoculation. 10µl of ceratoplatinin (partially purified) (30µg/ml) is enough to cause necrosis/ wilt. This proved that the complete drying of the pomegranate trees when infected by *C. fimbriata* is due to the toxin production. This method can be employed to screen seedlings, root stock etc. for wilt tolerance.



Point inoculation on leaf



Spread on leaf



Point inoculation on stem twig



Dipping of stem twig

Reaction of pomegranate to partially purified ceratoplatinin toxin of wilt pathogen *C fimbriata*

Endophytes and their bioefficacy against wilt pathogen:

Endophytes isolated from pomegranate (root and leaf), mango and guava (root) were evaluated. The dual plate assay showed that root endophytic bacteria, PRE4 from pomegranate was able to inhibit the growth of *Ceratocystis fimbriata* isolate IIHR-CFB. A clear zone of inhibition and less sporulation was observed in the dual plate. Another endophyte from leaf, PLE4 prevented the growth of IIHR-CFB isolate but there was no clear zone of inhibition. Moreover PLE4 induced more sporulation in IIHR-CFB grown areas in the dual plate assay.



PRE4

Control

Guava

Shoot borer incidence: The young plants (0-2 years) of guava in Karnataka and Andhra Pradesh were found to suffer significant damage (10-40%) due to shoot borer, *Microcolona* sp. Within an orchard, those planted at closer distance (2 x 1.2 m) had higher infestation of shoot borer compared to wider spacing (3 x 1.2 m).

Management of guava wilt: Endophytes isolated from guava were tested against a virulent isolate of *Fusarium solani* from Guntur. Out of six root endophytes tested, root endophyte GRE1 was ineffective and GRE4 completely inhibited the pathogen. Other endophytes GRE2, and GRE3 were moderate in their inhibitory effect. Among different fungicides tested for chemical control of guava wilt, benzimidazole fungicides viz.

carbendazim, thiobendazole and binomyl at 200 ppm and dithiocarbamate fungicide mancozeb at 100 ppm were very effective while chlorothalonil, copper oxychloride, propiconazole, thiophanate methyl and tebuconazole were effective at above 2000 ppm.

Nematode management: Soil application of neem cake enriched with *Bacillus amyloliquefaciens* @ 200 g/plant once in six months recorded minimum gall index (1.2) and maximum per cent reduction (47.7 and 70) of root knot nematode population in soil and roots, respectively in guava (cv. Arka Kiran)



Biopesticide treated Untreated Nematode infected roots

Papaya

PRSV management: A significant positive correlation between the aphid population and maximum temperature and relative humidity in the morning hours was recorded which influenced the incidence and spread of PRSV. Wind velocity and rainfall were not found to influence PRSV spread. The rate of spread of PRSV was faster in susceptible cultivar 'Arka Surya' ($r = 0.127$ units per week) compared to tolerant cultivar 'Red Lady' ($r = 0.087$ units per week). The epidemiology of PRSV in papaya has indicated random and scattered spread of virus. Integrated disease management (IDM) modules comprising of border cropping with castor and Sesbania, silver mulching and spraying of TDS1 (4.0 ml/L) and Viroguard (2.0 ml/L), which are sea weed extract products along with neem oil significantly reduced virus spread and increased the yield.

Passion fruit

Begomovirus type identification: Of 19 virus infected passion fruit samples tested by PCR at CHES Chettalli, all were positive for begomovirus and their satellites. The resultant PCR amplicon was of 2.7 kb, which corresponded to the region of partial CP, REP and IR region of the DNA-A-like sequence of the begomovirus. The PCR amplified product was cloned and sequenced. The virus and satellites associated with passion fruit were identified through pair wise nucleotide sequence identity (NSI) as Ageratum Yellow Vein Sri Lanka Virus (95%

NSI), Tomato Leaf Curl Bangladesh Betasatellite (89% NSI) and Tomato Leaf Curl Pakistan Alphasatellite (89% NSI) respectively.

Annona

Microbes to degrade mealybug wax: Studies were conducted to identify and isolate wax degrading gut microbes from wax moth, *Galleria melonella* which could be used for mealybug management. Two fungal and one bacterial strain were isolated from the mid gut of wax moth and were tested for their wax degrading capacity in mealybugs. The fungal isolate-1 was found to be capable of degrading mealybug wax *in vitro*. Six different strains of *Bacillus* sp. and *Psuedomonas* sp. were screened for wax degradation capacity under laboratory conditions. Among them, *Bacillus pumilus* was found promising followed by *Bacillus subtilis*

Natural enemies of mealybug: Three predators of mealybugs were recorded in Annona ecosystem. Among them a predatory gall midge, *Triommata coccidivora* (Diptera: Cecidomyiidae) was the predominant one (18/ fruit) followed by the Lycaenid butterfly, *Spalgis epius* (3/fruit) and lady bird beetle, *Cryptolaemus montrouzeri* (negligible).

Jamun

Fruit weevil: Screening of jamun accessions for resistance to insect pests revealed severe infestation (up to 100% on some accessions) of fruit weevils, *Curculio c-album* and *Curculio notobifasciatus* (Coleoptera: Curculionidae) on fruits. This is attaining a major pest status in different jamun plantations.



Fruit weevil damage on jamun *C. c-album* *C. notobifasciatus*

3.4.2. Vegetable Crops

Tomato

Biology and management of invasive whitefly: Solanum white fly, *Aleurotrachelus trachoides* (Back) develops through six life stages - egg, four nymphal instars and adult. Adults are 1-2 mm in size, and are covered with a white waxy layer. They congregate on lower surface of the leaves and appear as white, waxy material, and sticky honeydew coupled with black sooty mold. Mitochondrial cytochrome oxidase-1 (CO-I) was sequenced from *A. trachoides* and the BLAST results suggested that

A. trachoides collected on tomato had 100% similarity with three other accessions of *A. trachoides* found in the BLAST search. Results also confirmed species level identity of the pest collected from various host plants. Management studies revealed that new molecules viz., thiamethoxam 25% WG, diafenthiuron 50% SP and acetamiprid 20% SP were affective against whitefly nymphs and adults.



4th Instar whitefly nymphs

Adult of whitefly

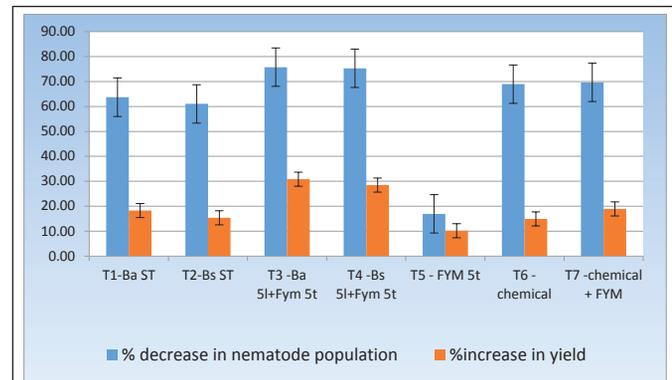
Host plant resistance for *Tuta absoluta* : Twenty one genotypes of tomato including 10 wild and 11 cultivated accessions were screened. Among the wild genotypes, *Solanum pennellii* (LA 1940), *S. chilense* (LA1963), *S. arcanum* (LA2157), *S. corneliomulleri* (LA1292, 1274) and *S. lycopersicum* (LA1257) were relatively resistant to *T. absoluta*. *In vitro* studies further confirmed the promising wild accessions *S. arcanum* (LA2157); *S. pennellii* (LA 1940) and *S. corneliomulleri* (LA1292) as good source of resistance against *T. absoluta*. The number of glandular trichomes (Type I, IV, VII) showed negative correlation in different genotypes of tomato with reference to larval number per plant, per cent damage and adult activity.

Management of *Tuta absoluta*: Garlic oil, lavender oil and ginger oil @ 0.1 % were effective against *Tuta* under laboratory condition. In the field, six sprays of silica (Potassium Silicate) @ 4 ml/l at weekly interval significantly reduced (about 70%) live mines of *T. absoluta*. Among insecticides, cyantranilipreole (10.26% OD @ 1.8 ml/L), chlorantranilipreole (18.5% SC @ 0.3 ml/L) and indoxacarb (14.5% SC @ 1 ml/L) were effective for the management *Tuta absoluta* with 2.9, 2.1 and 5.1 per cent fruit damage, respectively, compared to 35.8 per cent damage in untreated control.

Compatibility of insecticides with entomopathogenic fungi: Natural infection of *T. absoluta* with an entomopathogenic fungus, *Metarhizium anisopliae* was observed to an extent of 35 per cent. As different pesticides are being used in tomato ecosystem, their compatibility with the fungus was studied under laboratory conditions. Among the insecticides tested, azadirachtin 5% EC showed only 22 per cent inhibition of *M. anisopliae* fungal growth whereas other insecticides tested viz., lambda cyhalothrin 5 EC, indoxacarb 14.5 SC, thiamethoxam 25 WP, chlorantraniliprole 18.5 SC showed up to 60 percent

of the growth inhibition of the fungus.

Nematode management: Seed treatment with talc formulations of bacterial bioagents, *Bacillus pumilus* or *B. amyloliquefaciens* 1% WP at 20g/kg seed, substrate treatment at 10g/kg coco-peat and soil application of 5 tons farm yard manure (FYM) enriched with bioagents at 5 kg/ha recorded significantly higher yield (29.08 – 30.09% increase) and lower nematode population in soil and roots (73.99 – 74.72% decrease) of tomato cv. Shivam. Application of liquid formulations of bioagents as substrate treatment (ST) with *Bacillus subtilis* (Bs) or *B. amyloliquefaciens* (Ba) 1% A.S @ 5 ml/ kg coco peat in portrays and soil application of 5 tons of FYM enriched with either of the mat 5 l/ha recorded significantly higher yield (31.3 to 32% increase over control) and lower nematode population in soil and roots of tomato (75.3 – 75.8 % decrease).



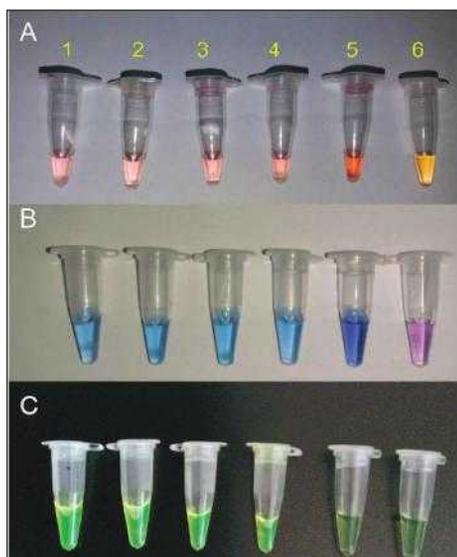
Effect of liquid formulations of bacterial agents on nematode management in tomato

Disease surveillance: Severity of bacterial leaf spot caused by *Xanthomonas axonopodis* pv. *vesicatoria* ranged from 5 - 50% in tomato and 1 - 15% in chilli in Andhra Pradesh and Karnataka. Highest severity (50%) was recorded in Kolar District and lowest in Chitradurga District of Karnataka and 35 - 42% in Madanapalli and Anantapur Districts of Andhra Pradesh.



Symptoms of *Xanthomonas axonopodis* pv. *vesicatoria* on Tomato

Detection system for Tomato Leaf Curl Bangalore Virus (ToLCBaV): A Loop-mediated Isothermal Amplification (LAMP) based detection system was validated for ToLCBaV infecting tomato. This is a relatively new technique for amplifying DNA and was very sensitive and specific for the detection of ToLCBaV. A set of four LAMP primers (i.e. F3, B3, FIP and BIP,) designed on the basis of the Ac1 gene of ToLCBaV were used.



Visualization of LAMP product using nucleic acid stains (A) Ethidium bromide (B) HNB (C) Calcein. Tube 1: positive sample for ToLCBV, 2-4: virus infected tomato sample, 5: Healthy tomato sample, 6: control

Chilli

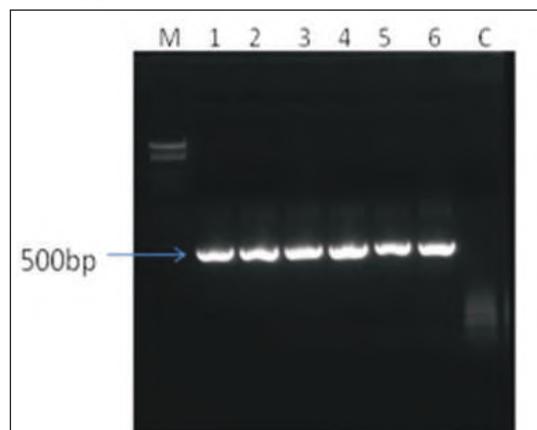
Management of thrips, *Scirtothrips dorsalis*: Five sprays of silica (Potassium Silicate) @ 4 ml/l at 10 days interval resulted in 60 per cent reduction of thrips population on chilli.

Phytophthora management in chilli and capsicum: Four contact fungicides viz., chlorothalonil 75%WP, copper oxy chloride 50% WP, copper hydroxide 77% WP, captan 50% WP and six systemic fungicides viz., fenamidone (10%) + mancozeb (50%) 60WG, famoxadone (16.6%) + cymoxanil (22.1%), iprovalicarb 5.5%+ propineb 61.25%WP, dimethomorph 50%WP, famoxadone 16.6% + cymoxanil 22.1% SC and Fosetyl Aluminium 80%WP were assayed up to 2000 ppm for *in vitro* efficacy against mycelia inhibition of *Phytophthora capsici*. Among them dimethomorph 50%WP @1000 ppm and chlorothalonil 75%WP @2000 ppm were the most effective fungicides for mycelial growth inhibition.

Begomovirus in chilli: At CHES Chettalli, of a total of 118 chilli samples collected from high humid tropic region of Western Ghats, 92 tested positive for begomovirus and their satellites. The chilli leaf curl incidence ranged from 10 to 60% in different places surveyed. Further,

pair wise nucleotide sequence identity (NSI) identified the virus and satellites associated as Chilli Leaf Curl Virus (ChiLCuV) and Tomato Leaf Curl Bangladesh Betasatellite (ToLCBDB) respectively.

Identification of Chilli Tospovirus resistance gene through NBS-LRR RGAs: Five sets of degenerate RGA primers were designed based on available RGA sequences in NCBI Genebank. The Genomic DNA from resistant and susceptible lines of chilli was isolated and PCR amplified using designed degenerate RGA primers. The PCR amplified products of RGAs from resistant lines were cloned and sequenced. Sequence analysis indicated 18 TIR-NBS-LRR type RGAs and 12 Non-TIR-NBS-LRR type RGAs. The clones MKMD361R, MKMD438R, MKMD442R, MKMD535R, MKMD561R, MKMD562R, MKMD465R, MKMD551R, MKMD431R, MKMD435R, MKMD555R and MKMD560R amino acid blast search and sequence analysis indicated these RGAs have high sequence homology with known Non-TIR-NBS-LRR type RGAs. The highest homology of 84 to 99% was realized with known RGAs of *Capsicum annuum* (RGA13, RGA14, RGA15 and RGA16). The other NBS resistant protein RGAs of *Nicotiana tabacum*, *S. lycopersicom*, *S. pennellii* and *S. tuberosum* showed 73 to 87% amino acid homology. All these are Non-TIR-NBS-LRR type RGAs.



RGA gene amplification in chilli line IIHR4585
M: Lambda DNA/EcoR1 marker, 1-6: Chilli line amplification, C: Healthy control

Epidemiology of vector borne viruses: Maximum temperature was negatively correlated while rainfall prevailing two weeks before was positively correlated with aphid population build up which in turn influenced the incidence of Cucumber mosaic virus (CMV), Chilli vein mottle virus (ChiVMV) and polerovirus. Relative humidity in the morning and wind speed significantly was correlated with the thrips population build up and subsequent spread of thrips transmitted GBNV. Maximum temperature and rainfall also significantly correlated with whitefly population build up and the incidence and spread of whitefly transmitted Chilli leaf curl virus.

Management: An IDM module comprising of border cropping with maize and raising of seedlings under nylon net cover, application of Seed-Pro and seedling dip in imidacloprid @ 0.5ml/L followed by main field spraying with TSD1, a sea weed extract at weekly interval up to fruit formation significantly reduced the incidence of Cucumber mosaic virus (CMV), Chilli vein mottle virus (ChiVMV), Chilli leaf curl virus (ChLCV) and Groundnut bud necrosis virus (GBNV) and increased the yield (42.6 t/ha).

Brinjal

Ash weevil management: Among different entomopathogenic nematode (EPN) species tested, *Heterorhabditis indica* caused the highest mortality of ash weevil (*Myloccerus subfasciatus*) both in pot trials (91.4%) and field conditions (65.13%). When integrated with entomopathogenic bacteria (EPB) *Bacillus subtilis*, it recorded 69.47% grub mortality and 76% reduction in leaf damage due to ash weevils in brinjal field. In another study, drenching of microbial agents viz., *Beauveria bassiana* and *Bacillus subtilis* significantly reduced the ash weevil infestation in brinjal.



Brinjal plants affected due to *Myloccerus subfasciatus*



Treatments with *H. indica* + *B. subtilis*



Treatments with *H. indica* alone



Grub mortality due to *H. indica*

Detection of phytoplasma infecting brinjal: Four little leaf infected samples of brinjal collected from Mysore (Hunsur) were confirmed for presence of phytoplasma by PCR using universal phytoplasma specific 16s RNA and secY gene primers. The resultant PCR amplicon of 1.8 kb corresponds to the region of 16s RNA gene of phytoplasma. The analysis showed that, the eggplant phytoplasma shared maximum sequence identity of 99.1 - 99.3% with previously identified eggplant little leaf (EF186820, AF228052, X83431), 99.2% with periwinkle little leaf (AF228053) and it belongs to the 16SrVI clover proliferation group. Based on the NSI and pair wise comparison, the phytoplasma was identified as *Candidatus Phytoplasma trifolii* (> 99 % NSI).

Okra

Botanicals against okra hoppers: Neem seed powder pellets (30g/L) and essential oil formulation (5 ml/L) recorded lower leaf hopper count of 4.2 and 4.3/plant compared to 8.4 in untreated control.

Efficacy of biopesticides for the management of *M. incognita*: Seed treatment of okra with liquid formulation of *Bacillus pumilus* 1% A.S @ 10 ml/kg seed and application of 20 tons of FYM enriched with *B. pumilus* @ 5 l /ha recorded maximum decrease in *M. incognita* population (70.19%) and higher yield (30.83%).

French bean

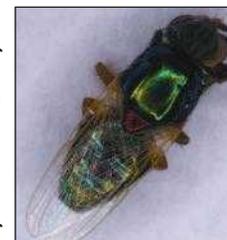
Detection of begomovirus in French bean: Out of 20 French bean viral infected samples collected (from Kushalnagar, Shivamogga and Chikkamangalore) and tested by PCR, 19 were positive for the begomovirus and their satellites. The virus and satellites associated with French bean were identified as Ageratum Yellow Vein Sri Lanka Virus (90% NSI) and Ageratum Yellow Vein Betasatellite (87% NSI) respectively.

Cabbage

Management of DBM: Neem seed powder pellets (30g/L) and neem seed powder extract (4%) were effective in management of diamond back moth with cumulative larval count of 1.6 and 1.8 larva/ plant compared to 5.5 larvae/plant in untreated control.

Drumstick

New pest record: Incidence of dipteran, *Physiphora aenea* was recorded for the first time on pods of drumstick causing severe damage and subsequent rotting. It was active during May- June with yield loss of 50-60 per cent. Soil application of



Adult of *Physiphora aenea*

neem cake @ 625 kg/ha, collection and destruction of infested pods, spraying of spinosad (0.3ml/l) or lambda cyhalothrin (0.6ml/l) was effective for the management of this pest.

Gherkins

Biomangement of nematodes: In gherkins cv. Ajax, application of biocontrol agents viz., *Bacillus subtilis*, *B. pumilus*, *B. amyloliquefaciens*, *B. megaterium* and *Pseudomonas putida* reduced the nematode population by 56.6% - 64.8% in soil and roots and increased the yield by 18.9 – 24.6 per cent.

Bottle gourd

Identification of Cucumber green mottle mosaic virus (CGMMV): The CGMMV infecting bottle gourd showed symptoms of mosaic, mottling leaves, mottling and uneven surface on fruits. Symptomatic samples in leaf dip preparations when observed under electron microscope revealed presence of rigid rod shaped particles of 300nm length. Sap extracted from infected sample in phosphate buffer on mechanical sap inoculation to cucumber, muskmelon, and pumpkin could be easily transmitted. Total RNA isolated from infected samples using RT-PCR with tobamovirus specific primer has resulted amplification of 0.5 kb DNA fragment from infected samples but not from healthy sample.



Cucumber green mottle mosaic symptoms on bottle gourd

Management of downy mildew in bitter gourd: At CHES Bhubaneswar, an effective, economically viable and environment-friendly strategy has been developed for the management of downy mildew on bitter gourd. Spraying with BS @1.5g/L (5 sprays at 10 days interval) could protect bitter gourd plants against downy mildew. Treatment resulted maximum yield (17 kg/plant) compared to control (7 kg/plant). It was also observed that Dispirin @ 2 tab/L in combination with diafenthiuron spray @ 2g/L could help recover the virus infected cucumber plants in the early stages.

Lettuce

Pesticide residues: Persistence of residues of

carbendazim, imidacloprid, metalaxyl, profenofos, fenazaquin, monocrotophos and thiophanate methyl in lettuce grown in poly-house was determined to be more than 15 days. Initial deposit of pesticide residues was very high (2.5 to 9.5 ppm) and half life was 7.2, 4.9, 4.1, 2.4, 5, 5.4 and 6.1days respectively for the above pesticides in lettuce. Based on the study, the recommended waiting periods for these pesticides in were 30, 6, 1, 23, 23, 37 and 32 days respectively.

3.4.3. Ornamental Crops

Tuberose

Biomangement of nematodes in tuberose: Dipping of tuberose (cv. Arka Nirantara) bulbs in *Bacillus subtilis* – 1 % W.P. suspension at 10 g/L of water followed by soil application of 5 tons/ ha of FYM enriched with *B. subtilis* (5 kg) recorded maximum decrease in nematode population in soil (67.9%) and roots (72.5%). This treatment also recorded the maximum increase in flower (29.7%) and spike yield (25.3%).

Varietal Screening for nematode resistance: Among 27 varieties/ hybrids of tuberose screened for resistance to root knot nematodes, the least number of galls was recorded in Swarna Rekha (GI – 1.03) followed by IIHR-5 (GI – 1.10) which showed highly resistant reaction under field conditions.

Marigold

Bud borer, *Helicoverpa* management: Thiodicarb 75 WP @ 1g/L followed by spinosad 45 SC @ 0.25 ml/L, indoxacarb 14.5 SC @ 0.75 ml/L and Bt @ 1 ml/L gave significant reduction of 94.40 %, 88.80 % and 77.59 % and 77.59 % of bud borer, respectively.

Calendula

Detection of begomovirus: Four viral infected calendula samples collected from Madikeri (Kushalnagar and Gonikoppal) confirmed for presence begomoviruses by PCR using universal begomoviruses specific primers. The virus associated with calendula were identified as Croton Yellow Vein Mosaic Virus.

3.4.4. General aspects

Biopesticide formulations: *Bacillus pumilus* (IIHR BP-2, NAIMCC – B-01213) is a promising bioagent that effectively controls nematodes and soil borne pathogens. ICAR – IIHR, Bengaluru has standardised the protocol for mass production of *B. pumilus*. Liquid formulations are



Bacillus pumilus
1% A.S.

more advantageous to farmers than talc based solid formulations due to longer shelf life. This product has a shelf life of 12 – 15 months. This bioagent resulted in 89.73% reduction in egg hatching of root knot nematode, *Meloidogyne incognita* and 88.5% mortality of its juveniles. In addition, it caused 15.48 - 26.5% increase in yield in several horticultural crops.

Mass production and formulation of entomopathogenic nematodes (EPN): A medium containing rice bran oil + corn flour could produce 2.2 to 6.9 lakh infective juveniles of EPN, which was about 13.6 to 34.9% higher recovery than the standard Wouts medium. Formulation in talc recorded 100 % survival of EPN up to 10 weeks for *Heterorhabditis indica* and six weeks for *Steinernema carpocapsae* and *S. glaseri* while with gel formulations, maximum shelf life of 12, 10 and 8 weeks was recorded at 4 °C for *S. glaseri*, *S. carpocapsae* and *H. indica*, respectively.



Talc and gel based formulations of EPN

Talc formulations were prepared for six *Bt* isolates with one *B. subtilis* reference strain for revalidation of nematicidal activity in tomato roots infested with of *M. incognita*. Cry6A gene isolated was sequenced and found homologous to cry6A from YBT. The cloned nematicidal cry gene Cry6A was subcloned to pRSET expression vector and expression was induced in BL21 E coli strain. The bioassay results were reconfirmed in pot experiments, wherein maximum per cent decrease in gall index was observed in two isolates namely 50F and KLP.

Herbal product ‘veggie wash’ to remove pesticide residues: A herbal veggie wash has been developed for dislodging pesticide residues from surfaces of fruits and vegetables. A combination of two herbal extracts in the proportion of 3:1, the ‘veggi wash’ was found to be superior to all other treatments resulting in 76% dislodging of surface residues which was 37 % higher than washing with water alone. The same was also more efficient in removal of surface residues of pesticides than a commercially available veggie wash used as check. The formulation was also made in liquid form but the solid form was better in terms of ease of transport and shelf life.

3.5. Crop utilization and farm mechanization

3.5.1. Crop utilization (Post- Harvest Management and Value Addition)

Fruits

Mango

Extension of storage life: Mango (cv. Alphonso) storage in unripe condition for one month at 8°C was achieved without any chilling injury by bi-layer coating (pectin and xanthan gum) or tri-layer coating using pectin, xanthan gum and methyl cellulose. At 13°C, mangoes could be stored for 25 days with weight loss of 5.9% compared to 9.0% weight loss in non-coated fruits.

Value added products: A process was developed for making dehydrated mango slices containing low sugar by vacuum infusion of ripe juice of Amrapali and Raspuri mango varieties into Totapuri mango slices. The infused dried mango slices were superior in colour and flavour than untreated control and had carotenoids content of 1765 µg /100g as compared to 335 µg/100g in osmo treated samples.

A probiotic mango RTS beverage prepared using the screened *Lactobacillus helveticus* strain showed an average sensory score of 6.8 on a scale of 9 after storage for four months under refrigerated conditions. There was a slight increase in acidity and decrease in sugar content during storage. A cell population of 4×10^8 cells/mL could be maintained during the storage period.

A mango bar prepared incorporating moringa leaf powder at different concentrations had significantly higher carotenoids (7.60 mg/100g) and polyphenols (2.32 mg GAE/g) compared to control after 90 days of storage. It exhibited similar organoleptic scores as that of control and was found to be safe with respect to aerobic plate count, yeast, mold and coliforms after 90 days of storage.

Management of anthracnose: Cost effective management of post-harvest anthracnose by pre and post-harvest treatments in mango (var. Amrapali) showed that treatment involving 3 sprays of hexaconazole (0.1%) followed by hot water treatment (52°C for 10 min) recorded least anthracnose severity as well as incidence (severity of 5.2% over 33.72% in control without spray and incidence of 10.70% over 51.60% in control).

Guava

Extension of storage life: In Guava, mature green fruits of cv. Arka Mrudula could be stored in unripe condition for 4 weeks at 8°C, 3 weeks at 12°C and 1 week at RT with less PLW, higher firmness and maintenance of quality by MA packaging in PE or D-955 films.

Improvement in packaging: Biodegradable fruit tray cushions made of recycled paper and banana pseudostem was improved by adding tamarind seed powder. The size of the tray was 300mm x 30mm, tray thickness 225GSm and Cobb value 226.51g/m². The tray with improved strength was tested as fruit tray cushions in guava packed in CFB boxes and transported by road for long distance.



Biodegradable fruit tray cushions for transportation of guava

Pomegranate

Antioxidants from rind : Methanol extraction of pomegranate rind gave highest yield of antioxidants (42 % with activity of 681 mg / g of AEAC units). Although acetone extract gave lesser yield (25 %) but activity of extract was high (1022 mg / g of AEAC units). Addition of 10 % water to acetone dramatically improved the yield of natural antioxidants to 30-35 % with good activity (1120 mg / g of AEAC units). No reduction in the activity of the antioxidants was observed when heated in solid state at 150° C for 30 minutes or in solution when heated at 100°C for one hour. Negligible loss in activity of antioxidants occurred when stored for 6 months at room temperature. Antioxidant activity of outer rind and inner mesocarp had comparable activity. Inner mesocarp contained more ellagitannins. The antioxidants from pomegranate rind appear to be superior to ascorbate class of antioxidants due to their higher activity and heat stability. In addition to their usage as natural antioxidants, these peel antioxidants also holds promise as nutraceutical food supplements for the alleviation of oxidative stress in humans.

Jackfruit

Value addition: Jackfruit RTS beverage after enzyme clarification prepared from 10 different accessions showed that Accn.53 (Thrithahalli) had highest overall acceptability score (3.72 out of 5.00)



Jackfruit RTS beverage

while the rest did not vary significantly among themselves. With regard to physico-chemical quality No.57 had the highest total soluble solids (30.5°Brix) followed by Dorechandra (29.17°) and G-12(No.75) which had 28.2° Brix. Fructose, glucose and sorbitol were the major sugars accounting for 49.33, 23.45 and 21.09 %, each respectively in Hulimavu accession and 36.43, 14.83 and 45.41% in MRS G-7 accession. The

orange flake accession (MRS G-7) has good potential for development of low GI drinks / foods due to its high level of sorbitol.

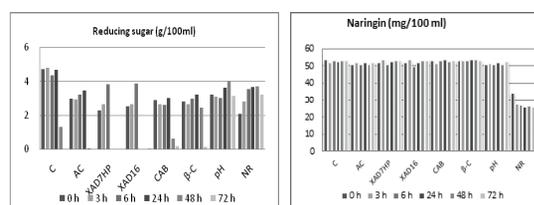
Jackfruit seed powder: The nutritional composition of jackfruit seed powder (Hulimavu) showed 60.62% starch, 2.05% crude fibre, 0.366% proteins and rich in phytochemicals like phenols (0.86%±0.09 mgGAE/g), flavonoids (1.57±0.17 mg Catechine q/g) and anthocyanins (6.17±0.82 µg Cyanidine q/g). It has a total antioxidant activity of 6.17±2.84 µgAAE/g and free radical scavenging capacity of 29.63±1.91 µg AAE/g. Jackfruit seed powder fortified chapathi (Indian bread) at 15% substitution showed reduction in total sugars by 23%, crude fibre increase by 600%, flavonoids increase by 30% and anthocyanins increased by 150%. In jackfruit seed powder (JFSP) fortified biscuits, refined wheat flour (maida) in biscuits could be substituted by upto 20% without affecting its sensory quality.

Pineapple

Value addition: Probiotic pineapple juice prepared using the screened *Lactobacillus helveticus* strain showed an average sensory score of 6.5 on a scale of 9 after storage for 45 days under refrigerated conditions. There was a slight increase in acidity and decrease in sugar content during storage. A cell population of 1.5×10⁸ cells/ml could be maintained during the storage period.

Pummelo

Value addition: Debittering of pummelo juice was carried out by reducing naringin and limonin on treatment with naringinase enzyme, Amberlite XAD7HP resin and pH adjustment to 4.5. Retention of reducing sugars was more in naringinase treatment due to enzymatic hydrolysis of sucrose and polysaccharides, total and non-reducing sugars were high in juice treated with Amberlite XAD7HP, Amberlite XAD16 and β-cyclodextrin resins. For the retention of vitamin C and phenolics, and antioxidant activity the most effective treatments were to increase pH to 4.5 and use of resins. Thus, debittering pummelo juice can be achieved by a judicious combination of strategies such as treatment with naringinase enzyme, increasing pH to 4.5 and Amberlite resins.



Effect of debittering treatment of pummelo juice on reducing sugars and Naringin content of juice.

Avocado: Optimal conditions to produce encapsulated

avocado powder was standardized as 160 to 180 °C, 10 ml/min feed flow and 10% maltodextrin, as it had maximum yield (11.83%), lower acidity; as also better visual appeal - maximum L^* (69.93), greenness (a^*) (0.80); besides non-enzymatic browning decreased during storage.

Vegetables

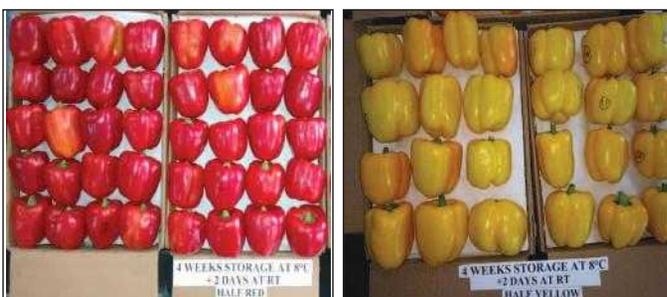
Extension of shelf life: Storage life of beans cv. Arka Sarath was found to be 20 days at 7°C, 16 days at 10°C and 12 days at 13°C without any chilling injury and maintenance of quality parameters as compared to 3 days under ambient conditions. A shelf life of 2 days at the duration and temperature regime mentioned above at 7°C compared to 1 day shelf life after following the duration and temperature regime mentioned above at 10 or 13°C.



Beans stored for 12 days at 13°C

Protocols for extending the shelf life of minimally processed fenugreek leaves and microgreens were standardized. In both cases, use of the optimized protocol resulted in an additional shelf life of 13 days during storage at 8 °C, compared to control samples

Red and yellow colour capsicum harvested at half maturity (50% colour development) could be stored for 4 weeks at 8°C without affecting the quality (with proper colour development) as compared to 3/4th and full colour maturity stage.



Capsicum harvested at 50% colouration and stored at 8°C for 4 weeks

Osmotically dehydrated carrot: Storage quality evaluation of osmotically dehydrated carrot slices indicated loss in carotenoid content from 30mg/100g to 15 mg/100g after six months of storage. Total phenols were reduced from 0.718 to 0.53 mg GAE/g. The product was highly acceptable as well as microbially safe after six months of storage.

Moringa products : Solar dried moringa leaf powder cv. Bhagya at 1% (T1) and 2% (T2) was incorporated into mango pickle. Total carotenoids (8.43 mg/100g) and total polyphenols (1.69 mg GAE/g) were significantly higher in pickle with 2% moringa leaf powder compared to control during storage period of six months. Organoleptically, T2 and control scored 6.8, while T1 scored relatively higher (7.35) even after six months of storage period. Samples were found to be within the microbiological safety limits of acceptance even after six months of storage under ambient conditions.

Moringa infusion/tea was prepared along with thulsi, ginger and lemon grass. Moringa infusion had high polyphenol content (15.2 mg GAE/ml) compared to other treatments. Flavonoids content was found higher in sample containing moringa along with thulsi (6.73 mg catechin/ml). Organoleptically moringa with thulsi sample scored highest.

Cytotoxicity studies: Ethanol (50%) and aqueous extracts of moringa leaf powder were treated against human cancer cell lines such as A375 (epithelial cancer cells), Hep G2 (liver cancer cells) and HeLa (cervical cancer cells) at concentrations ranging from 10-100µg/100µl at different time intervals (24, 48 and 72 h). Ethanol extract was more cytotoxic (79% inhibition@100µg/100µl after 72 h) to the epithelial cancer cells compared to aqueous extract of moringa leaf powder

Sanitizing of vegetables: The use of neutral electrolysed water (100ppm) as a sanitizer was effective in decontamination of *Salmonella*, *Listeria*, *Escherichia coli*, *Bacillus cereus* and *Staphylococcus aureus* from the surface of vegetables.

Flowers

Extension of vase life: Maximum vase life of 11.33 days was obtained with sucrose 1.5% in combination with patchouli essential oil at 250 ppm as compared to other treatments and 8 days in control (water alone) for Gerbera (variety Golden gate). Water uptake was higher in the beginning but reduced as vase life advanced, whereas transpiration loss increased towards the end of vase life in cut flowers. In tuberose var. Arka Prajwal value addition through tinting along with pulsing was carried out. Tinting did not affect vase life and tinted tuberose

had 8 days of vase life with larger diameter and hundred per cent floret opening.

Improvement in packaging: Polyethylene package (conventional method) resulted in higher per cent physiological loss in weight (PLW) of 6.2 in stem below the tuberos flower and higher fresh weight of flower head resulted in stem breakage/bending. A novel packing bag was developed and tuberos flowers packed in these had lesser PLW (3.22%) and spoilage (25.64 %) as compared to control (PLW-7.95% and spoilage- 54.35%), two days after road transportation. Marketable quality of tuberos flowers in these newly developed bags were 2 days as compared to a single day in control.



Conventional and newly developed bags

Mushroom value added products: Shelf life of mushroom nutritive powder (chutney powder) with stable nutritional and microbiological quality in heat sealed aluminum pouch packing stored at ambient (27±2°C) and refrigerated conditions can be upto six months.



Mushroom fortified puliyogare powder

Recipes for mushroom fortified puliyogare (tamarind rice mix) powder was standardized and its nutrition profiled.

Medicinal Crops

Standardisation of drying methods and packaging materials in Brahmi: Moisture content of the freshly harvested brahmi (*Bacopa monnieri* L) herbage was 88.76% which was brought to 7.71% in 15 hours (50°C) by cabinet drying, while shade drying took fifteen days to reach the final moisture content of 9.03%. The initial chlorophyll a and b values were 9.09 and 5.23, respectively and shade dried material showed better retention of chlorophyll with maximum chlorophyll a and b 7.61 and 5.12 respectively, after 3 months of storage. Bacoside content was found highest in cabinet and low cost polyhouse dried sample (1.77%) followed by sun, solar and shade dried samples (1.63, 1.43 and 0.97%, respectively). Maximum colour retention during

storage was under shade dried material stored in HDPE. Maximum texture value was recorded for the solar tunnel dried material stored in cartons. Aerobic plate count and yeast was log 3.85 and log 2.69 CFU/g, in fresh material respectively. Shade drying resulted in substantial increase in yeast population (log 5.19 CFU/g) and lower microbial counts were found in sun dried and low cost polyhouse samples.



*Brahmi (*Bacopa monnieri*) fresh (a) and dry (b) herbage*

3.5.2. Farm Mechanization

Power operated onion de-topper : A power operated onion de-topper was designed and developed for de-topping of leaves from the harvested onions. This machine consists of a feeding chute, de-topping unit, collection chutes and power transmission system. The de-topping unit is a set of counter rotating rollers of which one roller is a plain roller and the other has cutting edges. Leaves of onion are pulled in between these two rollers for shearing of leaves. The de-topped onion bulbs and sheared leaves are collected in the respective collection chutes. The machine is operated by a 3 phase, 2 hp electrical geared motor with reduction gear box and necessary chain and pulley power transmission system. The capacity of the developed machine is 200 kg/h with de-topping efficiency of 94 %.



Protray dibbler cum vacuum seeder: This machine is useful to sow single seed in plug tray of 50 and 98 cells for growing nursery seedlings. The rotary dibbling unit consists of dibbler drum fitted with nylon pegs for dibbling. A growing media filled protray is placed on the carrier

trolley and pushed below the dibbler drum. The pegs make 5-10 mm depressions for seed sowing in all the 50 and 98 cells of protrays. The vacuum seeder consists of a vacuum chamber fitted with hypodermic needles matching the cells in the protray and seed tray, which picks single seed by each needle and releases it into the protray cell. The vacuum seeder is operated by 0.75 hp vacuum pump. The seeds are picked by creating vacuum and are dropped into the dibbled protray by cutting off the vacuum. The capacity of the machine is ~100 protrays/h which is extremely useful for vegetable nurseries.



Fruit and vegetable vending van: A fruit and vegetable vending van consists of an evaporating cooling and misting systems for providing higher humidity required to maintain the moisture in fresh fruits and vegetables even under normal ambient conditions. In addition to evaporative cooling, frozen gel packs are placed in every crate to provide conducive microclimatic conditions to facilitate improved shelf life of fruits and vegetables. Freshness in fruits and vegetables is retained up to 36-48 hours or even more depending on the produce being stored. A 32" TV is provided to display the daily price list of fruits and vegetables. An audio system is also provided to announce the arrival and departure of the van to the customers. This audio visual system can also be used to disseminate other general information/ advertisement/ entertainment to general public during vending. A GPS system is mounted to track the movement of the vending van from remote place. An exhaust fan is provided to circulate air at the time of parking at the night. A 600 watts solar PV system with 8 hours back up is provided to meet the power requirement of all the electrical gadgets fitted in the van. The entire structure is fabricated out of SS 304 with 30 - 50 mm PUF insulation. Food grade plastic crates are used to store and handle fruits and vegetables. Arka High Humidity storage boxes designed and developed by ICAR-IIHR, Bengaluru are also included in the van for storage of green leafy vegetables. The vending van structure is mounted on the prime mover TATA Ace HT diesel operated vehicle.



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

The motorized growing media siever, mixer and protray/bag filler consists of i) growing media elevator ii) growing media siever cum protray filler and iii) growing media mixer cum bag filler. Growing media is filled in the loader of the growing media elevator and bucket elevator lift s the growing media from the loader to the sieving unit. The growing media siever consists of i) stationary drum and ii) rotating cylindrical screen. Three operators can sit near the filling unit and fill the cleaned media in the bags or protray. The growing media siever cum protray filler is operated with 2 hp, 3 phase, geared electrical motor (Out putrpm60). The growing media mixer has helical blades fitted for mixing and conveying the media. The conveying and mixing unit is powered by 2 hp, 3phase geared motor (50 rpm). Three numbers of bag filling outlets are provided at the end of the mixer with oscillating type valve control. The capacity of the machine is 1.5 – 2.0 ton/h.

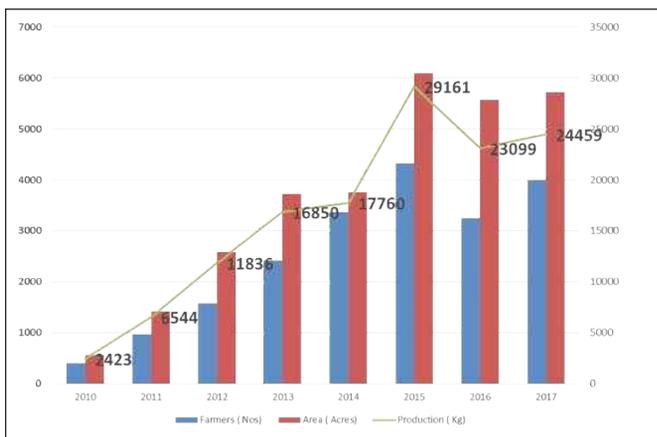


3.6. Economics of production, Marketing and Trade, Statistical Research and Computer Application

3.6.1. Economics of Production, Marketing and Trade

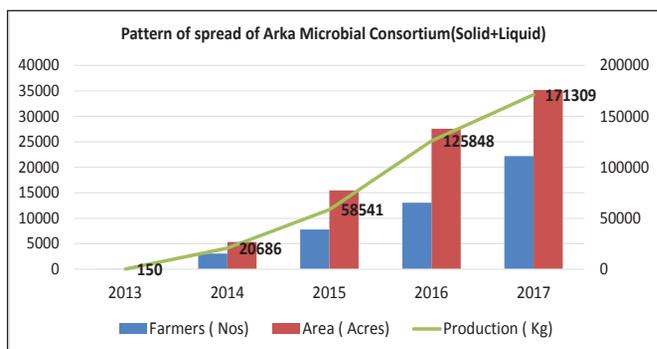
Economic impact in terms of spread and adoption of Arka banana special: Extent of spread, pattern of adoption and economic benefits due to adoption of Arka banana special technology distributed through IIHR's licensees since 2009 was evaluated. Twenty licenses were given between 2009-2017 to government institutions and KVKs (80%) and to private companies (20%). The cumulative production of this technology by all the licensees was 201.6 tons, which covered 47000 acres and 32000 farmers across growing regions. Eleven KVKs produced 17 tones annually, which covered more than 3700 acres and 2500 farmers. Two private companies produced 69.5 tons covering 17000 acres and 11500 farmers mainly in Karnataka, Andhra Pradesh and Tamil Nadu. Although, some of the licensees took the license in 2009 or 2010, they could not expand production or spread to more than 1000 to 2000 farmers indicating problems such as non-availability of funds on time from their supporting organizations for continued supply of the produce. A few KVKs totally depended on the orders coming from respective state departments for the supply. One of the

private licensees expressed that due to competition from KVKs, who supply at lower rates than that is possible for a private company, their sales declined on some years. Others indicated that due to consistent quality and good effort to create awareness among farmers, their produce was sold quickly. Use of Arka banana special foliar formulation helped farmers obtain 56% increase in yield and double the return due to increased yield and quality.



Annual Cumulative production and spread of Arka banana Special (KVKs= 11 numbers)

Economic Impact in terms of spread and adoption of Arka Microbial Consortium: Arka Microbial Consortium technology was licensed to 12 clients (3 Government institutions and 9 companies). During 2013-2017, 376 tons was produced, 83,000 acres area was covered and 46,000 farmers used the produce. Its production and availability is growing at 3% annual growth rate. The total gross revenue generated is Rs. 4 crores through its production and sale. Wide variation is seen in investment and capacity utilization between Government supported agencies and private start-ups. Start ups that opted to be on site incubatees at IIHR benefited substantially through incubation. Use of AMC on Pomegranate helped farmers in reducing the cultivation costs by 40% and helped increase yield up to 33%. Similar results were observed in pepper as well. Cost of cultivation reduced by 14% while yield increased by 22% in pepper.



Pattern of spread of Arka Microbial Consortium technology

Development of a score card for evaluation of technologies: A score card for evaluating technologies and feed-back from the licensees was developed based on the concept of ‘Competitive Performance Matrix’. The methodology includes the use of critical success factors for each one of the technologies as perceived by an innovator or a licensee, multiplied by the perceived weights attached to each one of the factors by each respondent multiplied and averaged across all respondents cumulated on to a point scale of 10 or 100. An average score of 6 or 60 is considered cut off mark for a technology to be evaluated as successful over a period of three consecutive years.

e-NAM implementation: About 585 markets are proposed to be integrated in to one e-platform to enhance competition and transparent price discovery. In, APMC, Palamner, Andhra Pradesh, 54 of the 74 traders participate in the e-NAM auction. About 15000 farmers are registered for supplying to e-NAM platform. Two hundred farmers are regularly supplying vegetables to e-platform. Twenty six per cent of the total quantity of vegetables arriving in APMC is traded through e-portal.

Economic analysis of fruit-based inter-cropping system: A total of six sapota-based fruit cropping systems were studied including control. None of the systems was found profitable in the first and second year of intercropping. The losses ranged from Rs.2845.5 in control to Rs.7216.3 in sapota and pomegranate intercropping system.

Economics of hybrid tomato seed production: The average per acre cost of cultivation was worked out to be Rs 1,89,404, comprising of Rs 1, 75,048 of variable costs and Rs 14, 356 of fixed costs. It was observed that the total costs were higher during 2016-17 owing to higher use of inputs. The share of cash inputs in total costs works-put only 53.46 per cent, while the share in total costs was 49.41 per cent. The share of total labour in the variable costs and total costs works out to be 55.18 and 50.47 per cent, respectively. The share of family labour both men and women, were 24.36 and 22.51 per cent, respectively in the variable costs and total costs respectively. Per acre average yield of hybrid tomato seed production (HTSP) for two years viz., 2015-16 and 2016-17 was 43.97 kg/ac. Farmers realized an average net return of Rs 1.22 lakh/acre and the BC ratio was 1.64. The yield, total cost of cultivation, gross return, net return and BC ratio was higher during 2016-17 due to better prevailing production situations. The average cost of production incurred by the farmers was Rs 4348/kg, while the average price realized was Rs 7145/kg. It was found that the risk involved in HTSP was about 51 per cent to realize the average yield and returns. It was observed that i) Private Cost Ratio (PCR0 was 0.63, ii) Domestic Resource Cost Ratio

(DRC) was 0.52 iii) Nominal Protection Coefficient on Tradable Output (NPCO) was 0.82, iv) Nominal Protection Coefficient on Input Tradable (NPCI) was 0.65, v) Effective Protection Coefficient (EPC) was 0.83 and vi) Profitability Coefficient was 0.65. Thus, the PAM analysis revealed that the export of tomato is both competitive and efficient. The average efficiency scores for technical, allocative and the economic efficiencies in HTSP were 0.7718, 0.8048 and 0.6138, respectively. Nearly 40 per cent of farmers were practicing efficient tomato production practices, while 26.67 per cent of farmers were found allocative efficient in production. Only about 6.7 per cent of farmers were found economic efficient.

3.6.2. Statistics Research

Development of statistical models for horticultural crops research

Method for dealing with high CV in perennial crop experiments: A methodology was suggested to deal with high CV in perennial crop experimental data of Totapuri rootstock trials. These trials were based on 16 characters. The results showed that robust ANOVA yielded P-value in the range of 5.28×10^{-36} (Mean fruit wt) to 1.3×10^{-10} (Fruit weight), as against the regular ANOVA approach, due to presence of multiple outliers, resulted in non-significance results among the treatments studied, for all traits (P value > 0.05). Precision gained (as assessed by the reduction in CV (%)) due to this approach was in the range of 17.6 % to 90.3 %. Hence, this study calls for employing robust ANOVA approach in testing the significance of evaluated treatments in a designed perennial crop experiment especially with high CV.

Non-parametric indices for varietal release based on multi-variate traits: A non-parametric based index was suggested by assessing the contribution of each genotype to GE interaction based on their relative performance (performance of a genotype compared to others) and stability over years, simultaneously based on various traits in Okra. Differential ranking of superior genotypes for individual traits, when summed up revealed OKMSH 2, 3 and 7 (in the same order) as superior. However, the modified approach based on combined index revealed OKMSH 7,2,3 (in the same order) as superior with least NP value as 0.08 (OKMSH 7). The stability for the trait YVMV (%) over years for OKMSH 7 (and with consistent ranking (2nd) in 4 out of 8 traits) had resulted in its superiority.

Robust ANOVA for analysis of outlier present ornamental crop experimental trails: A method was suggested to analyse experimental data having aberrant replication values in one or more treatments under

comparison, without deleting the same using robust ANOVA approach in China Aster. Statistical comparison of existing and robust method for eight different traits (by giving desired weights to the outlier replications across treatments) had revealed that the probability of type-I error had significantly reduced and the precision gained was in the range of 42.2 % to 55.7 %. The reduction in error sum of squares of 7.50% to 29.7% across traits was also observed.

Evaluation of China Aster genotypes based on multivariate traits for varietal release: An approach was suggested for releasing a promising line based on the combined performance over several traits/stability over season in china aster. Based on the existing parametric measure, it was noticed that IIHR CA J 17 followed by IIHR CA H3 and Local white has the best lines, arrived at by adding the individual trait based ranks. However, non-parametric approach had revealed that IIHR CA H3 followed by IIHR CA J 17 and Shashank were the superior ones. Superiority of IIHR CA H3 for quality traits (shelf life and stalk length) in terms of stability over years had resulted in its favour (with combined NP index 0.06).

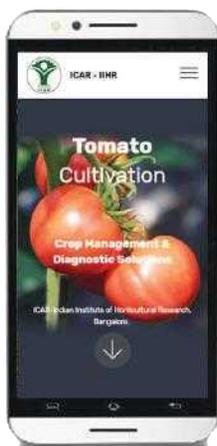
Statistical models for constructing selection indices for dwarf tree structure in Sapota: Fisher's linear discriminate function was constructed for sapota for selection among dwarf sapota trees (n=52). An equation represented as $Z = -11.12 + 0.033 \text{ BL} + 0.836 \text{ BB} + 0.083 \text{ EW}$ Spread could be used at early stage with 72% accuracy of prediction for selecting trees with dwarf structure. Further, both the run test (test for randomness of residuals) and Shapiro-Wilk test (normality of residuals) statistics values being > 1.96 ensured for the holistic nature of the model.

Statistical models in metabolite studies for avocado accessions: Statistical models were developed to ascertain the influence of various phenolic and flavonoids compounds on both the antioxidant activities DPPH and FRAP based on their evaluation at different parts of the fruit (pulp, seed and skin) of the four avocado collections. Optimized model results showed that Vanillic acid alone could account for 79% and 72% of the variability in DPPH and FRAP, respectively. More specifically, a model represented by the equations (DPPH = $29.87 + 0.125 * \text{Vanillic acid}$) and (FRAP = $7.252 + 0.04 * \text{Vanillic acid}$) were developed. Further, the holistic nature of the inference drawn was also tested based on detailed residual analysis. The run and Shapiro-wilk test statistics being within the critical region (at P<0.05), also ensures for the reproducibility of the results.

3.6.3. Computer applications

Mobile app on tomato cultivation: A mobile app was developed for tomato cultivation and its crop management.

The app includes crop production details such as land preparation, use of bio agents, nursery raising and seed rate, transplanting, drip irrigation, fertilizers and fertigation, inter-cultivation, IPM, IDM etc., The disease and pest management feature comprising of various diseases and pest affecting tomato crop are included along with its symptoms and control measures. Further, a query window for farmers is available to post their queries related to Tomato cultivation. In addition to the above, a query answering mechanism provided to the farmers to post their cultivation problems, seed availability etc. All these farmers queries were received by app admin and reply communicated by e-mail by domain experts. The application is available in English at present. So far, 12500 plus users downloaded the mobile app across the country.



Mobile app on Onion cultivation:

A mobile app on onion was developed that includes onion crop production aspects. viz., soil climate, sowing, nursery management, transplanting, broadcasting, planting bulbs, manures and fertilizers, weed control, irrigation, harvesting and yield, curing and storage, integrated disease management and pest management. The disease and pest management aspects comprising of various diseases and pests affecting onion crop were included with its symptoms



and control measures. Onion varieties released by IIHR and FAQs are included in the app. Further, a query answering mechanism for farmers to post their queries regarding onion cultivation is also available.

Decision support system (DSS) for Guava:

The DSS on Guava was developed for cultivation and crop management. The application was developed in windows platform with GUI using HTML and CSS scripting languages. The home page displays various contents for guava cultivation including soil and climate, propagation, nutrient requirements, irrigation methods, spacing and planting



of guava crop. Information about the guava varieties released at ICAR-IIHR with their description and other promising guava varieties with salient features was also included in the system. Further, the crop protection modules on guava crop was developed with disease and pest management information. Disease management modules was developed as auto scrolling objects, with various layers embedded in it. The user can choose by specific image where symptoms are matching and its causing organism, symptoms and management /control information are displayed on the screen. For farmer interaction, a query window on web application of guava is also incorporated by designing data forms through which they can post their cultivation problems. This will be very useful for farmers involved in guava crop cultivation.

Decision support system (DSS) for grapes:

The web application was designed and developed for Grape cultivation and management.

The structure and content of the application was developed for windows platform using web technologies. The index page displays contents for grape cultivation and provides links to important information on crop description, root-stocks, planting, spacing,



propagation, irrigation methods, training and pruning, growth regulators, soil and climate of grape crop. Information about the grape varieties released by IIHR and other promising varieties are also included. The webpage layout for displaying scrolling images for different pests and diseases of grape crop was structured using scripting languages with control measures for managing the crop protection information. This web application will be very useful for farmers involved in grape cultivation.

Characterization database and web retrieval system for rose :

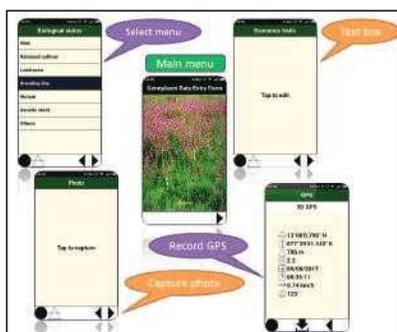
The database developed is based on the 60 DUS characters. Spray, fragrance and cut flower varieties information has been included and the database can be searched for varieties based on one/ more character/ properties. Images for each character of the varieties have been included, wherever available. Passport data of the variety if available, has been linked with the characterization information. The database is accessible on the intranet.



Main page of the web based GUI of rose characterization database

APP for collection of germplasm information:

An application for collection of germplasm passport information by a hand-held device (smart phone/ tablet) has been developed. The desktop application runs on all versions of Microsoft Windows. Data can be captured directly using the desktop software or an Android or Windows mobile device. Various features supported are- data selection from a menu, entering information in text box, capture photos through inbuilt camera of the handheld device, capture GPS coordinates and other features. The data captured can be uploaded from the hand held device to a database in a PC. The database can also be configured to upload the data to an FTP server.



Some screen shots of the germplasm data collection application

3.7. Agricultural Extension Research

3.7.1. Spread and acceptance of IPM technologies:

A new project was initiated to study the spread and acceptance of IIHR IPM modules. Preliminary survey was conducted to assess the spread of integrated nematode management module recommended by IIHR among tuberose growers, especially those growing Arka Prajwal. It was found that by using bio-nematicides of IIHR, the nematode infestation was well managed and brought down to zero percent infestation in the treated fields. Spike length increased up to 5 ft, with more number of flowers.

3.7.2. Group dynamic and social networks among women SHG members involved in economic activities:

A survey was conducted among the members of 12 self help groups of Kalghatgi and Dharwad taluks of Dharwad district. It was found that 32.5% members of SHG carried out income generating activities like savings and internal lending, dairy, vermicelli unit, *roti* making, tailoring etc. The SHG-based activities were availing credit (20%); attending trainings (17.5%); interacted within the group (17.5%) and resolved conflicts within the group (17.5%). Major constraints faced by the SHG members in carrying out income generating activities were, inadequate training opportunities (50.8%), limited access to interest free credit facilities (30%) and poor infrastructure for marketing of products (27.5%).

3.7.3: Multidimensional analysis of attributes of horticultural innovations:

Categorization of adopters of protected cultivation of vegetables (PCV) during 2008-2015, revealed the following constitution of adopter categories: innovators (6.3%), early adopters (20.63%), early majority (23.01%), late majority (29.36%) and laggards (20.63%).

Factors affecting spread of IIHR technologies:

Non-availability of seeds and planting material locally/ difficult to proceed, non-availability of specific details on water and nutrient, IPM and IDM recommendations, non availability of specific packaging technologies for each crop to suit different markets and non availability of holistic package with seeds/ planting materials like corporate Inc. were the major reasons for slow spread of IIHR technologies as felt by farmers/ entrepreneurs, officers/executives, marketing agencies and researchers respectively (Table).

Important reasons for slow spread of IIHR technologies and varieties/ hybrids (Overall ranking)

Reasons	Farmers / Entrepreneurs (N=62)	Officers / Executives (N=38)	Marketing Agencies (N=22)	Research-ers (Public & Pvt.) (N=18)
Seeds and planting materials are not available locally/ difficult to procure	54 (87.09) I	34 II	16 IV	15 II
Holistic package is not provided with seeds/ planting materials like corporate Inc.	51 II	31 III	20 II	17 I
Awareness programmes on IIHR technologies are inadequate	40 VI	28 IV	18 III	14 III
Suitability of variety/ product to different regions is not mentioned for all crops	45 V	23 VII	16 IV	12 V
Specific details on water and nutrient, IPM and IDM is not given with each crop	48 III	35 I	12 VII	14 III

Knowledge of IIHR technologies among input dealers, KVK/ Dept. staff and others is very less	38 VII	28 IV	15 VI	10 VI
Technology on organic cultivation/export production may be mentioned with varieties	48 III	25 VI	10 VIII	8 VIII
Specific packaging technologies for each crop to suit different markets are not available	31 IX	15 IX	21 I	9 XI
Details on costs, income, etc. is not available for each technology/ variety	35 VIII	19 VIII	10 VIII	10 VI

3.7.4: Communication behaviour of Arka Rakshak growers:

A study on communication behavior of Arka Rakshak Growers was conducted in 5 states based on proportionate random sampling in Mizoram, Maharashtra, Odisha, Uttar Pradesh, Kerala. Information seeking behavior, information processing and dissemination behavior was analyzed for 60 respondents. 38 % of the respondents were collegiate, middle aged, with medium land holdings (5-10 acres), with fair irrigation facilities (48 %), and with 14 years of experience in agriculture. KVK professionals and demonstration farmers of nearby villages were major source of information in Mizoram, under the sub head personal cosmopolite sources. Under personal localite category, field day/campaigns/meetings in the own village, contact farmer of own village, friends were the major information sources under professional, para-professional and nonprofessional category respectively. Under impersonal cosmopolite category, television (DD) was the major source of information. In Maharashtra, internet and social media and demonstration farmers of nearby villages/mandals, were the major sources of information under the sub head personal cosmopolite sources. Under personal localite category, field day/campaigns/meetings in the own village, FLD farmer of own village, friends were the major information sources under professional, para-

professional and nonprofessional category respectively. Under impersonal cosmopolite category, television (DD) was the major sources of information. In Odisha, it was again found that KVK professionals were the major source of information, followed by demonstration farmers of nearby villages/mandals under the sub head personal cosmopolite sources. Under personal localite category, field day/campaigns/meetings in the own village, FLD farmer of own village, friends were the major information sources under professional, para-professional and nonprofessional category respectively. Under impersonal cosmopolite category, television (DD) was the major source of information. In Kerala, it was again found Agriculture assistant/ Assistant Horticulture Officer/ Horticulture officer were the major sources information, followed by office bearers of farmers organization under the sub head personal cosmopolite sources. Under personal localite category, field day/campaigns/meetings in the own village, self-help groups and members, relatives were the major information sources under professional, para-professional and nonprofessional categories respectively. Under impersonal cosmopolite category, television (DD) was the major source of information. A strategic communication model was suggested based on the findings of the study as shown below.

Stakeholders involved/ Strategies	District	Block	Village
Organizers	KVKs, TMA, NGOs	Line department	Contact farmers, input dealers, AHO/HOs/ADHs
Facilitators	Resear Research Institutes (IIHR, NHRDF), SAUs	SMS of KVKs, NGO and HOs	HOs, FLD farmers, input dealers, progressive farmers
Beneficiaries	FLD FLD farmers, progressive farmers, SMS of KVKs and AHO/HO/ADH	FLD farmers, contact farmers, Progressive, input dealers	Tomato growers

Strategies	Train Training Programmes	Exhibitions/Fairs/ Training programmes/ Field visits	FLDs, Field days, Campaigns, Training Programmes
Overall strategies	Financial empowerment, Convergence & coordination of efforts; convergence with programmes and schemes with effective leveraging strategies for mass media publicity through various ICT tools especially social media.		



Strategic communication model

3.7.5: Evaluation of digitally documented videos of IIHR technologies: Four documentaries on Arka Rakshak Tomato Production Technology, Arka Kalyan-Onion variety of IIHR, Banana- production enhancement technologies, and IIHR Mango production enhancement technologies were produced by IIHR. The same have been uploaded to different social media viz., IIHR web page, You tube, IIHR Facebook page and Whats App. Accordingly a questionnaire has been developed based on the 14 variables which pertains to the quality and content of the four videos. The same has been shown to the 100 participants (50 farmers + 50 officials), data has been collected on quality, usefulness, effectiveness of message, timeliness, brevity, simplicity and content specificity etc. based on which further videos of IIHR will be prepared.

3.7.6: Producer Company Model towards providing extension services to horticulturists: Majority of the producer members of Puthari Farmers Producer Company Limited (PFPCCL), Sadalamma Horticultural Framers Producer Company Limited (SHFPCL) and Sangama Horticultural Farmers Producers Company Limited (SAHFPCL) were middle aged (36-45 years), where as that of Srigiripura Horticultural Framers Producer Company Limited (SRHPCL) were young (up to 35 years). Majority of the members of PFPCCL had college level education and were large farmers (above 10 acres), whereas those of FPOs had higher secondary level of education and were marginal farmers (up to 2 acres). Producer members of PFPCCL had annual transaction up to 10 lakhs, whereas that of the other FPOs had annual

transaction up to Rs. 25000. PFPCCL had around 100 members, whereas, the other FPOs had 1000 producer members which is mandatory for it to get SFAC support. The FPO supported by NABARD had Rs. 5 lakhs as share capital, where as all the other FPOs promoted by DOH had Rs. 10 lakhs as initial share capital.

All the three FPOs supported by DOH and SFAC have their own storage infrastructure and custom-hiring centres and the FPO supported by NABARD has started processing support, other FPOs are trying for such facility to be established. All the FPOs supported by DOH had the privilege of having government schemes on horticulture dovetailed. However, none of the FPOs could link their producer members towards credit facilities. Arranging adequate crop advisory through SAUs, research institutes and KVKs; effective input distribution at competitive price; introduction of technological interventions based on the commodities dealt by the producer members and facilitating marketing linkage were the critical success factors felt by the all the FPOs. In addition, built-in trust and facilitation of both farm and off-farm activities were the critical success factors felt by PFPCCL. Delayed distribution of inputs while dovetailing schemes; prevailing caste system as a constraint for membership drive; delay in license recognition from departments; delay in matching grant by SFAC; establishing links with financial institutes; running business activities (due to lack of experience) and delay in dovetailing. Govt. Schemes were the challenges faced by the FPOs. The perceived effectiveness of performance of FPOs was assessed through a nine-point scale against

suggested economic and social indicators as indicated in table below. The performance of the FPOs were fair towards all economic farm mechanization, cropping intensity, productivity of commodities, profitability from produce and value addition linkage, input availability, assured market price and assured buy-back, but comparatively unfair towards input availability, assured market price and assured buy-back, felt by the members of SHFPCL which needs attention by the FPO. Similarly, the perceived effectiveness of producer members towards

the social indicators such as knowledge on production technology, adoption towards production technology, access to training, input purchase, output marketing, reduced social conflicts, benefits for backward people and benefits for women was fair. However, the perceived effectiveness of members of SAHFPCL towards knowledge on production technology, adoption towards production technology, benefits for backward people and benefits for women was not fair, which needs immediate attention by the FPO.

Table. Perceived effectiveness of producer members towards social and economic indicators (n=65)

Economic Indicators	PFPCCL	SHFPCL	SAHFPCL	SRHFPCL
Farm mechanization	8.4	7.8	8.7	9.0
Input availability	8.6	7.0	5.4	8.0
Cropping intensity	7.5	7.0	9.0	8.9
Productivity of commodity	7.6	7.0	9.0	8.9
Profitability	8.1	9.0	6.0	8.7
Assured buy-back	8.2	5.0	9.0	8.8
Assured market price	8.6	5.2	7.0	8.7

Social Indicators	PFPCCL	SHFPCL	SAHFPCL	SRHFPCL
Knowledge on production technology	7.8	9.0	3.0	7.5
Adoption towards production technology	7.6	7.0	4.6	7.5
Access to training	8.2	7.0	6.6	7.6
Input purchase	8.6	9.0	5.0	7.6
Output marketing	8.1	9.0	2.6	7.6
Reduced social conflicts	8.1	7.0	7.5	7.2
Benefits for backward people	8.3	7.0	3.2	6.8
Benefits for women	7.3	7.0	2.9	6.9

Based on perception of producer members towards overall performance indicators there is need for FPOs to concentrate on certain important performance indicators such as eliminating political intervention, opportunity

for participation in decision making, selection/ election, transparency in financial transactions, adhering to rules, ways of raising funds, fixing the reserve funds, sharing the profit and dovetailing of government schemes.

4. All India Coordinated Research Projects

The ICAR-All India Co-ordinated Research Project (AICRP) on Fruits is head quartered at ICAR-IIHR, Bengaluru. Besides the ICAR-AICRP on Fruits, several All India Coordinated Research Projects on various

horticultural crops and one All India Network Project on pesticide residues are in operation at ICAR-IIHR. The details of the activities carried out under different AICRPs during the period under report are given below.

Project	Aspect	Achievement
All India Coordinated Research Project on Arid Zone Fruits	Crop Improvement	<p>Pomegranate: Fifty two single plant selections from Bhagwa OP/ hybrids planted in replicated trial were evaluated for pomological traits. Based on colour, flavour and organoleptic score, 10 hybrids/OP were found to be suitable for the preparation of good quality anardana.</p> <p>Annona: Out of five varieties evaluated for yield, ‘Arka Sahan’ recorded the highest number of fruits (85.3/plant), yield (40.48 kg/ plant) and fruit weight (480.50g).</p>
	Crop Production	<p>Annona: Canopy management practices were standardized for ‘Arka Sahan’ trees. Fertilizer requirement of ‘Arka Sahan’ could be reduced by 25% using biofertilizer consortium.</p>
All India Coordinated Research Project on Fruits	Germplasm maintenance	<p>Mango: A total of 728 accessions are being being conserved in the field gene bank. <i>Mangifera grifithii</i> scions have been collected from Andamans and grafted on non-descript rootstock. <i>Mangifera andamanica</i> grafts have been maintained for field planting.</p>
	Crop Improvement	<p>Guava: Varieties viz. Arka Mridula, SG 10-2, SG 10-3 and SG 10-4 exhibited better yield and yield attributing traits.</p> <p>Mango: A total of 10180 flowers from 2121 panicles of ‘Amrapali’ were crossed with pollens of ‘Vanraj’. And there was 0.45% fruit set. A total of 1116 flowers from 204 panicles of ‘Vellaikolumban’ were crossed with ‘Terpentine’. The fruit set was found to be 2.87%.</p> <p>Grapes: One hundred twenty flowers in each 20 bunches of ‘Red Globe’ were crossed with ‘Flame Seedless’ after emasculation. Two thousand seeds were extracted and upon seed stratification, two seeds had germinated and they treatments such as GA₃ application and are being maintained under mist chamber.</p>
	Crop Production	<p>Mango: Higher fruit yields of ‘Totapuri’ were realized on vigorous rootstocks viz. ‘Olour’ and ‘Terpentine’ while fruit yield per tree was less on dwarfing ‘Nekkere’ and ‘Vellaikolumban’ rootstocks.</p> <p>Mango flowering and yield were monitored in relation to weather parameters prevailed during the year.</p>
	Crop Protection	<p>Mango: Different formulations of entomopathogens were evaluated for their efficacy against mango hoppers. The oil based formulation of <i>Metarhizium anisopliae</i> @ 0.5 ml/l was the most effective treatment and resulted in > 80% reduction in hopper population.</p>

	Post harvest technology and marketing	<p>Mango: Post harvest losses assessment in ‘Totapuri’ variety in Karnataka and Andhra Pradesh indicated a total 23.65% loss which comprised of field level (7.04%), market level (10.65%) and retailers’ level (6.16%) losses.</p> <p>Banana: Post harvest losses for banana cv. Ney Poovan (Elakki) in Karnataka was 9.58% consisting of field level (2.43%), wholesalers’ level (1.11%), ripening and storage stage (1.47%) and retail level (4.57%).</p>
All India Coordinated Research Project on Vegetables	Germplasm evaluation	<p>Chilli: Entries EC809192 and EC809189 outyielded the three check varieties.</p> <p>Bell Pepper: Entries EC809026 and EC8090267 performed better than the two check varieties.</p> <p>Carrot: out of seven lines evaluated under AVT-I, two lines namely CARTVAR-7 (257.20 q/h) and CARTVAR-3 (204 q/h) gave significantly higher root yield than the other lines.</p> <p>French Bean: Ten new lines were evaluated for yield and yield attributing traits of them, seven lines are pole types and vegetable podded and remaining three are bush types. Pod yield ranged from 98.7 to 168 q/ ha.</p>
	Crop Improvement	<p>Chilli: Out of six entries evaluated in IET, 2015/CHIHBY 5 performed better and in AVT-I, out of seven entries evaluated, 2014/CHIHBY 7 performed better.</p> <p>Bell Pepper: In IET, out of five entries evaluated, Arka Mohini (LC) performed better while in AVT-II, 2013//CHIHBY 6 performed better.</p> <p>Brinjal: Out of A total of 8 entries, two entries viz; 13/BRBWRES-3 (490 q/ha) followed by 13/BRBWRES-4 (424 q/ha) performed better for yield and bacterial wilt resistance. In disease resistant trial (AVT-II), out of 16 entries evaluated, 2012/OKYVRES-5 recorded the highest fruit yield of 22.80 t/ha with 0% incidence of YVMV.</p> <p>Onion: During <i>kharif</i> under IET trial, out of 8 lines evaluated two lines namely ON14-04 (541.11 q/ha) and ON14-23(536.67 q/ha) gave significantly higher yield. Under AVT-1, Out of 10 lines evaluated, two lines namely OSK -1320 (433.33 q/ha), OSK-1317 (417.78 q/ ha), OSK-1306 (401.00 q/ha) gave significantly higher yield.</p> <p>Garlic: Under AVT I trail, out of nine lines evaluated during <i>rabi</i> season, two lines viz. GN14-13 (63.17 q/ha) and GN14-01 (62.75q/ ha) gave significantly higher yield and under AVT II trails, out of 6 lines two lines namely GPS-1330 (60.75 q/ha) and GPS-1332 (44.50q/ha) gave significantly higher yield.</p> <p>French bean: Out of the four entries evaluated in French bean Bush Varietal trial IET, Entry 15/ FBBVAR 1 gave maximum pod yield of 224 q/ha which out yielded both the checks. In AVT II, out of five entries, entry 13/ FBBVAR 3 gave maximum pod yield of 170 q/ha.</p>

		<p>Cowpea: In AVT I, six entries were evaluated. Entry 2015/COPBVAR-4 gave maximum pod yield of 217.5 q/ha and out yielded the check Lola</p> <p>Garden Pea : In IET, of seven entries tested, 2015/PEVAR-5 gave maximum pod yield (135.42 q/ha) and it behaved like mid-season variety. In AVT-I, out of the seven entries, entry 2014/PEVAR-2 gave maximum pod yield of 86.67 q/ha followed and outyielded both the checks.</p> <p>Dolichos (Pole type): In AVT-I, out of four entries tested, 2014/DOLPVAR-4 ranked first with pod yield of 235.03 q/ha. In AVT-II, out of four entries tested, 2013/DOLPVAR-3 gave higher pod yield of 273.90 q/ha followed by 2013/DOLPVAR-1 and 2013/DOLPVAR-2 with pod yield of 217.70 q/ha and 182.50 q/ha respectively out yielded both the checks.</p> <p>Bottle gourd: In AVT-I, out of four, two entries namely, 2013/BOGVAR- 1 (445.32 q/ha) and 2013/BOGVAR- 3 (421.25 q/ha) out yielded the check variety Pusa Samridhi (385.40 q/ha). In hybrid AVT-I, out of four hybrids, one entry namely, 2013/BOGHYB- 1 (432.04 q/ha) out yielded the check variety Pusa Samridhi (385.32 q/ha).</p> <p>Bitter gourd: In IET, out of five, four hybrids namely, 2014/BIGHYB-5 (94.22 q/ha) followed by 2014/BIGHYB-1 (73.16q/ha), 2014/BIGHYB-4(48.44/ha) and 2014/BIGHYB-2 (47.78 q/ha), out yielded the check hybrids, NBGH-167 (41.60 q/ha) and Pusa Hybrid-2 (46.22 q/ha).</p> <p>Ridge gourd: In varietal trial AVT-II, out of five, four entries namely, 2012/RIGVAR- 2 (343.32 q/ha) followed by 2012/RIGVAR- 3 (264.01 q/ha), 2012/RIGVAR- 5 (204.73 q/ha) and 2012/RIGVAR- 1 (200.96 q/ha) out yielded the check varieties.</p>
	Crop production	<p>Amaranth: Organic production of amaranth was found feasible and the yield recorded (13.1 to 14.6 t/ha) was comparable to inorganic treatment. Organic production module with Vermicompost (5 t/ha) +PSB (5 kg/ha) + Azospirillum (5 kg/ha) or FYM (10 t/ha) + PSB (5 kg/ha) + Azospirillum (5 kg/ha) (In addition to 20t/ha common FYM application) can be followed to get higher yield and pesticide free produce.</p> <p>Chilli: In fertigation studies, highest yield of dry chilli (4.1 t/ha) was recorded when entire fertilizer was fertigated through water soluble fertilizer at weekly interval. However, other fertigation treatments like NK fertigation and normal fertilizer fertigation were on par with WSF fertigation.</p>
All India Network Research Project on Onion and Garlic	Crop Improvement	<p>Onion: During <i>kharif</i> season, two onion lines each of IET, ON16-01 (357.04 q/ha) and ON 16-05 (345.19 q/ha); in AVT-I, ON 15-32 (462.22 q/ha) and ON 15-13 (440.74 q/ha); in AVT-II, ON 14-23 (463.70q/ha) and ON 14-15 (435.48 q/ha) gave higher bulb yield. During <i>rabi</i> season, two onion lines each of IET, ON16-11 (468.52 q/ha) and ON 16-13 (448.52 q/ha); in AVT-I, ON 15-18 (509.44 q/ha) and ON 15-16 (479.81 q/ha); in AVT-II, ON 14-11 (416.11 q/ha) and ON 14-25 (408.70 q/ha) gave higher bulb yield.</p> <p>Garlic: During <i>rabi</i> season, two lines each of IET, GN 15-83 (68.44 q/ha) and GN 15-70 (66.72 q/ha); in AVT-II, GN 14-27 (67.58 q/ha) and GN 14-17 (64.88 q/ha) gave higher bulb yield.</p>

All India Coordinated Research Project on Floriculture	Crop Improvement	<p>Tuberose: The performance of tuberose cultivars viz. Bidhan Rajani-1, Bidhan Rajani-2, GK-T-C4, Phule Rajani and commercial check as Arka Prajwal and Arka Nirantara with Mexican Single as local check was assessed at Bangalore conditions. ‘Arka Prajwal’ was found to perform better than other cultivars in terms of early days to flower bud appearance (102.07 days), spike length (101.39 cm), weight of single floret (2.29 g) and number of spikes per plant (4.53 no's/year).</p> <p>Gladiolus: Among the genotypes tested, IIHRG-12 was earliest for days taken to spike emergence and days to flower. Number of spikes per plant was recorded maximum in IIHRG-11(Arka Aayush). Based on the pooled analysis and considering the floral traits as well as corm production and quality of spikes ‘Arka Naveen’ with purple florets, IIHRG-11 (Arka Aayush) with pink florets and IIHRG-12 with violet florets were found suitable for cut flower purpose and were proposed for identification for varietal release.</p> <p>Marigold: Rooted plants of ‘Arka Bangara’, ‘Arka Bangara-2’ and ‘Arka Agni’ were supplied to seven AICRP centers for testing. Five new genotypes including that of IIHR varieties were tested for loose flower production. Proposal for three French marigold varieties (IIHR Fm-1, IIHRMo-2 and IIHRR Mo-4) that had completed testing and was recommended for release was submitted for varietal release.</p> <p>Chrysanthemum: Out of 13 genotypes evaluated, ‘Arka Pink Star’ was found promising for pot culture. The genotypes ‘Arka Yellow Gold’ and ‘Arka Kirti’ and ‘Rajat’ were found promising for loose flower yield.</p> <p>China aster: Out of four genotypes evaluated, ‘Arka Aadya’ and ‘Arka Archana’ were found better for early flowering and high yield.</p>
	Crop Production	<p>Tuberose: The cultivar ‘Arka Prajwal’ recorded highest production of flowers (25.30 t/ ha) with the use of combination of 75 % water soluble fertilizers (150:150:150 kg ha⁻¹NPK) + 25% straight fertilizers (50: 50: 50 kg ha⁻¹NPK).</p>
All India Coordinated Research Project on Medicinal and Aromatic Plants	Crop Improvement	<p>Ashwagandha: Out of 11 genotypes tested, maximum dry root yield was recorded in HWS8-18 (606.78 kg/ha) followed by ICAR-IIHR variety ‘Arka Ashwagandha’ (IWS-3) (579.72kg/ha). Highest withaferin-A content (0.625%) was recorded in ‘Arka Ashwagandha’ (IWS-3).</p> <p>Betelvine: Fifteen intervarietal crosses and twelve interspecific crosses were carried out. Among the hybrids evaluated, IIHR HY 06-4, a male hybrid, has given higher leaf yield (322 leaves/vine) followed by Hy 06-11 (167.48 leaves/vine) and Swarna Kapoori (130.78 leaves/vine). The Hy 09-16 is female hybrid gave high leaf yield with resistance to powdery mildew and field tolerance to leaf spots consistently over four seasons.</p>

	Evaluation of varieties and alternate standards:	Eight standards with three spacings were evaluated. Maximum girth (46.28 cm) was observed in <i>Erythrina subambrans</i> . Gall tolerant <i>Erythrina subambrans</i> performed better with leaf yield of 81.66/ vine at a spacing of 1.5 x1.0 m. Out of eight varieties evaluated under polyhouse, Godi Bangla produced maximum leaf (36.37 leaves/vine) 180 days after lowering.
All India Coordinated Research Project on Mushrooms	G e r m p l a s m evaluation	Among the four <i>Pleurotus sajor-caju</i> multispore selections, PL-17-01 showed highest biological efficiency (55.01%). Sporophores in <i>Lentinula edodes</i> strain LE-17-02 could be induced without cold water shock treatment and it yielded higher than other strains

All India Network Project on Pesticide Residues: Persistence of residues of following pesticides was studied on a number of fruit and vegetable crops, by conducting supervised field trials. The pesticides were applied at recommended (X) and double the recommended (2X) doses. The results are summarized below.

Crop	Pesticide	Half-life (days)		Residue persistence (days)	
		X	2X	X	2X
Grapes	Ethephon 39SL				
	Tebuconazole 430 SC	5.2	7.3		
Pomegranate	Trifloxystrobin 25 WG	4.4	4.5		
	Tebuconazole 50WG	5.5	6.6		
Tomato	Spiromesfin 22.9SC	3.0	3.7	10	15
Brinjal	Imidacloprid 17.8SL	5.2	5.2	10	15
Cucumber	Acephate 75SP	4.1	5.0	20	25
	Chlorpyrifos 20EC	2.0	2.3	15	15
	Cypermethrin 10EC	3.0	3.6	15	20
	Ethion 50EC	4.1	4.5	25	25
	Quinolphos 25EC	1.6	2.0	5	7
Capsicum	Cypermethrin 10EC	4.0	4.3	25	25
	Spiromesfin 22.9SC	1.1	1.7	15	20
Okra	Imidacloprid 17.8SL	2.0	2.0	7	10

5. Transfer of Technology

The Institute has a multi-dimensional approach in extension for effective transfer of technologies to various stakeholders. Accordingly, during the year 2017-18, the Division of Extension and Training, ICAR-IIHR, Bengaluru, organised need based advanced trainings on horticultural technologies and large scale demonstrations. It has also disseminated and popularized various technologies through mass media, group approaches, exhibitions, field days, interfaces, seminars, stakeholders meet, interaction meetings, consultations etc. The

Agricultural Technology Information Centre (ATIC) in the Institute also provided extension services through its single window concept.

Dissemination and popularisation of technologies was also taken up by ICAR-IIHR Regional Stations at Chettalli and Hirehalli in Karnataka, Bhubaneswar in Odisha and KVKs at Hirehalli in Tumakuru district and Gonikoppal in Kodagu district of Karnataka, details of which are given below:

5.1 Training Programs

5.1.1 ICAR-IIHR, Bengaluru

The Institute organized on-campus and off campus trainings as given below

On Campus Trainings

Title	Date(s)	No. of participants
Training on onion paste making	Apr 29	06
Training on hand pollination technique in custard apple hybrid Arka Sahan	May 03	55
Entrepreneurial training on mushroom spawn production & cultivation	May 18-26	33
Improved crop management practices in papaya & banana	Jun 6-7	49
Improved crop management practices in grapes & pomegranate	Jun 8-9	34
Advanced technologies for horticultural crops	Jun 12-17	21
In-house training on 'Safe Handling of Plant Protection Chemicals and Fertilizers and Optimum Use of Agro-chemicals'	Jun 19-21	20
Special training for the managers of Mahindra & Mahindra Limited On "Integrated Crop Management for Higher Productivity & Quality of Hot Chili"	Jun 20-22	15
Improved mushroom cultivation	Aug 31 - Sep 01	30
Entrepreneurial training on mushroom spawn production & cultivation	Sep 14- 22	33
Improved crop management practices for higher productivity, quality and safe production of horticultural crops	Oct 31 – Nov 04	19
Training program on soil, water, leaf and organic manure analysis - Production and quality control of bio fertilizers and bio control agents	Nov 20-25	06
Operation and maintenance of agricultural and horticultural machinery	Nov 30	50
Management of important horticultural crops with special reference to fruit crops for promotion of certified farm advisors	Dec 12-26	8
Entrepreneurial training on mushroom spawn production & cultivation	Jan 04-12	38

Post-harvest management and value addition in horticultural crops	Jan 16-20	22
Organic horticultural crop production technologies for NE Region	Feb 02-07	10
Protected cultivation and micro irrigation of vegetable, ornamental and fruit crops	Feb 19-22	30
Farmers training programme on conservation and cultivation of medicinal plants	Feb 26-28	40
Conservation & cultivation of medicinal plants	Feb 26-28	39
Organized visit cum training programme for the TANUVAS progressive farmers	Feb 27	34
Protected cultivation and micro irrigation of vegetable, ornamental and fruit crops	Mar 6-9	30
Special training course for the officers of CPWD on Emerging Trends in Urban Landscaping	Mar 6-9	20
High density planting in fruit crops to farmers of Kanchipuram, Tamil Nadu	Mar 16	40

Off-Campus Trainings

Title	Place	Date(s)	No. of participants
Training on conversion of coffee husk into compost	Chettalli, Kodagu District	Jun 13	25
Training for horticultural officers on bioinoculant production and quality control	Biocentre, Dept. of Horticulture, Hulimavu, Bengaluru	Jun 23	20
Mushroom cultivation training for Horticulture officers of Govt. of Karnataka	-	Jun, Jul and Aug	60
Use of Arka Microbial Consortium	Sadalamma Farmers Producers Company	Jul 22	50
Bio pesticides for nematode management in tuberose	Dharmapuri, Tamil Nadu	Sep 01	50
Identification and culturing of <i>Isaria fumosorosea</i> for management of sucking pests	ICAR-NBAIR, Bengaluru	Sep 11	20
Microbial inoculants and their registration process	UAS, Dharwad	Sep 29	100
Role of ICAR-NAARM in shaping agricultural research and education systems management	ICAR-NAARM Hyderabad	Sep31-Aug 01	50
National training on quality seed production technology of vegetable crops	Seed Science & Technology GKVK, Bengaluru	Oct 9-13	25
Use of Arka Fermented Cocopeat in nurseries	Kadiyam, East Godavari Dt. Andhra Pradesh	Nov 16	25

Operation and maintenance of agricultural and horticultural machinery	ICAR-KVK, MYRADA, Erode, Tamil Nadu.	Dec 05	100
Microbial technologies for horticultural crop production	Kumaraguru Institute of Agriculture, Erode	Jan 05	100
Training on improved varieties of IIHR & precision farming of vegetable crops	Mizoram	Jan 10	-
One day training on Oyster mushroom cultivation	KVK Hirehalli, Tumkur	Jan 28	35
One day training on potential of mushroom cultivation in Pasighat	Pasighat, Arunachal Pradesh	Mar 26- 29	24

International Trainings

Title	Date (s)	Number of participants
Feed The Future India Triangular Training Program (FTF ITT) on Post Harvest Technology in Horticultural Crops	Nov 6-20	Subject matter specialists (26) of development agencies from eight African and four Asian countries.
Short Term International Training Program (2017-18) under IAFS III on Recent Advances in Vegetable Production	Feb 15–25	Subject matter specialists (12) of development agencies from seven African countries.
Short Term International Training Program (2017-18) under IAFS III on Hitech Floriculture	Feb 15 – 25	Subject matterspecialists(8)ofdevelopment agencies from seven African countries.
Short Term International Training Program (2017-18) under IAFS III on Seed production Technique in Vegetables	Feb 28 – Mar 10	14 participants from seven African countries
Short Term International Training Program (2017-18) under IAFS III on Production Technology of Tropical and Sub-tropical fruits	March 10 - 31	13 participants from seven African countries

Off-campus training programmes/Field Days/ Interface meetings under Farmers FIRST programme

Programme and Place	Date (s)	No. of farmers
Farmers training on improved production technology for papaya, tomato & monitoring of demonstration plots	Apr 24	12 farmers
Animal health camp (infertility, mastitis, deworming) at Doddayeramagere and Vasappana Doddi	Apr 29	33 CB dairy animals 28 CB dairy animals
Training on improved fodder maize (afrial tall) and multi-cut COFS-30 sorghum and cowpea production technology	May 11	46 farm families
Training on improved fodder production for dairy at Kebbedoddi, Chkalegowdanadoddi and Balepura	May 20	54 farm families
Training on apiary management and INM in vegetable crops at Vasappanadoddi and Kebbedoddi	Jul 04	16 farmers

Interface meeting on IPM in vegetable crops and monitoring of demonstrations and video documentation of various models	Aug 02	18 farmers
Animal health camp (infertility, mastitis, deworming) at Balepura, Kebbe Doddi	Aug 19	29 CB dairy animals 27 CB dairy animals
Animal health camp and demo monitoring with NDRI Team	Aug 19	22 farm families and 40 animals
Training on balanced feeding management in dairy animals (mineral mixture and UMB)	Oct 21	90 dairy animals
Interaction meeting on improved management of small ruminants and improved production technology of tomato and chilli	Nov 09	16 farm families
Farmers training programme on improved management in cereals & pulses	-	75
Animal Health Camp (infertility, mastitis, deworming) at Hosadurga	Nov 14	23 CB dairy animals
Interface meeting with officers of Department of Agriculture and Horticulture on synergy programme	Nov 25	-
Interface meeting on production technology of watermelon	Dec 29	8 farm families
Interface meeting on drip irrigation in vegetable crops at Balepura and Vasappana Doddi	Jan 26	16 farm families and 4 officers
Interface meeting with floriculture farmers	Feb 27	-

5.1.2 CHES, Bhubaneswar

Tribal Sub-plan

In Rayagada district of Odisha, mango production technologies like effective management of canopy, soil and moisture management, use of micronutrients and plant growth regulators, integrated nutrient and pest management, suitability of intercrops and use of fruit fly trap were demonstrated and disseminated among the beneficiaries. The beneficiaries were provided with critical inputs like pesticides, micronutrients, fertilizers, minor farm tools, etc. With the adoption of scientific production techniques for mango cultivation, there was an increase in the yield (4-5 tonnes/acre) and income (Rs.

60000 – 65000/acre) of farming community. Tribal youth including women of different villages of Kashipur were trained through hands-on training programme on mango nursery production and management. In Mohana block, vegetable based interventions involving dissemination of commercial cultivation of underutilized cucurbits, backyard kitchen gardens for nutritional security and supplementary income, and minimal processing of raw jackfruits. Capacity building of beneficiaries for production of quality planting materials of popular cucurbitaceous crops and minimal processing of raw jackfruits has been carried out. In Gajapati, minimal processing of jackfruit and kitchen gardening were demonstrated.

The station organized six on-campus trainings as given below:

On-Campus Trainings

Title	Date(s)	No. of participants
Interactive meet on Urban Horticulture	Sep 24	75
Training programme on Horticultural interventions for sustaining tribal livelihood'	Sep 29	80

Interactive meet on Organic horticulture in rural and peri-urban areas: opportunities & constraints	Dec 29	150
Workshop on Pesticide free organic urban farming	Dec 13	80
One day training program on minimal processing of raw jackfruit	Mar 6	54
One day training cum exhibition on horticultural interventions for tribal livelihood	Mar 23	250

Off campus Trainings

Title	Place	Date(s)	No. of Participants
Krishaka Pathasala	Baramunda Play Ground	Mar 03	250

5.1.3. CHES, Chettalli

The station organized on-campus and off-campus trainings as given below

On-Campus Trainings

Title	Date(s)	No. of participants
Techniques of grafting (avocado) and budding (Coorg mandarin & rambutan)	Oct 05	02
Vegetable and mushroom cultivation	Mar 06	25

Off-Campus Trainings

Title	Place	Date(s)	No. of participants
Review of TSP activities and Input Distribution Programme	BR Hills	Jun 26	-
Management of pest and disease of horticulture through non –chemical methods	B R Hills	Nov 14	57
Exposure visit to Uddanur village, Hanur Hobli, Kollegala Taluk, Chamaraja nagara District	Uddanur, Kollegala Taluk	Nov 21	-
Training on management of vegetable nursery demonstration and input distribution programmes	BR Hills	Jan 08	200
Exposure visit to NIANP, Bengaluru under TSP project	ICAR-NIANP, Bengaluru	Feb 16	-
Exposure visit to CRSS, Coffee Board, Chettalli, Kodagu	CRSS, Coffee Board, Chettalli	Mar 06	-

5.1.4 KVK, Gonikoppal

The Krishi Vigyan Kendra organized 63 trainings on various technologies in the fields of horticulture and allied subjects

Type of Training	No.	No. of participants
On-Campus	30	1013
Off-Campus	33	1187
Total	63	2200

5.1.5 KVK, Hirehalli, Tumakuru

The Krishi Vigyan Kendra organized 54 trainings on various technologies in the fields of horticulture and allied subjects

Type of Training	No.	No. of participants
On-Campus	28	1246
Off-Campus	26	1082
Total	54	2328

5.2 Field Demonstrations

Title	Locations	No. of Demonstrations
ICAR-IIHR, Bengaluru		
Demonstration on IIHR Technologies of selected vegetable and fruit crops under Farmer- FIRST project of ICAR-NIANP	Hadonahalli, Doddaballapur Taluk, Karnataka	46
Gladiolus varieties from cormels	Bengaluru, Karnataka	1
Marigold varieties Arka Agni & Arka Bangara-2	Raichur, Karnataka	2
Velvet bean varieties Arka Dhanvantari, Arka Aswini, IIHR Sel 8	Mysore, Chtradurga, Gadag, Karnataka and Satara, Maharashtra	4
Use of IIHR Microbial Technologies for Pomegranate Plant Health Management	Gonihalli Village, Sira Taluk, Tumakuru Dt.	06
Use of Arka Microbial Consortium and Arka Actino-Plus in Potato	Horticultural Research and Extension Station (UHS, Bagalkot), Hassan, Karnataka	01

Arka Rakshak and Arka Samrat-Triple disease resistant high yielding tomato F ₁ hybrids	ICAR-IIHR	4
Chilli F ₁ hybrids	Block 3, ICAR-IIHR	
Watermelon F ₁ hybrid (Arka Akash) field demonstration	KVK, Tindivanam Tamil Nadu	01
Arka Harshitha of Brinjal variety in farmer's field.	UAHS, Shivamogga (Brahmavara and Mudigere) and UHS, Bagalkote.	OFTs – 6 MLTS -6
	Durgadahalli village, Tumkuru District.	01
Triploid seedless watermelon (Arka Madhura) demonstration both at open field (RHF) and poly house during Rabi	ICAR-IIHR, Bengaluru	01
F ₁ hybrid (Arka Nikita) demonstrated with high yield and good quality	KVK, Hirehalli ICAR-IIHR Bengaluru	02
Demonstration of Ice box watermelon (Arka Muthu)	Dodde Koppa in Kanakapura village	01
CHES, Chettalli		
Exotic vegetable cultivation	CHES Chettalli	1
KVK, Gonikoppal		
Field demonstrations on 9 aspects	Eight villages of Kodagu	90

5.3 Front Line Demonstrations

Crop	Title
KVK, Hirehalli	
Maize	Conservation Furrow (CF) as an <i>in-situ</i> moisture conservation to combat mid-season drought in maize
Pomegranate	ICM in pomegranate
Mango	Improved production practices & post harvest management in mango
China Aster	ICM in China Aster
Brinjal	Demonstration of Arka Actino-Plus (ACP) on growth & yield of brinjal
French bean	Demonstration of Bio-rationals in French bean
Tomato	ICM in Tomato
French bean-Arecanut intercropping	Areca nut + French bean intercropping system

Fruits & Vegetables	Nutrition Garden in Schools
Coconut	ICM in Coconut
Wild Boar	Management of Wild Boar in Farming system

5.4 Field Days

Title	Date & Place
ICAR-IIHR, Bengaluru	
Field day on Tomato F ₁ hybrid Arka Rakshak	Sep 02, Sanganakeri village of Gokak Taluk in Belagavi District
Demonstrate productivity potentials of ICAR-IIHR technologies	Sep 14, ICAR-IIHR
Field day on horticultural crops (vegetable crops)	Sep 14 at ICAR-IIHR, Bengaluru
ICAR- IIHR marigold varieties	Nov 16, Manvi, Raichur District, Karnataka
Field day on Arka Rakshak Tomato	Nov 21, Hannur, Chamarajanagar
Field day on Tomato F ₁ hybrid Arka Rakshak	Nov 21, Uddanur village, Hanur Hobli, Kollegala Taluk, Chamarajanagara District.
Field day on tomato F ₁ hybrid Arka Samrat & French bean variety Arka Suvidha (organic cultivation using Jeevamrutha)	Dec 12 at Durgadahalli village, Tumukur District
National Horticultural Fair on horticultural crops-improved vegetable varieties/hybrids and production technology	Mar 15-17 ICAR-IIHR, Bangalore
Sustainable production of pomegranate	Mar 26, Bellary
CHES, Bhubaneswar	
Dragon fruit production technology	Sep 01
Year round pineapple cultivation	Nov 03
Arka Rakshak-triple disease resistant tomato F ₁ hybrid	Feb 27, Kakatpur village, Puri District, Odisha
KVK, Gonikoppal	
Yard long bean variety Arka Mangala	Apr 11, Cherambane, Madikkeri
Yard Long Bean Variety Arka Mangala	May 12, Nalloor, Virajpet
Spine gourd hybrid Arka Neelachal Shanti	Aug 11, KVK Farm
Paddy variety KPR-1	Dec 08, Mythadi, Virajpet
Integrated crop management in Black pepper	Feb 03, Kunda, Virajpet
KVK, Hirehalli	
ICM in tomato crop (Arka Samrat)	Dec 12, Halekote
Field day on tomato	Dec 12, Durgadahalli
Field Day on French bean	Dec 12, Setupalya
Use of Jeevamrutha in French bean	Dec 12, Setupalya
ICM in coconut	Dec 15, Anupanahalli

Dryland horticulture under NICRA	Dec 15, D.Nagenahalli
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5.5 Farmers-Scientists Interface Meetings

Event/Occasion	Date	Place	No. of participants
ICAR-IIHR, Bengaluru			
IIHR technologies for FPO	Jun 01	FPO Anekal	22
Jack fruit management	Jun 24	IIHR, Bengaluru	120
Nematode management in fruits	Aug 08	Rayaboyanahatti, Gudekote, Bellary (D.T)	10
One-day farmers' Interaction meeting on nematode management in guava variety Arka Kiran	Feb 26	Vijayawada	340
National Horticultural Fair 2018	Mar 14-17	ICAR-IIHR, Bengaluru	80000-10, 0000
Nematode management	Mar 26	Laxmipura, Ballary village,	10
Use of Arka Microbial Consortium and Arka Actino Plus in Pomegranate	Dec 20	Gonihalli village, Sira Taluk, Tumakuru District	50
CHES, Chettalli			
Demonstration of coffee husk composting	Jun 13	Boikeri, Kodagu, Karnataka	25
KVK, Gonikoppal			
Prospects of avocado cultivation in Kodagu district	Jun 12	KVK, Gonikoppal	50
Avocado grading and marketing	Jun 21	KVK, Gonikoppal	40
Coffee and black pepper cultivation in plains	Sep 14	KVK, Gonikoppal	30
Dairy entrepreneurship development scheme	Sep 15	Madikeri	50
AMC users meet	Nov 07	KVK, Gonikoppal	75

5.6 On Farm Trials

Name of the trial / technology	Place	No. of trials
ICAR-IIHR, Bengaluru		
Demonstration of rose variety Arka Parimala	Udaipur	1
Demonstration of marigold varieties Arka Agni and Arka Bangara-2	Kalyandurga, A.P	1
Demonstration of marigold varieties Arka Agni & Arka Bangara	Darsi, Nelluru , Chittoor, Banavasi, A.P, Namkal, Salem, TN Vijayapura, Belgaum, Karnataka	8
China aster varieties Arka Aadya and Arka Archana	Mysore, Sirsi, Kolar, Bengaluru, Bider	5
Arka Rashmi	UHS, Bagalkot	8

Arka Udaya	UHS, Bagalkot	8
Farm trail of ridge gourd variety, Arka Prasan	Bagalkot, Arabavi, Yadgir, Bengaluru, Kolar, Mysuru, Tidagundi, Kalburgi, Kathalgere, Shivamogga, Davanagere, Bramhavar	13
Farm trail of ridge gourd hybrid, Arka Vikram	Bagalkot, Arabavi, Yadgir, Bengaluru, Kolar, Mysuru, Tidagundi, Kalburgi, Kathalgere, Shivamogga, Davanagere, Bramhavar	13
Watermelon F ₁ hybrid Arka Akash	KVK, Hiriyyur KVK Shivamogga KVK, Bramahvara DDH, Shivamogga EEU, Kathalgere ZAHRS, Shivamogga	02 02 02 02 01 01
Brinjal F1 hybrid Arka Harshitha	UAHS, Shivamogga	06
KVK, Gonikoppal		
Assessment of ginger varieties for higher yield	Hudikeri	03
Assessment of bitter gourd variety for higher yield	Bhagamandala	10

5.7 Exhibitions

Organized / Participated	Venue	Period
ICAR-IIHR, Bengaluru		
Kisan Mela	Motihari, Bihar	Apr 15 -19
Mango and Jack Fruit Exhibition Cum Mela	Lalbagh Bengaluru	May 05
National Conference on Horticultural Crops of Humid Tropics	CHES, Chettalli	May 22-22
SasyaSanthe 2017	UHS, Bagalkot	Jun 20-26
AgriIntex 2017- Agricultural International Fair	CODISSIA Trade Fair Complex, Coimbatore, Tamil Nadu	Jul 14-17
Telangana Udyana Mahotsavam, 2017	Hyderabad	Aug 27-31
Tuber Crops Technology Conclave & Agri-startup Meet-2017 and Centre-state Interface Meet	ICAR-CTCRI, Thiruvananthapuram.	Oct 27-28
Krishimela 2017	GKVK-UAS Bangalore	Nov 16-19
AgTech Summit 2017	FinTech Capital and Smart City, Visakhapatnam	Nov 15-17
Horticultural Fair	UHS, Bagalkot	Dec 22-24
Seva Utsav-2018	Basavanagudi, Bengaluru	Dec 30-Jan 02
5th Assam International AgriHorti Show, 2018	Dibrugarh, Assam	Jan 5-8
Mega Kisan Mela and Agri-Business Expo	ICAR-CPCRI, Kasargod	Jan 5-10
Kanakotsava	Ramanagar	Jan 10-12
Organics & Millets-2018 International Trade Fair	Palace Ground, Bangalore	Jan 19-21
Republic Flower Show	Lalbagh, Bangalore	Jan 19-28

Farm Machinery and Technology Demonstration Mela - 2018	V.C. Farm, Mandya	Feb16
Farmers' Conclave	ICAR-NIANP	Feb 16-17
National Seminar on Wild Wdible Fruits	Ponnampet , Koadagu	Mar 2-3
Krishi Unnati Mela-2018	IARI, Pusa, New Delhi	Mar 16-18
Eco Chetana	Shri Atal Bihari Vajpayee Sports Ground, Yadiyur, Jayanagar, Bengaluru	Mar 25
CHES, Bhubaneswar		
8th Krishi Fair	Puri	May 15-17
Orissa Krushak Samaj to commemorate World Food Day	Institute of Engineers, Bhubaneswar	Oct 16
ICAR-CIWA on occasion of Rashtriya Mahila Diwas and World Food Day	ICAR- Central Institute on Women in Agriculture (ICAR-CIWA)	Oct 16
Workshop on Agro-biodiversity	ICAR- National Rice Research Institute, Cuttack	Nov 17
Exhibition and Kisan Mela	Dr. Rajendra Prasad Central Agricultural University, Samastipur, Bihar	Dec 03-05
1st International Extension Congress 2018	ICAR-CIWA, Bhubaneswar	Feb 1-3
3rd ARRW International Symposium on 'Frontiers of Rice Research for Improving Productivity, Profitability and Climate Resilience' and workshop on "Food and Nutritional Security in India: Issues and Challenges	ICAR- National Rice Research Institute, Cuttack	Feb 6-8
State Agriculture Fair- Krushi Odisha 2018	Baramunda Play Ground, Bhubaneswar	Mar 6-9
CHES, Chettalli		
Farmers Conclave	ICAR-NIANP, Bengaluru	Feb 16-17
National Seminar on Edible Wild Fruits of Western Ghats: Conservation and Utilization – 2018	College of Forestry, Ponnampet, Kodagu, Karnataka	Mar 2-3
National Horticulture Fair	ICAR-IIHR, Bengaluru	Mar 15
CHES, Hirehalli		
National Conference on Fruit crops for humid tropics –Diversification and Sustainability	Madikeri, Kodagu	May 20-22
Jackfruit Diversity Fair	IIHR-Bangalore	Jun 24-25
Farmers Conclave	ICAR-NIANP, Bengaluru	Feb 16-17
KVK, Gonikoppal		
National Conference on Fruit Crops for Humid Tropics –Diversification and Sustainability	Madikeri	May 20-22
Integrated Farming Fystem and Paddy Field Day	Ponnampet	Sep 29
National Seminar on Wild Edible Fruits	Ponnampet	Mar 2-3
National Horticulture Fair	IIHR, Bengaluru	Mar 15-17
KVK, Hirehalli		
National Organic Trade Fair- Organics & Millets 2017 Department of Agriculture, Bengaluru Govt. of Karnataka	Palace Ground, Bengaluru	Apr 28-30
Jackfruit Diversity Fair 2017	IIHR Bengaluru	Jun 24

Siridhanya Mela by Dept. of Agriculture, Tumakuru	Tumakuru	Dec 14-16
Organics & Millets 2018 - International Trade Fair by Dept. of Agril, Govt. of Karnataka	Palace Ground, Bengaluru	Jan 19-21
Farmers Conclave	NIANP, Bengaluru	Feb 16-17
National Seminar on Wild Edible Fruits of Western Ghats Conservation and Utilization	College of Forestry, Ponnampet, UAHS Shivamogga	Mar 02-03
National Horticultural Fair 2018	ICAR- IIHR, Bengaluru	Mar 15-17

5.8 TV and Radio programmes

Scientists of the Institute presented 29 radio and 38 television programs on the technologies developed by the Institute and other related topics in horticulture.

5.8.1 Radio programs

The following radio programs were presented

Title	Date & Place	Station
Importance of Mango diversity fair – IIHR	May 23	AIR, Bengaluru
Improved Varieties of Brinjal	July 19	AIR, Bengaluru
Cultivation of amaranthus, palak, coriander and fenugreek	Aug 28	AIR, Bengaluru
Nutrient management in grapes and banana	Sep 15	AIR, Bengaluru
NellikayiyaSudarithabesayakramagalu	Sep 19	AIR, Bengaluru
Cultivation of garden pea	Sept 20	AIR, Bengaluru
Oyster mushroom cultivation	Oct 03	AIR, Madikeri
Scientific goat farming	Oct 04	AIR, Madikeri
Sharing of experience on integrated farming system	Oct 05	AIR, Madikeri
Vegetable cultivation	Oct 07	AIR, Madikeri
Information on international horti. fair of IIHR	Oct 07	AIR Bengaluru
Mono cropping in black pepper	Oct 08	AIR, Madikeri
Role of vaccination in Livestock	Oct 10	AIR, Madikeri
Functioning of Puthari Farmer producer organization	Oct 11	AIR, Madikeri
Sharing of experience on dairy farming	Oct 11	AIR, Madikeri
Wilt management in black pepper	Oct 12	AIR, Madikeri
Horticultural enterprises through self-help groups	Oct 19	AIR, Bengaluru
Bheema Fasal Yojane - Praja Pragathi	Oct 25	Radio Siddartha, Tumakuru
Technologies for profitable custard apple production	Nov 28	AIR, Bengaluru
Importance of lemon in dryland horticulture	Dec 28	AIR, Bengaluru
Diseases of tomato and their control measures	Jan 08	AIR, Bengaluru
Technology package for fig production	Jan 19	AIR, Bengaluru
Practices after forward pruning in grape vineyards	Jan 29	AIR, Bengaluru
Watermelon and okra cultivation in Karnataka	Feb 14	AIR, Bengaluru

National Horticultural Fair - 2018 of IIHR	Mar 10	AIR Bengaluru
Report on National Horticultural Fair - 2018 of IIHR	Mar 15	AIR Bengaluru
ICAR-IIHR released leafy vegetable varieties	Mar 15	AIR, Bengaluru
ICAR-IIHR released legume vegetable varieties	Mar 15	AIR, Bengaluru
Soil testing and soil health card	Mar 26	AIR, Bengaluru

5.8.2 Television programs

The following television programs were presented by the scientists of the Institute on different channels

Title	Date & Place	Station
Environmental friendly agriculture	Apr 17	DD Kishan
Arka Microbial Consortium of IIHR – Panel discussion	Apr 18	DD Kishan
Brinjal varieties	Apr 19	DD Chandana
IIHR Released Varieties of french bean	Apr 24	DD Chandana
Management of plantation crop during summer	May 02	DD Kishan
IIHR gladiolus flower cultivation	May 15	DD Chandana
IIHR Mango diversity fair – 2017	May 24	DD Kishan
Importance of Mango diversity fair – 2017	May 26	DD Kishan
Rambutan cultivation	May 29	DD Kishan
Jackfruit Diversity Show	May 29	DD Kishan
Jack fruit diversity fair at IIHR – 2017 Panel discussion	Jun 22	DD Kishan
Nematode management in guava	Jul 28	DD Chandana
International Symposium – press meet on golden jubilee of IIHR	Sep 04	DD Chandana
Varieties of gerbera flower	Sep 13	DD Chandana
New marigold varieties of IIHR	Sep 25	ETV
Rose cultivation in polyhouse	Sep 28	ETV
Technology of enrichment of FYM with biopesticides	Sep 28	DD Podhigai
Managing nematodes in tuberose	Sep 29	DD Podhigai
Management of cut worm in Ragi	Oct 11	Prajaa TV
New marigold varieties of IIHR	Oct 20	DD Chandana
Rose cultivation in polyhouse	Oct 25	DD Chandana
Biomangement of nematodes in tuberose	Oct 26	DD Chandana
Effective usage of organic wastes	Oct 30	DDKishan
Importance of Krishi Mela's and IIHR technologies	Nov 18	Samaya TV
Nematode management in tuberose	Dec 05	Makkal TV
Value addition in amla (Live Programme)	Dec 14	DD Chandana
Use of Jeevamrutha in French bean	Dec 27	DD Chandana

French bean Intercropping in coconut (Live Programme)	Dec 28	DD Chandana
IIHR Released legume vegetables	Jan 16	DD Chandana
Improved varieties of brinjal	Feb 16	DD Chandana
Importance of horticulture Fairs	Mar 15	DD Kishan
IIHR Horticulture Fair – 2018	Mar 15	B-TV
National Horticulture Fair – 2018	Mar 16	Sarala Jevana TV
Information on IIHR Horticulture Fair – 2018	Mar 16	TV 9
Tree base farming system in NICRA village	Mar 16	DD Chandana
IIHR released varieties of green leafy vegetables	Mar 16	DD Chandana
Okra varieties released at IIHR	Mar 16	DD Chandana

5.9 Agricultural Technology Information Centre (ATIC)

Agricultural Technology Information Centre (ATIC) was visited by 9224 stakeholders consisting of growers, entrepreneurs, trainees and students. Further, about 859 telephone / internet queries regarding crop cultivation, availability of technology products, research literature, training programs, pest and disease problems in crops were answered. Adoption of ICAR-IIHR technology products such as banana special, mango special, citrus special and vegetable special by farmers was also studied. A revenue of Rs.57.33 lakh was realized through sale of technology products, publications and other services.

5.10 Vegetable Breeder Seed Production Programmes and Seed village concept

Vegetable seed Production unit

During the year 2017-18, vegetable seed production unit organized vegetable breeder seed production programmes at IIHR campus and in farmer's field under Seed Village Concept. During this year a total quantity of 13983.50 kg seeds was produced including hybrids of 56 vegetable varieties

Seed Village Concept Success story

In order to meet the increasing demand of hybrids seeds, seed production of IIHR hybrids were undertaken in large scale at Haveri Districts of Karnataka state under seed village concept. Under this programme total quantity of 399 kg hybrids seeds were produced comprising important hybrid crops viz., tomato (180 kg) and chilli (219 kg). This programme was highly successful, and for the first time Institute was able to meet the demand for hybrid seeds from KVK & farmers.



Vegetable seed Production

5.11 Sale of Quality Seeds and Planting Material

5.11.1 ICAR-IIHR, Bengaluru

A total quantity of 14300.75 kg of vegetable seeds were sold to public/ private sector organisations and farmers, thereby earning a record revenue of Rs.1.36 crores.

Crop	Variety & Quantity sold (kg)
Tomato	Arka Vikas (4.365), Arka Saurabh (8.129), Arka Meghali (19.767), Arka Alok (0.276), Arka Abha (5.530), Arka Samrat (F1) (57.582), Arka Rakshak (F1) (145.141)
Chilli	Arka Lohit (52.070), Arka Harita (F1) 23.169), Arka Meghana (F1) (37.264), Arka Kyati (F1) (1.725), Arka Sweta (F1) (3.015)
Capsicum	Arka Mohini (0.010), Arka Gaurav (0.010)
Brinjal	Arka Shirish (0.421), Arka Kusumakar (29.57), Arka Haristha (1.490), Arka Keshav (25.756), Arka Anand (F1) (31.723)
Watermelon	Arka Manik (3.460), Arka Muthu (13.970), Arka Akash (0.019)
Round melon	Arka Tinda (27.190)
Bush squash	Patty Pan (0.380)
Pumpkin	Arka Suryamukhi (217.498), Arka Chandan (32.660)
Bottle gourd	Arka Bahar (201.490)
Bitter gourd	Arka Harit (6.234)
Ridge gourd	Arka Sujat (4.907), Arka Sumeet (0.275), Arka Prasan (3.322), Arka Vikram (3.250)
Okra	Arka Anamika (3606.630)
Onion	Arka Kalyan (350.486), Arka Niketan (64.135), Arka Pragathi (12.476), Arka Bindu (0.700), Arka Ujjawal (12.330), Arka Bheem (81.047), Arka Lalima [F1](66.520), Arka Kirthiman [F1] (46.012)
Radish	Arka Nishanth (5.578)
Cowpea	Arka Suman (307.465), Arka Garima (767.680), Arka Samrudhi (63.400)
Yard long bean	Arka Mangala (550.410)
Garden pea	Arka Ajit (66.400), Arka Karthik (94.090), Arka Priya (253.820), Arka Apoorva (132.800), Arka pramod (1.000)
French bean	Arka Komal (554.096), Arka Shartath (1159.980), Arka Arjun (464.880), Arka Suvidha (476.520), Arka Anoop (201.400)
Veg Amaranth	Arka Suguna (323.935), Arka Arunima (239.130), Arka Varna (0.100), Arka Samraksha (0.300)
Palak	Arka Anupama (1805.844)
Coriander	Arka Isha (147.900)
Dolichos	Arka Jay (114.081), Arka Amogh (452.684), Arka Sowmyam (102.800), Arka Sambhram (119.942), Arka Swagath (689.762), Arka Vistar (1.250), Arka Krishna (1.500)
Total	14300.75 kg

Plant Material Distribution

Crop	Quantity
Fruit crop grafts / plants (mango, guava, sapota, custard apple, jamun, jack fruit, grape, passion fruit, lime etc.)	62100 Nos.
Papaya seeds (Arka Prabhat and Arka Surya)	2.0 kg
Revenue generated	Rs. 20.75 lakh

5.11.2 CHES, Bhubaneshwar

Crop	Variety & Quantity (Kg)
Planting materials of fruit and vegetable crops (mango, guava, bael, custard apple, aonla, cucurbits, etc.)	23500 Nos.
Seeds of vegetable crops	Brinjal (6 kgs) and chilli (2 kgs)

5.11.3 CHES, Chettali

Crop	Variety & Quantity (Kg)
Papaya	Coorg Honey dew (215 gram)
Arka Seeds (Vegetable seed kit)	Mixed variety (79 packets)

Plant Material Distribution

Crops	No. of Plants
Pummelo	82
Sevelle lemon	49
Seedless lime	152
Coorg orange	7296
Coorg orange (grafted)	4
Passion fruit	1032
Avocado	5049
Avocado graft ed	2
Papaya	603
Pepper cuttings	1459
Hibiscus	119
Karonda	469
Rose plants	533
Malayan apple	657
Carambola	113

Crops	No. of Plants
Kokum	309
Dragon fruit	1955
Egg fruit	9
Rose apple	64
Grape fruit	35
Sour sop	404
Rambutan	2
Garcinia	118
Velvet apple	80
Bougainvillea	50
Ramphal	213
Rangpur lime	6
White sapota	8
Litchi seedlings	5
Litchi graft	70
Total	20947 Nos.
Revenue generated	Rs. 858625

5.11.4 CHES, Hirehalli

Crop	Quantity
Siddu Jackfruit Grafted Plants	496 Nos
Avocado (Butter Fruit) Plants	547 Nos
Betelvine Cuttings	1143 Nos
Dragon Fruit Cuttings	350 Nos
Passion Fruit Cuttings	32 Nos
Banana Fruits	1745.5 Kg
Papaya Fruits	3964 Kg

5.11.5 KVK, Gonikoppal

Planting Material Production

Crop	Variety and Quantity (Nos.)
Coffee (Robusta)	CXR (4000)
Areca nut	Theerthalli (4200)
Black pepper	P-1 (12800)

5.12 Supply of Farm Machinery

A revenue of Rs.23,49,085/- was generated by the supply of the following machineries/ drawings to various firms.

Technology transferred	Name of the firm/organization
Power operated onion seed extractor	M/s Team Flame Engg. & Solutions, Bengaluru.
One set of Spawn Machinery	Biocentre, Dept. of Horticulture, Govt. of Karnataka, Mysuru.
Fruits and vegetable vending van	KHF, Govt. of Karnataka, Bengaluru.

5.13 Sale of Mushroom Spawn and its Impact

5.13.1 ICAR-IIHR

Technology	Quantity/ Value
Spawn sold during the period April 2016-March 2017	41.73 tons
Revenue generated for the institute	Rs.26,82,560
Estimated Environmental impact	
Mushroom produced through 41.73 tons spawn @ 3 Kg fresh mushroom per kg spawn	125.19 tons
Employment generated @150 mandays/ ton / annum	18778 mandays (51 people employed for one year)
Protein produced @ 2.5% of fresh weight	3.12 tons
Land used for production @ 0.1ha/ ton	12.51 ha

Paddy/ wheat straw recycled @ 0.5 kg fresh mushrooms/ 1 kg dry straw	250.38 tons
Spent mushroom substrate (SMS) produced after crop harvest for organic manure @ 60% of dry straw used	150.22 tons
Prevention of air pollution	
Prevented the release of particulate matter @ 3 kg/ ton straw	751.14 kg
of carbon monoxide (CO) @ 60 kg/ton straw	15022.8 kg
of Carbon-di-oxide (CO ₂) @ 1460 kg/ton straw	365554.8 kg
of ash @ 199 kg/ton straw	49825.62 kg
of Sulphur di-oxide (SO ₂) @ 2 kg/ton straw	500.76 kg

5.13.2 CHES, Chettalli

Technology	Quantity / Value
Oyster Mushroom spawn	14.50 kg / Rs. 12645

5.13.3 KVK, Gonikoppal

Technology	Quantity
Oyster Mushroom spawn	80 kg



International training programme



Training for SHG members



Management of pest and disease of horticulture through non-chemical methods



Vegetable nursery demonstration and input distribution programmes for tribal farmers

6.1 Post Graduate Education

The main activities involve offering Ph.D. (Horticulture) and Ph.D. (PHT of horticultural crops) courses as an outreach program of IARI, New Delhi and facilitating research guidance and course work for students of various universities as per MoU. ICAR-IIHR has MoU with reputed universities such as UAS, Bengaluru; TNAU,

Coimbatore; JNKVV, Jabalpur; Acharya N.G Ranga Agricultural University (ANGRAU), A.P; UHS, Bagalkot; Jain University, Bengaluru; Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad; Graphic Era University, Uttarakhand etc., for offering higher education in horticultural sciences. Scientists of the Institute have been recognised as faculty/guides for offering course work and guide the students for research.

6.1.1 Courses offered for IARI/IIHR students

Course No.	Course Name	Course Leader
III trimester of 2016-17 academic session for IARI/IIHR students		
HORT621	Growth and development of horticultural crops	Dr. J. Satisha
FSC691	Seminar	Dr. Anuradha Sane
VSC691	Seminar	Dr. A.T. Sadashiva
VSC624	Advances in breeding for quality and special traits in vegetable crops	Dr. M. Pitchaimuthu
VSC621	Breeding of self-pollinated vegetable crops	Dr. K. Madhavi Reddy
VSC622	Biotechnology for vegetable crops improvement	Dr. E.S. Rao
FLA691	Seminar	Dr. T. Manjunatha Rao
FLA622	Value addition in ornamental crops	Dr. Sangama
PHT621	Processing of horticultural crops	Dr. R.B. Tiwari
PHT691	Seminar	Dr. H.S. Oberoi
AG504	Principles and practices of water management	Dr. Anil Kumar Nair
BIO504	Techniques in biochemistry	Dr. V. Keshava Rao
PLPATH513	Disease resistance in plant	Dr. M. Krishna Reddy
PLPATH604	Molecular basis of host pathogen interaction	Dr. S. Sriram
PGS503	Intellectual property and its management in agriculture	Dr. P.E. Rajasekharan
PP508	Physiology of plant mineral nutrition	Dr. R.H. Laxman
PP691	Seminar	Dr. K.S. Shivashankara
PGS506	History of agriculture	Dr. A.N. Ganeshamurthy
GP612	Diversity analysis	Dr. Tejaswini
GP620	Applied cytogenetics	Dr. A. Rekha
GP640	Advances in plant breeding	Dr. K. Hima Bindu

II trimester of 2017-18 academic session for IARI/IIHR students

FSC611	Breeding of fruit crops	Dr. M. Sankaran
FSC691	Seminar	Dr. Reju M. Kurian
VSC691	Seminar	Dr. A.T. Sadashiva
VSC623-2016	Advances in breeding for stress resistance in vegetable crops	Dr. K.Padmini
VSC672	Protected cultivation of horticultural crops	Dr. S. Shankara Hebbar
VSC512	Winter vegetables	Dr. Anil Kumar Nair
VSC513-2017	Breeding of cross-pollinated vegetable crops	Dr. B. Varalakshmi
FLA691	Seminar	Dr. T. Manjunatha Rao
FLA611	Commercial floriculture	Dr. H.P. Sumangala
FLA621	Advanced breeding of ornamental crops	Dr. C. Aswath
PHT614	Principles and practices of food handling and packaging	Dr. H.S. Oberoi
BIO691	Seminar	Dr. K K Upreti
MB507	Food microbiology	Dr. K. Ranjitha
MB504	Techniques in microbiology	Dr. G. Selvakumar
MBB511	Biotechnology-ii	Dr. T.R. Usharani
MBB601	Molecular breeding	Dr. D.C. Lakshman Reddy
MBB691	Seminar	Dr. P. Nandeeshha
MBB504	Plant tissue culture and genetic	Dr. P. Nandeeshha
MBB504-2017	Plant tissue culture and genetic engineering	Dr. P. Nandeeshha
PLPATH506	Principles in plant disease management	Dr. S. Sriram
PP503	Global climate change and agriculture	Dr. R.H. Laxman
PP508	Physiology of plant mineral nutrition	Dr. R.H. Laxman
GP612	Diversity analysis	Dr. M.V. Dhananjaya
GP643	Concepts in heterosis breeding	Dr. Tejaswini

I trimester of 2017-18 academic session for IARI/IIHR students

FSC602	National horticultural problems and current issues in fruit production	Dr. Reju M. Kurian
HORT601	Export oriented horticulture	Dr. D.V. Sudhakar Rao
VSC601	Hi-tech vegetable farming	Dr. S. Shankara Hebbar
VSC621	Breeding of self-pollinated vegetable crops	Dr. E.S. Rao
VSC622	Biotechnology for vegetable crops improvement	Dr. E.S. Rao
VSC691	Seminar	Dr. A.T. Sadashiva
FLA691	Seminar	Dr. T.Manjunatha Rao
AG502	Soil fertility and nutrient management	Dr. H.B. Raghupathi
AG691	Seminar	Dr. Anil Kumar Nair

PGS502	Technical writing and communication skills	Dr. R. Venkattakumar
PGS505	Agricultural research, research ethics and rural development programs	Dr. B. Balakrishna
PGS504	Basic statistical methods in agriculture	Dr. R. Venugopalan
BIO691	Seminar	Dr. Shamina Azeez
MBB501	Principles of biotechnology	Dr. T.R. Usharani
MBB504	Plant tissue culture and genetic	Dr. H.S. Vageeshbabu
MBB691	Seminar	Dr. P. Nandeesh
PLPATH508	Diseases of fruits, plantation and ornamental crops	Dr. S. Sriram
PLPATH691	Seminar	Dr. M. Krishna Reddy
PP601	Techniques in plant physiology	Dr. R.H. Laxman
PP602	Responses of plants to abiotic stresses	Dr. S.M. Manamohan
PP691	Seminar	Dr. K.S. Shivashankara
SSAC510	Management of problem soils and waters	Dr. L.R. Varalakshmi
GP612	Diversity analysis	Dr. M.V. Dhananjaya
PGS501	Library and information services	Shri. K.V. Shankara Prasad

Academic session 2017-18 for UHS(B)		
HST 601 (Ph.D)	Applied regression analysis (2+1)	Dr. R. Venugopalan
PMA 604 (Ph.D)	Advances in breeding of plantation crops and spices (1+1)	Dr. Smitha, G.R
BCI 606 (Ph.D)	Emerging trends in seed quality enhancement (2+1)	Dr. H.S. Yogeesh
PMA 603 (Ph.D)	Advances in Breeding of Medicinal & Aromatic Crops (2+1)	Dr. K. Himabindu

6.1.2 Students admitted to IARI/IIHR Ph.D programmes for the academic year 2017-18

Name of the student	Discipline	Name of the guide allotted
Naveen Kumar	Plant Pathology	Dr. M. Krishna Reddy.
Lokesh Babu	Plant Pathology	Dr. M. Krishna Reddy.
Ramesh A. N	Plant Biotechnology	Dr. Vageeshbabu S. Hanur
Soudamini	Horticulture & Floriculture	Dr. C. Aswath
Parvathi Bennurmth	Horticulture & Floriculture	Dr. Rajiv Kumar
Anamika Gurung	Horticulture & Floriculture	Dr. Rajiv Kumar

Ambarish. S	Agricultural Entomology	Dr. V. Venkataravanappa
Meghana. N	Agricultural Entomology	Dr. V. Venkataravanappa
Krishnappa Pujar	Forest Biology and Tree Improve ments	Dr. V. Venkataravanappa
Kavita Hegde	Agricultural Entomology	Dr. V. Venkataravanappa
Naqibullah	Horticulture	Dr. V. Venkataravanappa

6.1.3 Awards of M.Sc. and Ph.D. degrees

Student's name	University	Degree	Thesis Title	Name of the guide
Sandhya Rani	Dr. YSRHU, AP	Ph.D.	Characterization and cy-tological studies in pum-melo (<i>Citrus maxima</i> L)	Dr. M. Sankaran.
Alifa	UHS, Bagalkot	M.Sc	Studies on utilization of wild species of guava (<i>Psidium guajava</i> L.)	Dr. C. Vasugi.
Sunita Patil	Dr. YSR Horticultural University, AP	M.Sc	Standardization of growth regulators for rachis elongation in Crimson Seedless and berry/flower thinning in Red Globe grapes (<i>Vitis vinifera</i> L)	Dr. J. Satisha
Souravi K	Jain University, Bangalore	Ph. D.	Back from the brink, biotechnological approaches for integrated conservation of <i>Madhuca insignis</i> (Radlk)	Dr Rajasekaran
Kantesh Ambiger	UAS, Bangalore	M.Sc	An economic analysis of production risks, mar-keting risk and welfare implication of rainfed maize on substance farms of southern transi-tional zone of karnataka	Dr. D. Sreenivasa Murthy
Geetha G A	UAS, GKVK, Bengaluru	Ph. D.	Effect of temperature on reproductive physiology, fruit maturity and fruit quality of mango	Dr. K. S. Shivashankara
Lekha S	Jain University Ban-galore	Ph. D. (Bio-Chemistry)	Persistence and dissipa-tion of spiromesifen on cabbage, tomato and its degradatation in soil	Dr. Soudamini Mohapatra

Radhika B	Jain University of Bangalore	Ph. D. (Bio-Chemistry)	Persistence and dissipation of flubendiamide on capsicum, grapes and soil.	Dr. Soudamini Mohapatra
Shiva Prasad S. R	Kuvempu University, Shimoga	Ph. D. (Bio-Chemistry)	Phenological and biochemical changes associated with off season flowering and regular bearing habits in mango.	Dr. K. K. Upreti
Megha HS	Jain University	Ph.D (Biotechnology)	Molecular analysis and mapping drought tolerance traits in Banana	Dr. KV Ravishankar
R. Rajinikanth	JNTU, Hyderabad	Ph.D (Biotechnology)	Studies on molecular characterization of <i>Trichoderma viride</i> and biomanagement strategies of disease complex caused by RKN in cauliflower	Dr. M.S. Rao
E. Nandhini	UHS, Bagalkot	M.Sc (Hort)	Varietal evaluation for floral biology in relation to fruit and seed yield in okra (<i>Abelmoschus esculentus</i> (L.) Moench)	Dr.K.Padmini
Prakash Kerue	UHS, Bagalkot	Ph.D	Genetic inheritance of Yellow Vein Mosaic Virus Resistance and yield component studies in okra (<i>Abelmoschus esculentus</i> (L.) Moench)	Dr.M.Pitchaimuthu
Tejaswini Rathod	Dr.YSRHU, A.P.	M.Sc. (Hort.)	Evaluation of rootstock and scion in Brinjal (<i>Solanum melongena</i> L.) for enhancing the yield, quality & incidence of Bacterial wilt"	Dr.S. S. Hebbar

6.1.4 IIHR Scientists as External Examiners

- Dr. C. Aswath evaluated Ph. D. thesis of Mr. M. Muthuswamy entitled 'Transcript analysis and identification of factors regulating drought tolerance in Banana' submitted to Bharathidasan University, Palkalaiperur, Tiruchirapalli.
- Dr. C. Aswath evaluated and conducted a final viva-voce of thesis of Mr. Basavaraj Dalawai entitled "Evaluation and characterization of Heliconia genotypes for growth, Flower yield and quality under shade house condition" submitted to Department of Horticulture, UAS, Dharwad.
- Dr Aghora T S acted as external examiner for Oral Qualifying examination of three M.Sc Agri (Hort) students, College of Agriculture, Vijayapura of UAS, Dharwad.
- Dr. Tejaswini evaluated M.Sc. thesis of a student of TNAU, Coimbatore.
- Dr. B. Varalakshmi evaluated the M.Sc. (Hort.) Thesis entitled "Evaluation of Garlic (*Allium sativum* L.) genotypes for their growth, yield and quality parameters under central dry zone of Karnataka" UAHS, Shivamogga
- Dr. P. E. Rajasekharan acted as Ph.D. thesis examiner of Ignace Kindo entitled 'Ethnobotany of koraku tribals of balrampur district in chhattisgarh state, india', Bharthidasan University, Tiruchirapalli.
- Dr. Rupa, T.R. evaluated M.Sc. thesis of Mr. Girisha entitled "Delineation and assessment of micronutrients and preparation of thematic maps of Kanchipuram district in Tamil Nadu using GPS and GIS techniques" Tamil Nadu, Agricultural University, Coimbatore, Tamil Nadu.
- Dr. J.B. Mythili evaluated Ph.D. thesis of Mr. Vishnukiran Thuraga from Jawaharlal Nehru Technology University (JNTU), Hyderabad.
- Dr. K. Saxena acted as Ph.D. thesis examiner and external expert to conduct Ph.D. viva voce in University of Agricultural Sciences, Dharwad.
- Dr. S. Sriram, evaluated and was the external examiner for the thesis entitled "Studies on seed transmission and genome sequencing of *Piper yellow mottle virus* infecting black pepper" Kannur University, Kannur, Kerala.
- Dr. S. Sriram, evaluated and was the external examiner for the thesis entitled "Molecular Characterization of Potential Biocontrol Agents and Integrated Management of Stem Rot of Groundnut" the faculty of Bio Technology, JNTU, Hyderabad.
- Dr. R. Veere Gowda acted as external examiner for Oral Qualifying examination of M.Sc and Ph. D students, MPKV, Rahuri, Maharashtra.
- Dr K. Madhavi Reddy acted as external examiner for Oral Qualifying examination of M.Sc and Ph.D students, College of Horticulture, YSRHU University, Andhra Pradesh.
- Dr. M. Pitchaimuthu acted as external examiner to conduct final thesis viva-voce examination of Mrs. Nirmala, Ph.D Student in the Department of Vegetable Science, Horticultural college & research Institute, Coimbatore.
- Dr. M. Pitchaimuthu appointed as an external examiner to conduct qualifying examination of two M.Sc. (Hort) students, Ms. Feba Varghees and Mr. M. Shashidhar in the Department of Horticulture, College of Agriculture, Vellayani, Trivandrum, Kerala.
- Dr. K. V. Ravishankar acted as an External Examiner for Ph.D. degree (Molecular Biology and Biotechnology) thesis evaluation from University of Agricultural Science, Dharwad.
- Dr. P. Nandeeshha acted as external examiner for MSc (Biotechnology) Thesis evaluation from TNAU, Coimbatore.
- Dr. V. Venkataravanappa acted as external Examiner for M. Sc Thesis evaluation from UAS, G.K.V.K, Bengaluru and UAS, Dharwad.
- Dr. Venkataravanappa conducted the Ph. D. final viva voce of a student of Plant Pathology, UAS, Dharwad.
- Dr. M. S. Rao acted as external Examiner for Ph.D. Thesis Evaluation from Gurunanak Dev University, Amritsar.
- Dr. V. Sridhar acted as external Examiner for M. Sc. (Ag. Entomology) thesis evaluation from Agricultural College and Research Institute, Madurai (TNAU).
- Dr. R. Umamaheswari acted as external Examiner for M. Sc. (Ag. Nematology) thesis evaluation from Tamil Nadu Agricultural University, Coimbatore.
- Dr. P. V. Rami Reddy acted as external Examiner for M. Sc. (Horticulture) thesis evaluation from Dr. YSR Horticultural University, Venkataramanna gudem, AP.
- Dr. C. Aswath conducted the final viva voce for Ph.D. (Applied Botany) students of Mangalore University and HC & RI, Coimbatore.

- Dr. Rajiv Kumar conducted the final viva voce for M. Sc. (Floriculture and land scape) students of Horticulture College, Dr. Y.S.R. Horticultural University, Venkataramagudem and Kerala Agricultural University, College of Horticulture, Vellanikkara, Kerala.
- Dr. M. Sankaran acted as external examiner for M. Sc. (Fruit Science) Thesis evaluation from College of Horticulture, Dr. YSRHU, Anantharajupet, Andhra Pradesh.
- Dr. C. Vasugi acted as external examiner for M. Sc. Thesis on “Evaluation of Jackfruit (*Artocarpus heterophyllus* Lam.) local genotypes under coffee ecosystem of lower pulney hills” by Chandrashekar K. G, Department of Horticulture, TNAU, Coimbatore.
- Dr. C. Vasugi acted as external examiner for conducting thesis viva voce examination for evaluating M.Sc. thesis entitled “Studies on mutation and poly-ploidization in acid lime (*Citrus aurantifolia* Swingle)” by Lokesh Bora, Department of Agri. (Hort) TNAU, Coimbatore.
- Dr. B. L. Manjunath acted as external examiner for evaluation Ph. D. thesis on “Growth yield quality and profitability of wheat (*Triticum aestivum* L.) from the Department of Agronomy, IGKV, Raipur, Chattisgarh and M. Sc. (Agri.) thesis evaluation from U.A.S, Raichur, Karnataka.
- Dr. P. E. Rajasekharan acted as Chairman for conducting the open defence of Anup Balan, thesis entitled ‘Evaluation of Palynology and taxonomy of India endemic taxa of leguminosae’ at the Department of Botany Sir Syed College.
- Dr. P. E. Rajasekharan acted as Chairman for conducting the open defence of Brinda chander, thesis entitled ‘Evaluation of Extraction, isolation and characterization of lead molecules from plant extracts against ndm-1 producing *Escherichia coli*’, SRM University, Kattankulathur.
- Dr. P. E. Rajasekharan acted as Chairman for conducting the open defence of Neethu RS, thesis entitled ‘Production purification and characterization of tannase from *Aspergillus* species in solid state and submerged fermentation’ Kerala University.
- Dr. P. E. Rajasekharan acted as Chairman for conducting the open defence of Aswani K, thesis entitled ‘Pollination ecology of selected taxa of Zingiberaceae’ Department of Botany, Calicut University.
- Dr. P. E. Rajasekharan acted as Chairman for conducting the open defence of Joemon Jacob on the thesis entitled "Seed storage and embryo cryopreservation studies in *Calamus hokerianus* Bees, *C.nagbetta* and *C.vattayila* three endemic rattan palms of peninsular India)", Department of Botany, Kannur University, Sir Syed College, Thalipparamba on 16 January 2018.
- Dr. P. E. Rajasekharan acted as the chairman for Board of Adjudicators facilitated the conduct of viva and open defence of Ms. Souravi K at Jain University, Jayanagar on the thesis entitled ‘Back from the Brink: Biotechnological Approaches for Integrated Conservation of *Madhuca insignis* (Radlk.) H.J. Lam.
- Dr. G. Selvakumar acted as external examiner for conducting thesis viva voce examination of Ph. D. student from Dept. of Microbiology, TNAU, Coimbatore.
- Dr. D. Sreenivasa Murthy acted as external examiner for Ph. D. (Agricultural Economics) thesis evaluation and conducted the final viva voce of a student from UAS, Raichur.
- Dr. R. Venugoplan acted as external examiner for Ph. D. (Biostatistics) thesis evaluation from NIMHANS, Bangalore.
- Dr. R. Venkattakumar conducted the final viva-voce for Ph.D. thesis on “A multidimensional study on dairy entrepreneurship among youth in Telangana state" by Mr Raghavendra D.V of UAS, Raichur.
- Dr. R. Venkattakumar conducted the final viva voce for Ph. D. students of National Dairy Institute (NDRI), Deemed University.
- Dr. B. Narayanaswamy conducted the viva voce for Ph. D. student of PJAUT, Hyderabad.
- Dr. G. C. Acharya acted as external examiner for conducting thesis viva voce examination of M.Sc. students from the Department of Fruit Science and HT.
- Dr. J. B Mythili acted as an external examiner for conducting thesis viva voce examination of Ph. D. student from Department of Bio-Technology, Kukatpally Campus, JNT University, Hyderabad.
- Dr. R. H. Laxman acted as external examiner for M.Sc. student (Crop Physiology) thesis evaluation from UAS, Dharwad.
- Dr. D.V. Sudhakar Rao, acted as external examiner for conducting the qualifying viva voce examination of three M.Sc. students Dr. Y.S.R. Horticultural University, Venkataramanna-gudem, West Godavari, A.P.

- Dr. A. Carolin Rathinakumari served as External examiner and evaluated the M.Tech. thesis entitled “Investigation on energy requirement for chopping of selected agricultural biomass in relation to particle size” of Mr. T. Naveen Kumar, UAS, Raichur.
- Dr. H. S. Yogeasha acted as external examiner to conduct the final viva-voce examination of Mr. Kotesh Lamini, Ph.D. student in Seed Science and Technology from UAS, Dharwad.

6.2 Training and capacity building of ICAR-IIHR staff (HRD)

The following is the list of trainings attended by staff of ICAR-IIHR during the year 2017-18.

Category	Total number of employees	Total number of employees undergone training
Scientist	139	14
Technical	139	23
Administrative & Finance	57	10
SSS	101	6
Total	436	53

- Dr. P. D. Kamala Jayanthi participated in the training on “Isolation and identification of semiochemical cues involved in insect-plant interactions, a case study with invasive species *Lycorma delicatula*” under Fulbright-Nehru Fellowship for Professional and Academic Excellence Chemical Ecology Laboratory, Penn State University, State College, Pennsylvania, USA from September 28, 2017 to January 28, 2018.
- Dr. M. Sankaran participated in the training programme on “Devanahalli Pummelo” held on August 30, 2017.
- Dr. M. Sankaran participated in the training programme on “Genetic resource management of mango” organized by COH, Mysore from December 4-24, 2017.
- Dr. C. Vasugi participated in the training programme on “Exploitation and conservation of plant genetic resources in major, minor and under exploited fruits” at COH, Mysore from December 4-24, 2017.
- Dr. P. C. Tripathi attended training programme on “Policy for science and science for policies” at

National institute of advance studies, IISc Campus, Bangalore from January 1-5, 2018.

- Dr. Soudamini Mohapatra participated in the training cum certification on “Global Gap” organized by Karnataka state Mango Development and Marketing Corp Ltd, Bangalore held on December 28, 2017.
- Dr. C. K. Narayana attended training programme on “Improvement on Crop Management Practice in Banana and Papaya” by Managers of Coramandal International Ltd at ICAR-IIHR held on June 07, 2017.
- R. Venkattakumar Participated in training programme “The International Partnership Convention under Food for the Future India Triangular Training” (FTF ITT) for Point of Contacts (POCs) of Partner Countries from Asia and Africa and Partner Institutions in India” at MANAGE, Hyderabad from June 28 to July 01, 2017.
- Dr. T. R. Rupa attended Training Program on “Experimental designs and statistical Data analysis” held at ICAR-IASRI, New Delhi from September 11-20, 2017.
- Dr. T. K. Radha attended training program on “Developing winning research proposals in agricultural Research” held at Hyderabad from August 1-5, 2017.
- Dr. D. Kalaivanan participated in the training cum certification course on “Radiation safety aspects of gamma irradiation chamber (Category –I Irradiator)” at BARC, Mumbai, India from January 08–16, 2018.
- Dr. Leela Sahijram participated in the training “Expert, evaluation of biotechnology project for SBIRI-BIRAC”, DBT, Govt. of India, New Delhi.
- Dr. M. Senthil Kumar, Scientist attended 21 days ICAR sponsored winter school on “Sustainable organic production practices -an approach to mitigate climate change and rural livelihood security” at GKVK, UAS, Bengaluru from Dec 01-21, 2017.

6.2.2 Training imparted to short term students at ICAR-IIHR

Short term training was provided to students for their curriculum as listed below:

- Two B.Sc (Biotechnology) students from UAS, Hassan completed their short term project work.
- One M.Sc student from the Department of Biotechnology Mount Carmel College, completed short term project work.

- One M.Sc student from Hindusthan College of Arts and Science, Coimbatore completed short term project.
- One M.Sc (Biotechnology) student from Graphic Era University, Dehradun completed short term project.

6.4 ARS Probationers who underwent professional attachment training at IIHR

Name of the Scientist	Name of the Parent Institute	Name of the Guide
Mr. Y. Ravi, ARS Scientist	ICAR- National Research Center on Seed Spices, Ajmer	Dr. R Veere Gowda
Mr. Vidya Sagar, ARS Scientist	ICAR-IIVR, Varanasi	Dr. M. Pitchaimuthu

7. Awards and Recognitions

7.1 Awards

- ICAR-AICRP on Fruits with its headquarters at ICAR-IIHR received Chaudhary Devi Lal Outstanding All India Coordinated Research Project Award 2016 on ICAR Foundation Day 2017. Dr. Prakash Patil, Project Coordinator, received the award from the Hon'ble Minister of Agriculture and Farmers Welfare, Shri. Radha Mohan Singh at National Agriculture Science Complex (NASC) on 16th July 2017. This award is in recognition of outstanding performance of the ICAR-AICRP on Fruits and its cooperating centers for its output and its impact.



Dr. Prakash Patil receiving the award from the Hon'ble Minister of Agriculture and Farmers Welfare, Shri. Radha Mohan Singh

- Dr. A.T. Sadashiva, Principal Scientist & Head, Division of Vegetable Crops, was conferred with “Dr. M.H. Marigowda National Endowment Award 2016” for the Best Horticultural Research by UAS, Bengaluru. The award was conferred by Shri Siddaramaiah, Hon’ble Chief Minister of Karnataka on November 2017 during Krishi mela 2017 held at UAS, GKVK, Bengaluru.
- Dr. B. Hanumanthegowda, Subject Matter Specialist (Plant Protection) received “Dr. R. Dwarakinath Best Extension Worker Award conferred for outstanding contribution in the field of Agril Extension by UAS, Bangalore. Award was conferred by Shri Siddaramaiah, Hon’ble Chief Minister of Karnataka on November 2017 during Krishi mela 2017 held at UAS, GKVK, Bengaluru.



Dr. A.T. Sadashiva & Dr. B. Hanumanthe Gowda receiving Dr. M.H. Marigowda National Endowment 2016 and Dr. R. Dwarakinath Best Extension Worker Awards

- Dr. A.N. Ganeshamurthy, Dr. T.R. Rupa, Dr. D. Kalaivanan, Dr. H.B. Raghupathi, Dr. G.C. Satisha, Dr. Srinivasa Rao and Dr. Mahendra Kumar were conferred with “Dhiru Morarji Memorial Award” for Best Article in Agricultural Sciences 2016-17 on 5th December 2017 for the article entitled ‘Fertiliser management practices for horticultural crops’ issue of Indian Fertilisers by the Fertiliser Association of India (FAI) published in November, 2016.



Dr. T.R. Rupa receiving the Dhiru Morarji Memorial Award

- Dr. P.C. Tripathi received the “Meritorious service medal” from International Society of Horticultural science, Belgium during September 2017.
- Dr K. Madhavi Reddy received “Dwarika Nath Memorial Gold Medal – 2014” conferred by Indian Society of Vegetable Science, Varanasi to Mr P. Naresh for best Ph. D thesis entitled ‘Genetic and molecular analysis for resistance to viruses (cucumber mosaic virus and chilli veinal mottle virus), drought tolerance and fruit quality traits in chilli (*Capsicum annum* L.) under the supervision of Dr. K. Madhavi Reddy during June 2017.
- Dr. A. Bairwa, Dr. E. P. Venkatasalam, Dr. R. Uma Maheswari, Dr. R. Sudha and Dr. B. P. Singh received the “All India Best Publication Award 2017 for the paper on “Effect of cultural practices on potato cyst

nematode population dynamics and potato tuber yield” published in Indian Journal of Horticulture.

- Dr. P. D. Kamala Jayanthi was awarded “Fulbright-Nehru Academic and Professional Excellence Fellowship (Research)” for the year 2017-18 by J. William Fulbright Foreign Scholarship Board (FFSB), Washington, D.C. to carry out Semiochemical work at PennState University, USA.
- Dr. Saju George received the “Young Scientist Award” from Society of Krishi Vigyan and Association of Aqua culturists ICAR-CIFA during the National Seminar on 1st National Conference on Improving Income of Farmers through Agriculture through Development Interventions during December 2017, held at CIFA, Bhubaneswar.
- Dr. V. Sridhar received “The Best Scientist award” in the 3rd South Asian Education, Awards-18 in EET-CRS presented in Hyderabad, on March 2018.
- Dr. V. Sridhar was conferred with AZRA Fellowship award for the year 2018 for outstanding research contributions in the field of IPM in ornamentals and vegetable crops at BHU, Varanasi, Feb 10, 2018.
- Dr. V. Venkataravanappa received the “Scientist of the Year Award-2017” in the category of Agriculture in the “5th International Conference on Agriculture, Horticulture and Plant Science” in June-2017 held at Rishikesh, Uttarakhand, India.
- Dr. H. P. Sumangala was conferred with “Award for Excellence in Floriculture, Extension and promotion of Green Living concepts” by Indian Flower & Plant Industry Excellence Awards 2018, by Media Today Group during Flora Expo 2018, held at Pune, February 23, 2018.
- Dr. B. Hanumanthe Gowda, Matter Specialist (Plant Protection) received “Best KVK Scientist Award” conferred By Indian Society of Extension Education for outstanding contribution in the field of Agril. Extension, during ISEE National Seminar, BAU, Bhagalpur, Bihar, 2017.
- Dr. G.C. Acharya was conferred with Krushak Bandhu Award felicitated by Orissa Krushak Samaj
- Dr. G Karunakaran was awarded the H.S. Mehta Memorial Best Young Scientist Award-2017 by Mehta Foundation, Salem, organized by Lt. Amit Singh Memorial Foundation, CHAI, New Delhi and JAU, Junagarh, Gujarat on 28th May, 2017.

7.2 Best Paper/ Poster/ Presentation Awards

- Different sources of potassium and their method of application influences growth, yield and quality of Grapes Seedless (*Vitis vinifera* L.) by C.V. Sharad Y. Pushpavathi, J. Satisha, K.S. Shivashankara, G.C. Satisha, Sunita Patil and S. Sriram - Best poster presentation in the paper International Symposium of Horticulture Priorities and emerging trends, held at IISc Campus, Bengaluru, September 5-8, 2017.
- Study on pollen morphology and germination of Liliium (*Lilium Longoflorum*) by C.V. Pavia authored by Bhandari, N. S. Thaneshwari and C. Aswath - Best ISHS oral presentation award in the "International Symposium on Horticulture Priorities and emerging trends" held at IISc Campus, Bengaluru, September 5-8, 2017.
- Commercial multiplication of gerbera from young capitulum explants by R. Rashmi, C. Aswath and M. V. Dhananjaya - Best oral presentation award in the International Symposium on Horticulture Priorities and Emerging Trends, held at IISc Campus, Bengaluru, September 5-8, 2017.
- Impact of training programmes on adoption of mushroom production technology by T.M. Reddy, K. Achala Paripurna, G.A. Atheequalla and R. Venkattakumar- Best E-poster award in the International Symposium on Horticulture Priorities and Emerging Trends, held at IISc Campus, Bengaluru, September 5-8, 2017.
- Identification of stable source of resistance to chilli leaf curl virus through challenge inoculation with whitefly (*Bemisia tabaci*) by Rajeev Kumar Yadav, M. Krishna Reddy, K V Ashwathappa, Manish Kumar and K. Madhavi Reddy - Best Poster Award in the International Symposium on Horticulture: Priorities and Emerging Trends, held at IISc Campus, Bengaluru, September 5-8, 2017.
- Automatic portray conveying and dibbling unit for vegetable nursery by A. Carolin Rathinakumari - First Prize in National Conference on New Vistas in Vegetable Research towards Nutritional Security under Changing Climate Scenario, held at Tamil Nadu Agricultural University, December 6-9, 2017.
- Disease dynamics and mitigation of anthracnose in mango in view of climate change by A. K. Saxena, R. Thilaka Rani and K. Rathnamma - Best paper presentation in National Conference on Rural Resources Management for Climate

Smart Sustainable Agriculture, held at Barapani, Meghalaya, September 11-13, 2017.

- Identification of alternate fungicides for the management of carbendazim resistance in *Fusarium* species causing wilt in gladiolus and marigold by M. K. Kumawat, N. K. Chandran, S. Sriram - Best poster award in National Symposium on Emerging trends in plant health management in relation to climate change, organized by Indian Phytopathological Society, held at College of Horticulture, Bengaluru campus, UHS (Bagalkot) during September 12-13, 2017.
- Varietal improvement in pomegranate—Approaches, challenges and accomplishments by Murthy, B. N. S. and Chandrakant M. Awachare - Best oral presentation award at 2nd National Seminar – Cum – Farmer’s Fair- Pomegranate for Health, Growth and Prosperity, held at ICAR-NRCP, Solapur, April 28-30, 2017.

7.3. Recognition

7.3.1. Professional Societies

- A. K. Saxena acted as Associate Editors for the Journal of Horticultural Sciences published by Society of Promotion of Horticulture, ICAR- IIHR, Bengaluru. A.T. Sadashiva was conferred with Fellowship of National Academy of Agricultural Sciences (NAAS), New Delhi
- A.T. Sadashiva was nominated as Member, Editorial Committee of the Vegetable Science, Indian Society of Vegetable Science, ICAR-IIVR, Varanasi
- B.L.Manjunath, acted as Member of the Editorial Board of Agricultural Science Digest.
- B.L.Manjunatha, acted as Member of the Editorial Board of Journal of Horticultural Sciences.
- B.Varalakshmi was elected as Joint Secretary of the Society for the Promotion of Horticulture.
- B.Varalakshmi was nominated as Editor of the Journal of Horticultural Sciences, of Society for the Promotion of Horticulture (SPH), ICAR-IIHR, Bengaluru.
- B.Varalakshmi was nominated as reviewer of the Indian Journal of Horticulture, HSI, New Delhi.
- Aghora T S was nominated as Associate Editor of the Journal of Horticultural Sciences, of Society for the Promotion of Horticulture (SPH), ICAR-IIHR, Bengaluru
- Aghora T S was nominated as Executive Council member of Society for the Promotion of Horticulture (SPH), ICAR-IIHR, Bengaluru
- C. Aswath acted as member of Editorial Board of a scientific Bulletin of SNBG National Scientific Center of the RAS, Russia.
- C. Aswath was nominated as Fellow of International Society for Noni Science, Chennai, for the year 2018.
- Debi Sharma, was elected as Vice-President, Association for Pest Management in Horticultural Ecosystem, Bangalore.
- D.V. Sudhakar Rao served as Associate Editor for the Journal of Horticultural Sciences, Society for Promotion of Horticulture, IIHR, Bengaluru.
- E. Sreenivasa Rao selected as Associate editor of Journal of Horticultural Sciences published by Society of Promotion of horticulture
- G. Selvakumar, served as Editor of the Journal of Horticultural Sciences (SPH, Bengaluru).
- H.P. Sumangala acted as Editor of Indian Society of Ornamental Horticulture, New Delhi.
- K. Hima Bindu acted as Associate Editor in the Editorial Board of the Journal of Horticultural Sciences, Bangalore.
- K. Hima Bindu acted as member in the Editorial board of Journal of Medicinal Plants.
- Leela Sahijram was elected as Representative of India on ISHS Council (International Society for Horticultural Science), Leuven, Belgium
- M. Krishna Reddy was elected as Fellow of Indian Virological Society, New Delhi.
- M. Krishna Reddy was elected as President, Association for Pest Management in Horticultural Ecosystem, Bangalore.
- M.R Dinesh, C. Aswath, P.C. Tirupati and T.S Aghora was recognized as conveners of "International Symposium on Horticulture: Priorities and Emerging Trends" held during September 5-8, 2017, Bengaluru by International Society of Horticulture Science (ISHS), Belgium.
- P.C. Tripathi nominated as Member of Editorial Board of Progressive Horticulture. HETC, Chaubattia, Uttarakhand R. Venugoplan was

recognized as an Editor, Journal of Horticultural Sciences, ICAR-IIHR, Bangalore. Rajiv Kumar acted as member in Editorial board of the journal Current Horticulture

- S. Sriram acted as member of Editorial committee, Journal Mycology and Plant Pathology, Udayapur
- S. Sriram served as Associate Editor, Pest Management in Horticultural Ecosystem
- Sujatha A. Nair acted as Associate Editor in the Editorial Board of the Journal of Horticultural Sciences.
- T. M. Gajanana was selected as a Member of the Editorial Board, Indian Society of Agricultural Marketing, Hyderabad.
- V. Venkataravanappa acted as Member in Editorial Boards of the Journal Proceedings of the National Academy of Sciences India Section B: Biological Sciences and Archives of phytopathology and Plant Protection.
- Vageeshbabu S. Hanur acted as Editor of Journal of Horticultural Sciences, International Journal of Life Sciences and Bioinfo Publications.
- Veere Gowda was nominated as Editorial Board Member of ARCC Journals, HAU, Karnal, Haryana.

7.3.2 Membership in Institute Management Committee/ others

- A. K. Saxena was recognized as Member, Editorial board of ICAR-IIHR, magazine 'Bagwani'
- A.T. Sadashiva has been nominated as Member of IMC of NIANP, Bengaluru.
- B. Varalakshmi has been nominated as member of the R&D Recognition Committee of Institute for Evergreen Bioscience Pvt. Ltd during the year 2017-18.
- C. Aswath acted as external expert member for selection of Assistant and Associate Professors the Department of Horticulture, MPKV, Rahuri, March 26-27, 2018.
- C. Aswath acted as external member for Board of Studies on January 31, 2018, of the Department of Life Sciences, Christ College, Bengaluru.
- C. Aswath nominated as a member in the selection committee for the post of Scientist, Central Silk Board, CSB Complex, B.T.M. Layout, Madiwala,

Bengaluru, on January 2018. C. Aswath served as a member of eminent Jury Panel on August 7- 8, 2017, KBITS. Govt. of Karnataka.

- C. Aswath served as a member of eminent Jury Panel on August 7-8, 2017, KBITS, Govt. of Karnataka.
- C. Aswath served as an expert member on the screening-cum evaluation and selection committee meeting for promotion and placement of teachers under Career Advancement scheme-2006 from June 14, 2017 to June 16, 2017, at UAS, GKVK, Bengaluru.
- C.K. Narayana served as Chief Guest for National Science Day programme of Nisarga Vidyanikethan, Hessarghatta Road, Bengaluru.
- C.K. Narayana was nominated by AGM & Governing Body, ICAR, as Regional Coordinator (South) of ICAR-National Agricultural Education Accreditation Board for a period of three years from 2017-2020.
- C.K. Narayana served as Judge for Evaluation of Best Poster during 'National Conference on Horticultural of Humid Tropics: Diversification for Sustainability', on May 20, 2017 at Madikere.
- Debi Sharma was nominated as member of 45th Scientific Advisory Committee (SAC) of ICMR-National institute of Occupational Health, Ahmedabad.
- D.V. Sudhakar Rao has served as member of RAC of ICAR-DOGR, Rajgurunagar, Pune.
- D.V. Sudhakar Rao was nominated by ASRB as member (Outside expert-Post Harvest Technology) for the DPC of scientist of DOGR.
- E. Sreenivasa Rao is Member of Institute Management Committee of ICAR-DOGR.
- G.C. Acharya acted as a member of the State level Agricultural Exhibition and Krushak Patshala "Krusha Odisha-2018" being organized by Agriculture and Farmers Empowerment Department, Govt of Odisha
- G.C. Acharya nominated as member of the Onion Seed Verification under Directorate of Horticulture, Govt of Odisha at Maharashtra and Bhubaneswar under NSC and NHRDF
- G.C. Acharya nominated by Dept. of Agriculture and Farmers Welfare, Govt of Odisha as a member of State Level Monitoring Committee for

- implementation of the CDB schemes for year 2017-18.
- H. Yogeehsa acted as member of the Selection Committee for the faculty positions in "Seed Science and Technology" held in August 18, 2017 at University of Agricultural Sciences, Raichur
 - H.P. Sumangala acted as External advisor for Government of Andhra Pradesh, AP Urban Greening and Beautification Cooperation Limited, under the domain of urban biodiversity/ native ornamental flora from Feb 11, 2017 to Feb 10, 2019.
 - H.P. Sumangala acted as judge the exhibits during Independence Day and Republic Day Horticultural show held at Lal Bagh, Bengaluru.
 - H.P. Sumangala was recognized as a Panelist in the panel discussion on Commercial floriculture Industry during Indian Flower & Plant Industry Excellence Awards 2018, at Orchid Hotel Pune.
 - H.S. Oberoi was appointed as a panelist for Post Harvest Technology session during the Stakeholders Consultation Meeting on Science, Technology & Innovation in Agriculture on September 01, 2017, organized jointly by ASSOCHAM and DST at MNIT, Jaipur.
 - H.S. Oberoi has been appointed as a Member of IMC of ICAR-CIPHET, Ludhiana for three years (2017-2020).
 - J. B. Mythili nominated as DPC member (outside expert- Biotechnology) ICAR- DOGR, Pune for scientist placement/ promotion to next higher research grade under revised CAS.
 - K. Hima Bindu acted as expert member (Plant Breeding) in selection committee for Central Silk Board, Bangalore.
 - K. Hima Bindu acted as member in National Organizing Committee of National conference on Conservation and Utilization of Medicinal and Aromatic Crops, COH, Mudigere, UAHS, Shimoga.
 - K. S. Shivashankara was nominated as a subject matter expert for the DPC of ARS scientist at SBI, Coimbatore
 - S.K. Shivashankara was nominated as Chairman for the DPC of technicians at NRC Banana, Trichi.
 - S.K. Shivashankara was nominated to Institute Management Committee of CISH, Lucknow
 - Leela Sahijram served as Expert, Subject-specialist, Biotechnology, Institute of Wood Science & Technology (IWST), Bangalore (under ICFRE, Dehra Dun).
 - Leela Sahijram served as External Expert for the Institute of Wood Science & Technology, Bengaluru, for recruitment to SRF positions and as external subject-matter expert, evaluation of completed projects.
 - Leela Sahijram was appointed as Advisory Member of National Symposium on Recent Advances in Floriculture and Urban Horticulture in Global Perspective, Jan 4-5, 2018, BCKV, Mohanpur, Nadia, WB.
 - Leela Sahijram was nominated as a Member for Research Advisory Committee, Institute of Wood Science & Technology Bangalore.
 - M.A. Suryanarayana acted as an expert for reviewing research projects of PSMA of UHS, Bagalkot on March 5-6, 2018.
 - Mohapatra, S. acted as External Member, Technical Evaluation Committee for evaluating the Technical bids for procurement of LC-MS and GC-system by ICAR-Indian Institute of Spices Research, Kozhikode.
 - Mohapatra, S. acted as member of the Technical Sub-committee constituted by Karnataka State Mango Development and Marketing Corp Ltd.
 - P. D. Kamala Jayanthi Served as Member for Plant Protection Committee on Doubling Farmers Income constituted by the Dept of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Govt. of India.
 - P. D. Kamala Jayanthi was conferred with Fellowship of National Academy of Agricultural Sciences (NAAS), New Delhi.
 - P.C. Tripathi acted as Expert for the Brain storming session for Finalization of Production and Post Harvest Trials of AINPO&G, July 21, 2017, DOGR, Rajgurunagar Pune.
 - P.C. Tripathi acted as judge for Poster session of National Conference on Horticultural Crops of Humid Tropics - Diversification for Sustainability May 20-21, 2017 at Madikeri,
 - P.C. Tripathi acted as panelist of Session –I of National Workshop on Doubling the Income of Mango Growers in India, May 18-19, 2017, ICAR-

IIHR, Bangalore.

- Pious Thomas was conferred Fellow of the International Society for Noni Sciences, Chennai.
- S. Sriram acted as IMC member of NRC for Banana, Trichy, Tamil Nadu.
- S. Sriram acted as IMC member of NRC for Pomegranate, Sholapur, Maharashtra.
- S. Sriram acted as member of Editorial committee, Journal Mycology and Plant Pathology, Udayapur.
- S. Sriram served as Associate Editor, Pest Management in Horticultural Ecosystem.
- Sudha Mysore has been nominated as member of the panel deliberating the Innovators meet at CTCRI, Bhubaneswar Centre, November 16-18, 2017.
- Sudha Mysore has been nominated as member of the panel deliberating the review of National Science, Technology Innovation Policy, 2017 on December 2017 at IIT Delhi.
- Sudha Mysore has been recognised as a 'Member of Expert Advisory Group' constituted by DST's Technology Development & Transfer (TDT) division for a period of five years to assist and mentor universities in forming technology enabling centres, w.e.f January 2018.
- Sudha Mysore was nominated by DG, ICAR as a member of the panel deliberating the review of National Science, Technology Innovation Policy, 2017 on November 2017 at NIAS, Bangalore.
- T. Manjunatha Rao served as judge to the exhibits during Independence Day and Republic Day Horticultural show held at Lal Bagh, Bengaluru.
- V. Ravindra was nominated as Chairman, Assessment committee in December 2017 for

ICAR technical personal at Indian Institute of Oil Palm Research Pedavegi, A.P.

- V. Sridhar was nominated as Entomology expert for conducting interviews for the posts of Scientists B in the Central Silk Board on Jan 11th 2018.
- Veere Gowda was nominated as Editorial Board Member of ARCC Journals, HAU, Karnal, Haryana.
- Venkattakumar appointed as member in the 9th Scientific Advisory Committee meeting on December 13, 2017, at KVK, Doddaballapur.
- E. Sreenivasa Rao is Member of Scientific advisory committee of NHRDF from 2015-2017.
- P.E. Rajasekharan acted as Chairman for Prof. M. Sabu award oral presentations, 10th to 13 November 2017, IAAT symposium at New Delhi, Elected as councillor of IAAT for the next 3 years from 2018.
- P.E. Rajasekharan acted as Chairman for Selective Augmentation of Research and Development of Kerala State Council for Science Technology and Environment, Sastra Bhavan, Pattom, Kerala
- P.E. Rajasekharan acted as Member Expert Committee on Access and Benefit Sharing of Karnataka Biodiversity Board, Bangalore.
- P.E. Rajasekharan chaired the SARD review meeting held at Sastra Bhavan, Pattom, Thiruvananthapuram.
- G. Senthil Kumaran served as member, FAD-20, BIS, New Delhi.
- G. Senthil Kumaran served as member, Institute Management Committee of ICAR-Central Institute of Agricultural Engineering, Bhopal.

The Institute has collaborative research and development linkages with several national (DST, DBT, NABARD, NASF, NMPB etc.) and international (IITA, Bioversity International etc.) organisations and universities. Gaps identified in the ongoing research projects of the institute are taken up through externally aided collaborative research projects on a pre-determined time scale. Research in the frontier areas such as climate resilient agriculture, transgenic crops, insect biosystematics, biocontrol strategies for disease

management and pesticide residues were undertaken as network or Outreach programs. The Scientists regularly contribute to the publication of package of practices of various horticultural crops published by SAU's. Scientist of the Institute actively collaborate with the State Departments of Horticulture and Agriculture (Karnataka) in implementation of centrally aided schemes like RKVY, NHM, CHD, etc. Following are the externally aided projects under operation at the Institute.

8.1 Foreign Collaborative Projects

Title of the project	Principal Investigator	Funding agency
Studies on certain ecosystem services in multivarietal orchards of mango	Ganeshamurthy, A.N.	Bioversity International
Enhancing the banana production through developing <i>Fusarium</i> wilt resistant varieties and benefit sharing with small holder farmers of Africa [Indian Component-Breeding for improved bananas with <i>Fusarium</i> wilt (<i>Fusarium oxysporum fsp cubense</i>) resistance]	Rekha, A.	IITA (International Institute of Tropical and Agriculture, Nigeria)

8.2 National Fellow Project

Title of the project	Principal Investigator	Funding agency
Studies on phyto-semiochemicals involved in insect-Plant interaction of major horticultural pests: Deciphering chemical cues	Kamala Jayanthi, P.D.	ICAR

8.3 National External Funded projects

Title of the projects	Principal Investigator	Funding agency
Development and Transfer of Technology from Queensland University of Technology, Australia to India for Bio-fortification and Disease Resistance in Banana. Sub Project: Transfer and evaluation of Indian banana with FoC construct	Usha Rani, T.R.	BIRAC (Biotechnology Industry Research Assistance Council, GoI enterprise)
Establishment of Horti-Bioincubator at ICAR-IIHR under Biones	Sudha Mysore	BIRAC
Monitoring of Pesticide Residues at National Level	Soudamini Mohapatra	CSS, Min. of Agriculture
Screening of RIL and BIL families of the cross <i>Citrullus Lanatus</i> var. <i>Citroides</i> X <i>C.lanatus</i> var. Arka Manik and mapping of resistance to watermelon bud necrosis virus	Sreenivasa Rao, E.	DBT
Marker assisted breeding to develop a bacterial wilt resistant chilli paprika variety (<i>Capsicum annum</i> L.) suited for the tropical regions of India	Madhavi Reddy, K	DBT

Introgression of begomovirus resistance genes in tomato (<i>Solanum lycopersicum</i> L.) using MAS and Genomic approach	Sadashiva, A.T.	DBT
Development of high throughput nano-biosensor for the detection of <i>Salmonella</i> spp. in food	Shamina Azeez	DBT
Identification and breeding of Tospovirus resistance in chillies (<i>Capsicum annum</i> L.) using molecular markers	Krishna Reddy, M.	DBT
Preventing Extinction and improving conservation status of threatened medicinal plants- <i>Madhuca insignis</i> through application of Biotechnological tools	Rajasekharan, P.E.	DBT
Development of nematode management strategies under protected as well as open field conditions and dissemination of the technology among rural women	Rao, M.S.	DBT
Identification and breeding of Tospovirus resistance in chillies (<i>Capsicum annum</i> L.) using molecular markers	Krishna Reddy, M.	DBT
Preventing Extinction and improving conservation status of threatened medicinal plants- <i>Madhuca insignis</i> through application of Biotechnological tools	Rajasekharan, P.E.	DBT
Development of nematode management strategies under protected as well as open field conditions and dissemination of the technology among rural women	Rao, M.S.	DBT
Ecology of thrips and Tospovirus interactions in tomato and watermelon pathosystems	Usharani, T.R.	DBT
Development of technology for enhancing egg laying in Vanya Silk moths by application of host plant volatiles	Kamala Jayanthi, P.D.	DBT
Exploring diversity, genomic and transcriptome profiling and phytosemiochemicals of banana pest complex in NER region – An ecological and molecular approach	Kamala Jayanthi, P.D.	DBT
Screening for resistance to Nematodes in traditional Banana Cultivars and wild species of Tripura and other NE Region	Rao, M.S.	DBT
Development of Pre & Postharvest bunch care management methods for fresh banana	Narayana, C.K.	DBT
Knocking-out the virus: Elimination of the endogenous Banana streak viral sequences from banana through genome editing with CRISPR-Cas9 system	Manamohan, M.	DBT
Screening of Banana germplasm from the NE for <i>Fusarium</i> wilt resistance and molecular characterization in contrasting genotypes	Ravishankar, K.V.	DBT
Capacity building of rural women for enhancing household income and nutrition through mushroom cultivation	Meera Pandey	DSIR
Morphogenetic characterization of native virulent <i>Phytophthora</i> isolates inciting vine rot and fruit rot of pointed gourd emerging in Odisha and devising IDM module in participatory mode	Sangeetha, G.	DST, Govt. of Odisha
Introgression of pungency genes from wild species through marker-assisted selection in chilli (<i>Capsicum annum</i> L.) – to breed suitable commercial pepper cultivation for industrial use	Madhavi Reddy, K.	DST-SERB
Identification and mapping of ToLCNDV resistance loci and introgression of resistance genes through molecular assisted selection in chilli (<i>Capsicum annum</i> L.)	Lakshmana Reddy, D.C.	DST-SERB

Undertaking the changes in host-pest interactions and dynamics in mango under climate change scenario	Kamala Jayanthi. P.D.	ICAR (NICRA)
National Initiative on Climate Resilient Agriculture (NICRA) for XI th Plan	Bhatt, R.M.	ICAR (NICRA)
National Initiative Climate Resilient Agricultural Technology Package at Village Level	Loganandhan, N.	ICAR (NICRA)
Genomics-mediated taxonomic and functional analysis of endophytic microbiome in horticultural crops and plant-microbe interaction studies	Pious Thomas	ICAR AMAAS
BIOCLAY – The novel LDH nanocarrier system in increasing the persistence of Bt toxins	Asokan, R.	ICAR AMAAS
All India Network Project (AINP) on Pesticide residue	Soudamini Mohapatra	ICAR
ICAR-NPTC - Functional genomics of plant type, maturity and fruit quality traits in Mango	Dinesh, M.R.	ICAR
Network Project on Transgenics in Crops (NPTC): Functional genomics: <i>Fusarium</i> wilt resistance and drought tolerance in Banana	Ravishankar, K.V.	ICAR
Network Project on Transgenics in Crops (NPTC) : Development of transgenic Banana Cv. Rasthali resistant to <i>Fusarium</i> wilt	Usha Rani, T.R.	ICAR
Micro/ <i>in vitro</i> propagation of underutilized vegetable crops and supply in the state of Odisha	Meenu Kumari	MIDH (NHM), Dir. of Hort., Govt. of Odisha
XII Plan Scheme “National Agriculture Innovation Fund (NAIF)”. Component-2: Establishment of Agri-Business Incubation (ABI) centres	Sudha Mysore	NAIF, ICAR
Policy imperatives for promoting value chains of agricultural commodities in India	Gajanana, T.M.	ICAR-NIAP
Diploma in Agricultural extension services for input dealers	Saju George	MANAGE through SAMETI, UAS
Promotion of Farmer Producer Organizations (FPOs) towards doubling farmers income	Saju George	NABARD
Molecular mapping and identification of candidate genes for anthracnose fruit rot disease resistance in chilli	Madhavi Reddy, K.	NASF
Enhancing decomposition rate and quality of bio-waste through microbial consortia for improving soil health	Ganeshamurthy, A.N.	NASF
Training on “Conservation and Cultivation of Medicinal Plants”	Smitha, G.R.	NMPB
Standardization of seed germination and seed storage protocols in endangered medicinal and aromatic plants	Yogeesha, H.S.	NMPB
Utilization of pomegranate for development of functional Medicinal ingredients	Debi Sharma	NMPB
Preparation for Plant variety Protection and DUS Testing through ICAR-SAU system and conduct of DUS test on Tomato, Brinjal, Okra and Garden Pea), Cucumber (<i>Cucumis sativus</i>), Bottle gourd (<i>Lagenaria sinceraria</i>), Bitter gourd (<i>Momordica charantia</i>), Pumpkin (<i>Cucurbita moschata</i>), Pointed gourd (<i>Trichosanthes dioca</i>), Watermelon and Muskmelon	Sadashiva, A.T. Singh, T.H. (Brinjal), Pitchaimuthu, M. (Okra & cucumber), Mohan, N. (Garden Pea), Varalakshmi, B. (Bitter gourd & Bottle gourd) & Sreenivas Rao, E. (Pumpkin, Watermelon and Muskmelon)	PPV & FRA

Development of guidelines for the conduct of test for Distinctiveness, Uniformity and Stability of Chilli, Sweet Pepper and Paprika (<i>Capsicum annuum</i> L.)	Madhavi Reddy, K.	PPV & FRA
Validating crop specific DUS testing guidelines for Amaranth, Palak and Ridge Gourd	Varalakshmi, B.	PPV & FRA
DUS testing centre on Mango	Dinesh, M.R.	PPV & FRA
DUS testing centre for Papaya and Custard apple	Vasugi, C.(Papaya) Sampat Kumar, P. (Custard apple)	PPV & FRA
Formulation and Validation of DUS Testing Guidelines for Betelvine (<i>Piper betle</i> L.)	Hima Bindu, K.	PPV & FRA
Establishment of Nodal DUS centre at IIHR, B'lore for Tuberose floriculture crop	Usha Bharathi	PPV & FRA
Establishment of DUS nodal centre at IIHR, Bangalore for China aster floricultural crop	Rajiv Kumar	PPV & FRA
Establishment of DUS nodal centre at IIHR, Bangalore for jasmine floricultural crop	Sujatha A. Nair	PPV & FRA
Establishment of National Repository of Rose at IIHR	Tejaswani	PPV & FRA
DUS centre for Ornamental Crops (Rose & Chrysanthemum)	Tejaswini	PPV & FRA
Validation of DUS testing guidelines for marigold	Tejaswini	PPV & FRA
Establishment of DUS nodal centre at IIHR, Bangalore for carnation floricultural crop	Dhananjaya, M.V.	PPV & FRA
Establishment of Referral Lab/accreditation to conduct special tests for plant variety protection in horticultural crops	Aswath, C.	PPV & FRA
Production of Quality Planting Material of Coorg Mandarin and Future Horticultural Crops through CHES, Chettalli	Senthil Kumar, R.	RKVY, GOK
Collaborative studies on hyperspectral response of horticultural plantations	Raghupathi, H.B	RRSC-South, NRSC, ISRO, Dept. of Space, GoI.
Incompatibility studies in tuberose (<i>Polianthes tuberosa</i> L.)	Usha Bharathi, T.	SERB, New Delhi

8.5 Linkages with other ICAR and Government Institutions

Strong linkages are established with various ICAR institutes like NBAIR, NIANP, IISR, NRRI, NRC for Banana, NRC for Pomegranate, Directorate of Onion and Garlic, etc. and other organisations like DST, DBT, IWST, PPV and FR authority, NHB, NASF, NSC, State Seed Corporations, State Departments of Agriculture, Horticulture, Water Shed, Water Resource etc., for taking up collaborative and joint research programmes like joint exploration for germplasm, exchange and testing of elite breeding lines, conduct of biotechnology research, developing DUS guidelines and conduct of training and awareness programmes. The Institute also extends laboratory facilities for analysis and testing of products, and shares parental lines on payment basis to various universities, states and national seeds corporations for further commercialization.

8.6 Linkages with private sector

The Institute has strong linkages with the private sectors particularly with seed companies and pesticide companies. Seed companies approach the Institute for exchange of seed materials/germplasm for research and purchase of potential parental lines for further commercialization. Pesticide companies take up evaluation of their new products for bio efficacy and residues through supervised field trials as paid-up trials. The Institute also extends laboratory facilities for analysis and testing of produce/products on payment basis to various stake holders including private firms.

9. Publications

9.1 Research Papers

1. Alfia MA, Vasugi C, Honnabyraiah MK, Adiga DJ, Shivapriya M and Vincent L. (2017). Phenological stages of wild species and cultivated species of guava (*Psidium guajava* L.). *Int. J. Pure App. Biosci.* **5**(6): 464-474.
2. Almansour B, Suryanarayana MA, Kalaivanan D, Umesha K and Vasundhara M. (2017). Effect of FYM, inorganic fertilizer and bio-fertilizers on growth, herb and oil yield and oil quality of basil (*Ocimum basilicum*). *Medicinal Plants.* **9**(4): 250-258.
3. Arthikirubha A, Jayanthi KPD, Sridhar V and Verghese A. (2017). Local host fruiting pattern and climate variations impact fruit fly *Bactrocera dorsalis* population trends. A regional fruit fly population tracker for management options. *Ind. J. Agril. Sci.* **87**(11): 1460-1465.
4. Arun MN, Bhanuprakash K, Hebbar SS and Senthivel T. (2017). Effects of seed priming on biochemical parameters and seed germination in cowpea [*Vigna unguiculata* (L.) Walp] *Legume Res.* **40**(3): 562-570.
5. Arun MN, Hebbar SS, Bhanuprakash K and Senthivel T. (2017). Seed priming improves irrigation water use efficiency, yield and yield components of summer cowpea under limited water conditions. *Legume Res.* **40**(5): 864-871.
6. Arunachalam T, Gorrepati KTP, Ahammed SR, Kavitha S, Banerjee K, Sankar V and Chavan KM. (2017). Comparison of organic and conventional farming for onion yield, biochemical quality, soil organic carbon, and microbial population. *Arch. Agron. Soil Sci.* **63**: 1-12.
7. Arunkumar B, Lingaiah HB, Singh TH, Venugopalan V and Jyothi K. (2017). Linex tester analysis for the study of combining ability in eggplant (*Solanum melongena* L.). *Environment and Ecology.* **35**(2B): 1136-1141.
8. Arutselvan R, Reddy KM and Makesh Kumar T. (2017). Rapid detection of tomato leaf curl Bengaluru virus through loop mediated isothermal amplification assay. *Virus Dis.* **28**: 303-308.
9. Asiya KR, Amarananjundeswara H, Aravinda Kumar JS, Doddabasappa B and Veere Gowda R. (2017). Performance of garlic (*Allium sativum* L.) genotypes for growth and yield traits under eastern Dry Zone of Karnataka. *Journal of Pharmacognosy and Phytochemistry.* SP1: 213-216.
10. Asma Naz, Umesha K, Smitha GR, Sreeramu BS and Gowda MAP. (2017). Influence of harvesting stages and drying methods on growth yield and quality of black night shade (*Solanum nigrum* L.). *Medicinal Plants.* **9**(3): 167-171.
11. Awachare CM, Kurian JM, Upreti KK and Laxman RH. (2018). Morpho-physiological diversity in Annona species. *Sci. Hort.* **234**: 58-62.
12. Babu RK, Sumangala HP, Rupa TR, Sangama and Nair SA. (2018). Effect of fertigation, irrigation and mulching on growth, flowering and yield parameters in African marigold. *Int. J. Curr. Microbiol. App. Sci.* **7**(3): 685-692.
13. Badiger M, Pitchaimuthu M and Rao GP. (2017) per se Performance, Correlation and Path Coefficient Analysis in Okra [*Abelmoschus esculentus* (L.) Moench]. *Trends in Biosciences.* **10**(18): 3314-3317.
14. Bairwa A, Venkatasalam EP, Umamaheswari R, Sudha R and Singh BP. (2017). Effect of cultural practices on potato cyst nematode population dynamics and potato tuber yield. *Ind. J. Hort.* **74**(1): 91-96.
15. Bhaganna H, Salimath PM, Aghora T S, Nagarajappa A and Guru Prasad S (2017). Genetic diversity analysis by D² Clustering of yield and yield attributing traits in french bean (*Phaseolus vulgaris*) *J. of Pharmacognosy and phytochemistry* **6**: 1331-1335.
16. Bhargav V, Kumar R, Rao MT, Bharathi UT, Dhananjaya MV and Kumari P. (2018). Characterization of China aster (*Callistephus chinensis*) genotypes by using DUS guidelines. *Ind. J. Agril. Sci.* **88**(1): 138-144.
17. Bhargav V, Kumar R, Rao MT, Bharathi UT, Dhananjaya MV, Kumar S, Babu RK and Kumari P. (2018). Evaluation of China aster [*Callistephus chinensis* (L.) Nees] F₁ hybrids and their parents for qualitative and quantitative traits. *Int. J. Curr. Microbiol. App. Sci.* **7**(2): 1654-1661.
18. Bhargava V, Kumar R, Shivashankara KS, Rao MT, Dhananjaya MV, Sane A, Bharathi UT, Venugopalan

- R, Roy TK. (2018). Diversity of flavonoids profile in China aster [*Callistephus chinensis* (L.) Nees.] Genotypes. *Industrial Crops & Products*. **111**: 513–519.
19. Bhat PS, Saroja S, Rajendra Prasad BS, and Ranganath HR. (2017). Efficacy of newer molecules in the management of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) an invasive pest on tomato (*Lycopersicon esculentum* Miller). *Pest Manag. Hort. Ecosyst.* **23** (2):59-62.
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- ## 9.5 Technical Bulletins/ Folders
- ### 9.5.1 Technical Bulletins/ Books
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- ### 9.5.2 Extension folder
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 5. Sadashiva AT, Shankara Hebbar, Anil K Nair, Krishna Reddy M, Madhavi Reddy K, Singh TH, Sridhar V, Senthil Kumar M and Nage Gowda NS (2018). Arka Rakshak and Arka Samrat: High yielding tomato F₁ hybrids with triple disease resistance to Tomato Leaf curl Virus + Bacterial Wilt + Early blight. Extension Folder No. 101 (English, Kannada & Hindi), Published by ICAR-IIHR, Bengaluru, pp. 4.
 6. Saju George, Prabhakara B, Veerendra Kumar KV (2017). Brochure on Seven points towards doubling the farmers income (Kannada)
 7. Sudha Mysore (2018) Technology Commercialization - way forward. Technology Brochure, ICAR- IIHR, Bengaluru.
 8. Sudha Mysore, Gajanana, D Sreenivasa Murthy & V Dakshinamoorthy (2017), Prajwal brings smiles to millions, Folder (English, Kannada and Hindi)
 9. Suresh, S.C. and Saju George (2017) Extension

Folder on Scientific Rabbit Farming.

10. Suresh, S.C. and Saju George (2017) Extension Folder on Scientific Dairy Farming
11. Sudha Mysore (2018) Technology commercialization, success stories, folder (Kannada, Hindi & English)

9.6 Patents granted

Patent was granted (No. 292394) for the invention Invert Emulsion formulation of *Trichoderma harzianum* (Patent application number 3603/CHE/2010). Innovator: Sriram, S.

10. Research Projects

List of Ongoing Institute Projects (2017-18)

Division of Fruit Crops

HORTIHCIL2015 (Common for all the Projects)

010: Genetic improvement of fruit crops for improved productivity, quality and resistance to biotic and abiotic stresses. Project Leader: Rekha, A.

Sub-Projects

- 010 (1):** Collection and evaluation of mango germplasm and hybrids. PI: Dinesh, M.R.
- 010 (2):** Breeding Jamun and sapota for dwarf tree stature with higher productivity. PI: Rekha, A.
- 010 (5):** Breeding papaya for PRSV tolerance. PI: Vasugi, C.
- 010 (6):** Incorporation of bacterial blight resistance in pomegranate. PI: Anuradha Sane
- 010 (8):** Improvement of guava for yield and quality. PI: Vasugi, C.
- 010 (9):** Rootstock and mildew resistance breeding in grapes. PI: Linta Vincent
- 010 (10-H) Radiation Induced Mutation Breeding in / 010(10):** Papaya (*Carica papaya* L.). PI: Karunakaran, G.
- 010 (11):** Improvement of annona for yield and quality. PI: Sakthivel, T.
- 010 (12):** Improvement of pummelo and grape fruit for yield and quality. PI: Sankaran, M.
- 010(13-H)/ 010(13):** Characterization of jackfruit accessions for vegetable and table purposes. PI: Karunakaran, G.

011: Development and refinement of production technology of fruit crops. Project Leader: Reju M. Kurian

Sub-Projects

- 011 (1):** Canopy management and crop regulation in fruit crops (Grapes, annona and pomegranate). PI: Satisha, J.
- 011 (2):** Enhancing productivity through high density

planting (Guava, jamun, pomegranate and fig). PI: Sampathkumar, P.

- 011 (3):** Exploitation of stock-scion interactions (Mango, annona, jackfruit, fig and grapes). PI: Reju M. Kurian
- 011 (4):** Optimizing water and nutrient management (Papaya, guava, mango, sapota, annona and grapes). PI: Manjunath, B.L.
- 011 (5):** Fruit based mixed cropping systems (Annona, Mango and sapota). PI: Manjunath, B.L.
- 011(6-H)/ 010(14):** Performance of Dragon fruit (*Hylocereus* sp.) cultivars under different training systems in open as well as shade net condition. PI: Karunakaran, G.

Division of Vegetable Crops

020: Genetic improvement of vegetable crops for improved productivity, quality and resistance to biotic and abiotic stress. Project Leader: Sadashiva, A.T.

Sub-Projects

- 020 (1):** Breeding tomato for resistance to biotic and abiotic stresses and gene pyramiding for ToLCV resistance through MAS. PI: Sadashiva, A.T.
- 020 (2):** Breeding for biotic and abiotic stress resistance and diversification of male sterile lines in chilli (*Capsicum annuum* L.). PI: Madhavi Reddy, K.
- 020 (3):** Breeding brinjal for resistance to bacterial wilt with high yield and quality attributes through marker-assisted selection (MAS). PI: Singh, T.H.
- 020 (4):** Breeding Cucurbitaceous Crops (Watermelon and Muskmelon) for yield & resistance to biotic stresses through marker assisted selection (MAS). PI: Sreenivasa Rao, E.
- 020 (5):** Breeding okra varieties/ hybrids for yield, quality & resistance to biotic stresses through MAS. PI: Pitchaimuthu, M.
- 020 (6):** Breeding French bean varieties for resistance to biotic and abiotic stresses and Cowpea varieties for resistance to rust & cowpea aphid borne mosaic virus through marker-assisted selection (MAS). PI: Aghora, T. S.

- 020 (7):** Breeding garden pea for resistance to biotic and abiotic stresses and dolichos for yield and quality attributes through marker-assisted selection (MAS). PI: Raghu, B.R.
- 020 (8):** Breeding onion for resistance to biotic and abiotic stresses with high bulb yield and quality attributes through marker-assisted selection (MAS). PI: Veere Gowda, R.
- 020 (9):** Evolving F1 hybrids in tropical carrots with high yield and quality through marker-assisted selection (MAS). PI: Veere Gowda, R.
- 020 (11):** Breeding ridge gourd and bitter gourd for resistance to biotic stresses integrating marker assisted selection (MAS). PI: Varalakshmi, B.
- 020 (12):** Breeding cucumber varieties / hybrids for resistance to biotic stresses through marker assisted selection. PI: Pitchaimuthu, M.
- 020(13):** Breeding cluster bean (*Cyamopsis tetragonolobus* L.) for yield, quality and resistance to biotic stresses. PI: Smaranika Mishra
- 020(14):** Harnessing the genetic potential of *Momordica sahyadrica* through wide hybridization. PI: Bharathi, L.K.
- 020(15):** Breeding pumpkin, summer squash and bottle gourd for yield, quality and biotic stress tolerance. PI: Dhananjaya, M.V.
- 020(16):** Breeding bell pepper (*Capsicum annuum* L. var. *grossum*) for biotic and abiotic stress. PI: Smaranika Mishra
- 020(17):** Breeding radish (*Raphanus sativus* L) for yield, quality and heat tolerance. PI: Padmini, K.
- 020(18) / 130(2):** Restoration of fertility in interspecific F₁ hybrid between *Solanum melongena* and *Solanum macrocarpon*. PI: Padmini, K.

021: Development and refinement of Production technology of Vegetable crops. Project Leader : Hebbar, S.S.

Sub-Projects

- 021 (1):** Water management and rainfed production in vegetable crops. PI: Anil Kumar Nair
- 021 (2):** Organic farming in vegetable crops. PI: Senthikumar, M.
- 021 (3):** Protected cultivation & precision farming in

vegetable crops. PI: Hebbar, S. S.

Division of Floriculture & Medicinal Crops

030: Genetic improvement of ornamental crops for improved productivity, quality and resistance to biotic and abiotic stress. Project Leader: Tejaswini

Sub-Projects

- 030 (1):** Genetic improvement of tuberose for high concrete yield and resistance to nematode. PI: Usha Bharathi, T.
- 030 (2):** Genetic improvement of gladiolus for quality and resistance to biotic stresses. PI: Rao, T.M.
- 030 (3):** Evolving Rose varieties (both open and polyhouse) for quality and resistance to powdery mildew, black spot and thrips. PI: Tejaswini
- 030 (4):** Breeding *Dianthus* species (Carnations, Pinks and Sweet Williams) for quality. PI: T. Usha Bharathi
- 030 (5):** Breeding Gerbera for quality. PI: Aswath, C.
- 030 (6):** Breeding Chrysanthemum and China aster for quality. PI: Rajiv Kumar
- 030 (7):** Breeding crossandra for quality and novelty. PI: Aswath, C.
- 030 (8):** Breeding jasmine for high flower yield, concrete and resistance to Eriophyid gall mite (*Aceria jasmine*) and blossom midge (*Contarinia maculipennis*). PI: Dhananjaya, M.V.
- 030 (9):** Breeding Anthurium for high quality cut flower. PI: Aswath, C.

031: Development and refinement of production technology of ornamental crops. Project Leader: Sujatha A. Nair

Sub-Projects

- 031(3):** Enhancing water and nutrient use efficiency in flower crops under open field (Chrysanthemum, Crossandra) and protected (Gerbera) cultivation. PI: Sujatha A.Nair
- 031(4):** Identification of pollutant absorbent ornamental shrubs/ trees. PI: Sumangala, H.P.
- 031(5):** Standardization of precision production technologies in flower crops (Marigold, Gladiolus and China aster). PI: Sumangala, H.P.

031(6): Optimization of resource use for rose under open and protected conditions. PI: Sujatha, S.

032 / 120: Genetic improvement of Medicinal Crops. Project Leader: Hima Bindu, K.

Sub-Projects

032(1) / 120 (2): Evaluation of *Coleus forskholii* hybrids for tuber yield and forskolin content. PI: Hima Bindu, K.

032(2) / 120 (3): Identifying high yielding and high L-dopa lines in *Mucuna species*. PI: Hima Bindu, K.

032(3) / 120 (7): Genetic amelioration of Kalmegh (*Andrographis paniculata* Nees) for yield and quality. PI: Hima Bindu, K.

032(4) / 120(8): Genetic Improvement of *Centella asiatica* by Polyploidy Breeding. PI: Smitha, G.R.

033 / 121: Production and phytochemical studies in medicinal plants. Project Leader: Dr. M.A. Suryanarayana

Sub-Projects

033(1) / 121(3): Production Technology for Mandukaparni (*Centella asiatica*). PI: Suryanarayana, M.A.

033(2) / 121(4): Development of agro-techniques and post-harvest management of Brahmi (*Bacopa monnieri*). PI: Smitha, G.R.

Division of Post Harvest Technology & Agricultural Engineering

040: Development, refinement and demonstration of post-harvest handling, storage and processing technologies for minimization of post-harvest losses and production of value added products. Project Leader: Harinder Singh Oberoi

Sub-Projects

040(1): Extension of storage life and quality maintenance of fruits (mango, papaya, guava, sapota) and vegetables (okra, beans, brinjal, colour capsicum, chillies) for minimization of post-harvest losses. PI: Sudhakar Rao, D.V.

040(2): Post harvest management and value addition of cut flowers, filler flowers and foliage. PI: Sangama

040(3): Development of protocols to extend the shelf life and to eliminate microbiological hazards in ready-to-use salad and leafy vegetables

(carrot, radish, onion, cucumber, coriander and fenugreek leaves). PI: Ranjitha K.

040(4): Design and development of storage systems for fresh fruits, vegetables and flowers. PI: Bhuvanewari, S.

040(5): Nutritional profiling, nutraceutical potential and value-addition of under-utilized crops – Avocado, Karonda, Pummelo, Rambutan, Ivy Gourd and Sweet Gourd. PI: Shamina Azeez

040(6): Utilization of un-marketable and processing waste of horticultural crops for value addition. PI: Narayana, C.K.

040(7): Studies on the preservation of fruits by Hurdle processing and development of nutritionally innovative health drinks. PI: Doreyappa Gowda, I.N.

040(8): Development of fruit and vegetables based nutritious snacks and convenient products (mango, papaya, pineapple, aonla, guava, jackfruit, kokum, carrot, pumpkin, tomato, beetroot, bitter 'gourd and muskmelon). PI: Tiwari, R.B.

040 (9): Development of functional ingredients (leaf powder and encapsulated leaf concentrate) from *Moringa oleifera* leaves. PI: Pushpa Chetan Kumar

040(10): Development of technologies for production of probiotic processed fruit products. PI: Harinder Singh Oberoi

041/141: Development of machinery for production and processing of horticultural crops. Project Leader: Senthil Kumaran, G.

Sub-Projects

041(1) / 141(1): Development of machinery for cultivation and on farm processing of onion and planting material production in vegetable and fruits. PI: Senthil Kumaran, G.

041(2) / 141(2): Development of machinery for processing of pomegranate and mushroom. PI: Carolin Rathinakumari, A.

Division of Plant Pathology

050: Diagnostics and Integrated management of viral diseases of tropical horticultural crops. Project Leader: Krishna Reddy, M.

Sub-Projects

050(4): Development of quick detection methods and vector host interaction of Phytoplasmas causing big bud disease of tomato and little leaf of brinjal. PI: Samuel, D. K.

050(5): Diagnosis and management of viral diseases of cucurbitaceous crops. PI: Mahesha, A.

050(6): Diagnosis, epidemiology and integrated management of Vector borne viruses diseases of Horticultural crops (Bitter gourd, Chilli, Capsicum, Tomato and Papaya). PI: Krishna Reddy, M.

051: Integrated management of fungal and bacterial diseases of tropical horticultural crops. Project Leader: Saxena, A.K.

Sub-Projects

051 (1): Development of disease prediction models for yellow rust in grapes var. Bangalore blue. PI: Saxena, A. K.

051 (4): Host Pathogen interactions with special reference to fungal wilts of fruit crops. PI: Sriram, S.

051(9): Epidemiology and management of Phytophthora leaf blight and fruit rot in hot and sweet pepper (*Capsicum annum* L.). PI: Sandeep Kumar, G.M.

051(10): Identification and integrated disease management of bacterial leaf spot of tomato and chilli. PI: Samuel, D.K.

053: Genetic improvement and development of production and utilization technology of tropical mushrooms. Project Leader: Meera Pandey

Sub-Projects

053 (1): Development and utilization of mushroom technology as a biological tool for sustainable nutrition, health and green environment. PI: Meera Pandey

053(2): Standardization of optimum casing material formulation for production of milky mushroom (*Calocybe indica*). PI: Chandrashekhara, C.

Division of Entomology and Nematology

060: Integrated Insect pest management in tropical horticultural crops. Project Leader: Shivarama Bhat, P.

Sub-Projects

060 (1): Surveillance and management of fruit crop pests. PI: Reddy, P.V.R.

060(7): Development of neem cake/ neem seed powder based formulations for the management of major insect pests of vegetable crops. PI: Shivarama Bhat, P.

060(8): Development of forewarning models for sucking pests and thrips borne viral diseases on chilli. PI: Prasannakumar, N.R.

060(9): Current scenario of arthropod diversity of drumstick (*Moringa oleifera* Lam.) and management of major pests. PI: Shivarama Bhat, P.

060(10): Management of *Myloccerus subfasciatus* infesting brinjal using microbial agents. PI: Ganga Visalakshy, P.N.

060(11): Ecologically mediated interactions of host plants – Mealy bugs – Natural enemies in fruit crops. PI: Jayanthi Mala, B.R

060(13): Feasibility of enhancing fruit set in *Annona* (cv. Arka Sahan) and polyhouse grown cucurbits through insect pollinators. PI: Reddy, P.V.R

060(14): Bioecology and integrated management of South American tomato moth, *Tuta absoluta* (Meyrick 1917). PI: Sridhar, V.

060(15): Studies on the invasive whitefly *Aleurothrixes trachoides* (Back) (Hemiptera: Aleyrodidae), in India and development of management strategies. PI: Gopalkrishna Pillai, K.

063: Integrated Nematode Management in tropical Crops. Project Leader: Rao, M.S.

Sub-Projects

063(2): Evaluation of bioefficacy of entomopathogenic nematodes for biological control of insect pests in horticultural crops. PI: Umamaheshwari, R.

063(3): Biomangement of nematode induced disease complex in horticultural crops (pomegranate, guava, capsicum, gherkins, gladiolus, gerbera, crossandra etc.). PI: Rao, M. S.

Division of Plant Physiology and Biochemistry

070: Understanding the physiological and biochemical mechanism and their application for improving productivity and quality of mandate horticultural crops. Project Leader: Bhatt, R.M.

Sub-Projects

- 070 (2):** Metabolic adaptations under low moisture stress and salinity, and potential of growth regulators and microbes in improving tolerance in papaya. PI: Upreti, K.K.
- 070 (3):** Phenotyping pea and french bean genotypes for tolerance to high temperature stress. PI: Laxman, R.H.
- 070 (4):** Physiological studies on impact of low-moisture and high temperature stresses in capsicum (*Capsicum annum* L.). PI: Bhatt, R.M.
- 070(8):** Physiological interventions to induce early and regular flowering in Alphonso mango. PI: Ravindra, V.
- 070(9):** Extraction and method optimization of natural antioxidants and pigments from pomegranate peel and flowers. PI: Rao, V.K.
- 070(10):** Studies on impact of water stress on physiology, bioactive compounds and gene expression profiling in Kalmegh. PI: Pritee Singh
- 070(11):** Assessment of floral metabolite profiles and their influence on fruit set in mango. PI: Shivashankara, K.S.
- 070(12)/ 081 (1):** Pesticide residue studies in fruits and related environment. PI: Soudamini Mohapatra
- 070(13)/ 081 (8):** Evaluation of chemical pesticide residues in exotic vegetables. PI: Debi Sharma
- 070(14):** Effect of processing on pesticide residues in horticultural commodities. PI: Partha P. Choudhury
- 070(15) / 130 (5):** Biochemical and molecular investigations in relation to seed quality assurance in vegetable crops. PI: Yogeesha, H.S.

Division of Soil Science and Agricultural Chemistry

080: Soil, nutrient and water management in horticultural crops and cropping systems. Project Leader: Raghupathi, H.B.

Sub-Projects

- 080 (1):** Micronutrient related constraints in fruit and vegetable crops for correcting nutrient imbalances. PI: Satisha, G.C.
- 080 (4):** Nutrient dynamics (N, P, K) of conventional and speciality fertilizers under drip fertigation in horticultural crops. (Banana, Papaya, Tomato and Cauliflower). PI: Varalakshmi, L R
- 080(6):** Development and Standardization of soilless cultivation of vegetables on Arka Fermented Cocopeat under protected conditions. PI: Kalaivanan, D.
- 080(7):** Development of Nutrient Management Module for Guava under High Density Planting System. PI: Rupa, T.R.
- 080(8):** Evaluation of mango poly-embryonic rootstocks (RS) and RS X Scion combinations for nutrient uptake and translocation efficiency in poly-embryonic mango, guava and papaya. PI: Shivananda, T.N.
- 080(9):** Influence of rootstock and scion combinations on nutrient acquisition and utilization in Solanaceous Vegetable crops. PI: Raghupathi, H.B.
- 080(10):** Identification of suitable rose rootstocks for tolerating bicarbonate toxicity (High pH) and salinity for poly houses and open field conditions. PI: Varalakshmi, L.R.

081: Addressing soil health and environmental safety in horticultural crops and cropping systems. Project Leader: Ganeshamurthy, A.N.

Sub-Projects

- 081(9):** Development of Actinobacterial Liquid Inoculants for Growth Promotion, Nutrient and Health Management in Pomegranate. Radha, T.K.
- 081(10):** Development of a Management Practice for Acquisition of Fixed Phosphorus by AM Fungi and PSB combination in Vegetables. PI: Ganeshamurthy, A.N.
- 081(11):** Anhydrobiotic engineering of efficient plant growth promoting Rhizobacterial strains for production of bioencapsulated vegetable seeds. PI: Selvakumar, G.

Division of Social Sciences and Training

090: Improving knowledge and skill of stakeholders for improving productivity of

horticultural crops and impact assessment of adopted technologies. Project Leader: Venkatta Kumar, R.

Sub-Projects

- 090(6):** Group Dynamic and social networks among women SHG member's involved in economic activities. PI: Reddy, T.M.
- 090(7):** An Analysis on 'Producer Company' model in Providing Extension Services to Horticulturists. PI: Venkattakumar, R.
- 090(8):** Evaluation of Digitally Documented IIHR Technologies for its effectiveness and utility. PI: Narayanaswamy, B.
- 090(9):** Multidimensional analysis of attributes of horticultural innovations and their impact on adoption. PI: Balakrishna, B.
- 090(10):** A Study on Communication Behavior of Horticulture Farmers. PI: Atheequilla, G.A.
- 090(11):** Spread and acceptance of ICAR-IIHR technologies. PI: Achala Paripurna, K.

091 / 150: Development and Application of economic, statistical and ICT tools & strategies for improving and assessing productivity of horticultural crops. Project Leader: Sudha Mysore

Sub-Projects

- 091(1) / 150 (1):** Assessing the socio-economic impact of horticultural technologies on crop diversification, farm income, employment and trade. PI: Sudha Mysore
- 091(2) / 150 (3):** Economics of factor productivity and production efficiency in selected horticultural crops. PI: Sreenivasa Murthy, D.
- 091(3) / 150 (4):** Development of statistical models for horticultural crops research. PI: Venugopalan, R.
- 091(4) / 150 (5):** Development of database and program modules for horticultural crops. PI: Chandra Prakash, M.K.
- 091(5) / 150 (6):** Development of Decision Support System for selected horticultural crops. PI: Reena Rosy Thomas
- 091(6) / 150 (7):** Studies on Emerging Marketing Models of horticultural crops to link farmers to market. PI: Gajanana, T.M.

Division of Plant Genetic Resources

100: Plant Genetic Resources Management in Horticulture crops. Project Leader: Tripathi, P.C.

Sub-Projects

- 100(4):** Identification of zygotic seedlings in polyembryonic varieties of mango using molecular approaches. PI: Anuradha Sane
- 100(7):** Characterization and genetic diversity analysis of 'Future fruit crop' genetic resources. PI: Anuradha Sane
- 100(8):** Collection, characterization, evaluation, utilization and domestication of native fruits and vegetables of Western Ghats. PI: Tripathi, P.C.
- 100(9):** Association mapping and genetic diversity analysis in pomegranate (*Punica granatum* L.) germplasm using microsatellite markers. PI: Kanupriya
- 100(10):** Evaluation of under-utilized fruits for yield, quality and adaptability. PI: Tripathi, P.C.
- 100(11):** Development of an Online Information System for the Plant Genetic Resources of IIHR. PI: Radhika, V.
- 100(12):** Development of Epidemiological Models for Viral Diseases in Horticultural Crops. PI: Radhika, V.
- 100(13):** Augmentation, characterization and conservation of land races and wild relatives of selected horticultural crops (vegetables - *Solanum* wild gene pool, *Momordica* species; fruits – Mango, Pomegranate and Custard Apple). PI: Rajasekharan, P.E.
- 100(14):** Collection and characterization of tamarind (*Tamarindus indica* L.) for development of diversity maps. PI: Kanupriya

101 / 130: Development and refinement of efficient seed production and plant propagation technologies in key horticultural crops. Project Leader: Yogeesh, H.S.

Sub-Projects

- 101(1) / 130 (6):** Ultra low and low moisture drying as a cost effective technique to extend seed longevity of horticultural crops under ambient storage. PI: Yogeesh, H.S.

Division of Biotechnology

110: Development, refinement and use of biotechnological approaches for horticultural crop improvement and production. Project Leader: Leela Sahijram

Sub-Projects

- 110(10):** Development of Bt transgenic brinjal for resistance to the shoot and fruit borer, *Leucinodes orbonalis* Guenee. PI: Vageeshbabu, H.S.
- 110(11):** Gene mining and trait based pyramiding for abiotic stress tolerance. PI: Manamohan, M.
- 110(13):** Modifying genome methylation pattern in embryos to harness useful and stable variants in horticultural crops. PI: Leela Sahijram
- 110(14):** Developing Cucumber mosaic virus (CMV) resistant transgenic chilli (*Capsicum annum*) through RNAi strategy. PI: Usha Rani, T.R.
- 110(15):** Cloning and characterization of Nematicidal Bt genes effective against the nematodes infesting horticultural crops. PI: Nandeesh, P.
- 110(16):** Tissue culture systems in horticultural crops with reference to management and exploitation of endophytes. PI: Pious Thomas
- 110(17):** Forskolin production in cultures of *Coleus forskohlii* transformed with *Agrobacterium rhizogenes*. PI: Mythili, J.B.
- 110(18):** Tilling in papaya for enhancing shelf life. PI: Vageeshbabu, H.S.
- 110(19):** Identification of elite germplasm line/s for multi-traits by using tightly linked molecular markers in chilli. PI: Lakshman Reddy, D.C.
- 110(20):** Micropropagation of Guava cv Arka Kiran – a pink-pulped variety. PI: Mythili, J.B.
- 110(21):** Micropropagation and field evaluation of PRSV Tolerant Papaya of Integeneric Lineage. PI: Pious Thomas

160: Identification & utilization of small RNAs, genes and markers in the improvement of horticultural crops. Project Leader: Asokan, R.

Sub-Projects

- 160(1):** Identification of novel miRNAs and their targets for artificial miRNA mediated management of

insect pests of horticultural crops. PI: Asokan, R.

- 160(2):** Towards bacterial blight resistance in pomegranate (*Punica granatum* L.): *In silico* comparative analysis for identification of *Xanthomonas axonopodis* pv. *punicae* interacting genes in pomegranate. PI: Radhika, V.

- 160(3):** Identification of genes and markers linked to parthenocarpy. PI: Ravishankar, K.V.

161: Application of Bioinformatics in target gene validation for genome engineering of some important insect pests of horticultural crops. Project Leader: Asokan, R.

Central Horticultural Experiment Station, Chettali

170: Development, refinement and popularization of cropping system models for improving productivity of horticultural crops in high altitude regions of Western Ghats of India. Project Leader: Bharathi, L.K.

Sub-Projects

- 170 (1):** Collection and evaluation of under-utilized fruits for humid tropics. PI: Awachare Chandrakant Madhav
- 170 (6):** Studies on bee pollination and bee keeping under humid tropics. PI: Priti Sonavane
- 170 (7):** Performance evaluation of vegetable cultivation in humid tropic region of Coorg. PI: Sankar, V.
- 170 (8):** Management of Coorg Mandarin decline. PI: Venkataravanappa, V.
- 170(9):** Diagnosis of viral and viral-like diseases associated with fruits, vegetables and ornamental crops in high humid regions of Western Ghats of India. PI: Venkataravanappa, V.

Central Horticultural Experiment Station, Bhubaneswar

180: Development and refinement of technologies for improving productivity of fruit and vegetable crops in east coast regions of India (Bhubaneswar). Project Leader: Acharya G.C.

Sub-Projects

- 180 (1):** Collection, evaluation, characterization, conservation and documentation of germplasms

- of fruit crops of Eastern India. PI: Kundan Kishore
- 180 (5):** Collection, evaluation and improvement in *Capsicum* spp. for desired characters. PI: Naresh, P.
- 180 (6):** Collection, evaluation and improvement in *Maringa* and leafy vegetables of eastern region for desired characters. PI: Acharya, G.C.
- 180 (7):** Collection, evaluation and improvement of
- legume vegetables for desired characters. PI: Meenu Kumari
- 180 (8):** Development of production technologies of fruit crops. PI: Deepa Samant
- 180 (10):** Monitoring & Management of diseases in fruit crops. PI: Sangeetha, G.
- 180 (12):** Monitoring and management of major diseases in vegetable crops. PI: Mandal, S.

11. Commercialization of Technologies

11.1 Technology Transfer

The Institute Technology Management Unit (ITMU), IIHR is responsible for undertaking technology commercialisation through non-exclusive licensing of

technologies. During the financial year 2017-18, 40 technologies were transferred to 53 companies and an amount of Rs. 1, 47, 85,800/- was generated as income from utilization of IP assets.

Technologies Commercialised through Licensing

Theme Area	No. of Companies	No. of Technologies	Income From IP assets
Seed and Planting Material	08	13	2695000
Crop Protection Technologies	36	13	11416900
Post Harvest Technologies	07	11	319450
Farm Implements & Machineries	02	03	29500
Biotechnological products & Services	Nil	Nil	Nil
Royalties			324950
	53	40	1,47,85,800

ITMU also undertakes the activities of Consultancy Processing Cell by providing consultancy services as per the specific requirements of the clients. The ICAR-IIHR is well recognised for its R&D capabilities and the activities under CPC are growing year after year fetching the Institute substantial 'income of Rs Rs. 1, 18,51,989/- during the financial year 2017-18. Besides

these activities, the ITMU is also responsible for undertaking 'Agri-Business Incubation' related activities by providing handholding and capacity building support for entrepreneurs and start-ups in scaling up technology products from lab scale to commercial scale. During the financial year 2017-18, an amount of Rs.3,93,586 was realised by incubation activities.

Income generated by utilization of IP assets

Sl.No	Activities	Income from IP assets (in Rs)
1.	Technology Transfer	1,47,85,800
2.	Consultancy Services	1,18,51,989
3.	Incubation Activities	3,93,586
GRAND TOTAL		2,70,31,375

11.2 BPD Activities

The main activities of the Agri-Business Incubation Centre of ICAR-IIHR during the year 2017-18 were as follows,

1) Enrollment of seven members during the financial year 2017-18

1. M/s Devatharu Homes and Foods
2. M/s Vanproz Agrovet
3. M/ s Uttham Enterprise
4. M/s R L associate

5. M/s Ganpath products
6. M/s Natura Crop Care
7. M/s Bhavani Biochemicals

2) Preparation of detailed project reports for availing bank loans to incubatees on

- Jackfruit Processing Unit
- Osmotically Dehydrated Fruit Processing Unit

3) Filing patents on

- A method for sustained in vitro micropropagation of papaya with the management of interfering endophytic microorganisms- Innovator: Dr. Pious Thomas
- A novel kairomone formulation and septa design for attraction of female *Bactrocera dorsalis*- Innovator: Dr. P. D. Kamala Jayanthi
- CRISPR Assisted Cleavage Polymorphism- Innovator: Dr. E. S. Rao

4) Organization of events under the Zonal Technology Management Centre, Agri -Business Incubation project and BIRAC BioNEST

- A team of Five Ethiopian Delegates from Tigray Biotechnology Institute (TBI) representing Government of Ethiopia visited ICAR-IIHR on 3rd August 2017 along with the Business manager, Agrinnovate India Ltd, New Delhi, exploring possible avenues for collaboration and technology back stopping. The Institute Technology Management Unit (ITMU), ICAR-IIHR, Bangalore coordinated the programme. The Ethiopian team sought technical collaboration with ICAR-IIHR, through AgIn, New Delhi for capacity building programmes through hands on training and technical support to Ethiopia for commercial technology transfer with special reference to (i) Mango propagation, (ii) Organic farming production technologies, (iii) precision farming in vegetable crops through use of yield enhancing practices, and (iv) use of Neem soap and Pongamia soap etc.
- ICAR-IIHR Organized a Consultative Workshop on 16.8.2017 with officials of Department of Horticulture, Government of Karnataka and Vice-Chancellors of SAUs in Karnataka for "Promotion of Horticulture technologies in Karnataka".



- An Entrepreneurship Development Programme on "Technology Intervention and Business Planning in Horticulture for FPOs" was organized ICAR-IIHR, by HTM-BPD at the Center of Excellence for Precision Farming Training in Horticulture crops, Maddur, Mandya district on 6th December 2017. A total of 50 participants, representatives and members from FPO Mysore, Mandya & Madikeri and self-help group members from Maddur attended the programme. The detailed information about the incubation facilities at IIHR were also explained to the benefit of the participants.



- An Awareness Programme on ICAR-IIHR Technologies to GPS Institute of Agricultural Management -Bengaluru by HTM-BPD, IIHR, Bengaluru on 13 December 2017 was organized under Agri-Business Incubation Project 'Establishment of ICAR-IIHR, by HTM-BPD. A total of 23 trainees attended the programme.
- An Awareness Programme on ICAR-IIHR Technologies to Students of MS Ramaiah Institute of Technology -Bengaluru was organized under Agri-Business Incubation Project ICAR-IIHR, by HTM-BPD. A total of 20 pre final year students attended the programme.

5) Participation in entrepreneurship events

- Festival of Innovation and Entrepreneurship (FINE) at *Rashtrapati Bhavan* New Delhi : ICAR-Indian Institute of Horticultural Research, Bengaluru was one among the 17 and odd Agri Business Incubation centres of ICAR, that participated in the Festival of Innovation and Entrepreneurship (FINE) at *Rashtrapati Bhavan* (19th to 23rd March 2018) organised by The President's Secretariat in association with Department of Science & Technology/National Innovation Foundation-India. The BPD Unit of ICAR-IIHR provided an opportunity and a platform to two of its on-site incubatees to showcase their technologies and the innovative ways through which ICAR-IIHR has been supporting them start and expand their Horticulture ventures at Festival of Innovation and Entrepreneurship (FINE). The

event was inaugurated by Honourable President of India, Shri. Ram Nath Kovind. Hon'ble Secretary DARE & Director General ICAR, Dr. Trilochan Mohapatra, visited the ICAR-IIHR's incubatees stall, interacted with the incubatees and appreciated the efforts put forth by IIHR through

its technologies and the support it has rendered to its incubatees. The on-site incubatees of ICAR-IIHR, Mr R Manoj Kumar and Mr. Bharath Naik were provided an opportunity to participate in the Roundtable meeting at RPC hall of Rashtrapati Bhavan.



12. RAC, IRC, IMC- Major Recommendations

12.1. Research Advisory Committee

The Research Advisory Committee Meeting (RAC) of IIHR was constituted vide Council's office order No. Hort-7-8/2013-IA-V dated March, 2017. The first meeting of the full committee for the year 2017-2018 was held under the Chairmanship of Prof. Goutam Kalloo, Formerly DDG (Hort.), ICAR & Ex-Vice Chancellor, JNKVV, Jabalpur at IIHR, Hesaraghatta, Bengaluru from 18-19th July 2017.

Chairman: Dr. Goutam Kalloo

Members: Dr. S.N. Pandey,
Former ADG (Hort.),
ICAR, New Delhi

Dr. Pritam Kalia,
Ex-Head, Division of Vegetables,
ICAR-IARI, New Delhi

Dr. T.P. Rajendran,
Former ADG (Pl. Protection),
RIS for Developing Countries, New Delhi

Dr. G.D. Joshi,
Retd. Dean (Agriculture), KKV,
Dapoli, Ratnagiri

Dr. Srinath Dixit,
Director, ATARI, Zone VIII,
Bengaluru

Dr. T. Janakiram,
ADG (Hort Sci),
ICAR, New Delhi

Director, ICAR-IIHR

Member-Secretary : Dr. E. Sreenivasa Rao

Major recommendations:

- The degree of heterozygosity in parentage and pedigree of all released varieties may be assessed to understand the combining ability and predict their performance for development of hybrids/varieties in breeding programs of different fruit crops (esp., Mango)
- Identification of morphological, physiological and molecular markers for developing reliable indices for the selection of dwarfing rootstocks in important fruit crops may be pursued.
- Utilisation of wild species for study of CMS diversification and disease resistance especially the TOSPO viruses of vegetable crops needs to be pursued. Pre-breeding program should be given emphasis.
- Work on pollinators to be intensified, particularly, a module or system approach needs to be devised for improving bee populations. The influence of recommended pesticides on the pollinators biology may be studied. More emphasis on the non-*Apis* pollinators is important where they are strong communities for pollination.
- Breeding for development of varieties for protected cultivation should be given emphasis. There is need for development of varieties for bio-fortification especially for micronutrient and antioxidants.
- Vegetable improvement especially for resistance to bacterial wilt needs priority at CHES, Bhubaneswar. Emphasis should be given on races/strains, their corresponding genes and markers in network mode for development of bacterial wilt resistant varieties/hybrids.
- Marker assisted pyramiding of *er1* and *er2* genes for resistance to powdery mildew along with rust should be carried out in commercially important garden pea varieties.
- Latest genome editing technologies like CRISPR/Cas9, ZFN etc. may be used to hasten breeding cycle in vegetables. CRISPR/Cas9 gene editing and RNAi techniques for virus resistance in potential crops may be expedited
- A small team may be constituted to carryout Gap analysis and explore new avenues for taking up projects that are relevant to current industry need and trend in ornamental crops. Focus areas should include
 - Speciality flowers (Ornamental gingers, Barleria, Coloured tuberose etc.), Indoor plants and succulents
 - Breeding varieties suitable for extraction of Natural colours
 - Promotion of nutrient film technique to enhance the productivity of flower

- Possibility of transgenic root stocks for tackling soil borne pathogens in fruit crops may be explored.
- Work on Induced systemic resistance (ISR) and Systemic acquired resistance (SAR) should be given priority.
- Characterisation of pathogens belonging to different geographical regions (to Race/ strain level) and deployment of specific resistant genes may be taken up. In future, Strain names and their corresponding genes may be given for all resistance claims.
- Standardizing improved package of practices for profitable organic cultivation (sources of nutrients and bio-pesticides) in mango, grapes, papaya and other important horticultural crops should be given emphasis.
- Post-Harvest incubation facility has to be established in the Institute. For this, Quality Control Laboratory integrated with packaging facilities need to be developed.
- Research work on minimal processing and Post-Harvest waste utilization of horticultural crops should be strengthened.
- The web applications on crop management and diagnostic modules developed by the Institute may be hosted on ICAR and Kisan portals. The performance and extent of use of these applications needs to be documented.
- Long term pest scenario may be assessed in relation to changing climatic and crop husbandry parameters.
- The Institute may analyse crop protection research applications towards cost-effective pest management of fruits and vegetables. For this pest management packages with data may be sent to State Extension system including Extension departments of SAUs for incorporation in their Package of Practices of all horticultural crops.
- Deposition of isolates in Culture banks and molecular fingerprinting of all IIHR bio-pesticides may be done to assess and maintain strain identity. This may be placed in the IIHR website and a catalogue of licensed bio-pesticide formulations may be developed.
- Residues of agrochemicals and their metabolites in the horticultural crop commodities due to various processing techniques may be analysed. The

Institute may develop a procedure for safe food processing to the MSMEs and major FPIs. For this purpose, Plant Protection, Plant Physiology and Biochemistry and Post-Harvest Processing divisions may work together.

12.2. Institute Research Committee (IRC) Meeting

Chairman: Dr. M.R. Dinesh,
Director, ICAR-IIHR,
Bengaluru

Members: All Scientists of the main Institute & its regional stations.

Member -Secretary : Dr. C.K. Narayana,
Incharge, PME Cell.
ICAR-IIHR, Bengaluru

The 87th IRC Meeting was held from 8th March to 11th April, 2017, under the Chairmanship of Dr. M.R. Dinesh, Director, ICAR-IIHR, Bengaluru. The meeting started with the welcome by Member Secretary, IRC. The new scientist who joined ICAR-IIHR after 86th IRC meeting, viz., Sh. B.M. Muralidhara was introduced to the house. All the ongoing research projects of the Institute & its regional stations were reviewed and the plan of work for the year was formulated. Many new research projects were also presented for consideration of the house. Following are the recommendations of the IRC for individual projects.

Major Recommendations:

1. Genetic improvement of fruit crops for improved productivity, quality and resistance to biotic and abiotic stresses

- In mango, it was suggested to give a status report on germplasm screening for pests and diseases especially anthracnose, fruit fly and stone weevil.
- In mango, as the resistance source for *Verticillium* wilt has been identified, work on rootstock compatibility studies may be taken up along with management aspects.
- In mango, volatile profiling of the accessions should be carried out.
- In the organoleptic quality evaluation of fruits of sapota progenies, pulp texture (grittiness) should be considered as one of the important traits.
- In jamun, as development of dwarf variety is one of the objectives, mutation breeding may be attempted and further with association of a physiologist, the

parameters related to dwarfness for early screening may be taken up.

- In jamun, while collecting germplasm, the trees may be marked in situ during the peak bearing season for one or two years and only better performing genotypes may be brought to the FGB.
- In papaya for PRSV resistance breeding, evaluation of intergeneric progenies, parents, F₁ and BC₁ progenies should be raised simultaneously in the same field for better understanding of genetics of inheritance in the population structure.
- In pomegranate, a large number of progenies have been developed. They have to be sequentially screened for resistance to BLB by artificial screening those progenies showing resistance may be studied for desirable plant yield and quality attributes.
- As Daru and 31874 is showing good resistance, they may be involved in hybridization work of pomegranate intensively.
- In the interspecific hybridization program for wilt in guava, the source of resistance needs to be confirmed prior to hybridization. As the wilt in guava is of complex nature, resistance to nematodes may also be studied in the wild species. Moreover, simultaneous evaluation for wilt and nematodes has to be taken up as pot culture study under laboratory conditions using available wild species.
- For improvement of yield and quality in guava, attempt may be made to introduce the wild relative *P. friedrichsthalianum* for hybridization.
- In guava, while evaluating the hybrids for their suitability of processing, the biochemical and nutrient profile may be estimated in the processed product also.
- As synchronization of flowering is a problem in annona, the technical programme to be modified to develop self-fruitful types by careful choice of parents (ArkaSahan x Balanagar and ArkaSahan X 19/26) for hybridization.
- The pummelo accessions and promising progenies needs to be screened for leaf miner susceptibility.
- In jackfruit, it was suggested to observe the stability of identified traits *in situ* in the elite selection made. The selections may be propagated and field planted for conservation.
- While collecting information on utility, ITK may

be documented along with farmer's description of economic and fruit traits.

2 Development and refinement of production technology of fruit crops

- In Crimson Seedless grapes, spraying lower concentration of GA3 (<5 ppm) may be attempted for rachis elongation as even at a little higher concentration phytotoxicity is reported. In addition, GA3 @5ppm may also be tried.
- Information on pest and disease incidence if any may be furnished in the studies involving high density planting.
- In the abiotic stress study on Annona, root cation exchange capacity (RCEC) may be observed for salinity tolerance.
- The cost benefit ratio and as well as benefit to soil health should be taken into account before any recommendation is made.

3. Genetic improvement of vegetable crops for improved productivity, quality and resistance to biotic and abiotic stress

- The success stories on adoption of improved varieties of vegetables released by IIHR has to be documented. Individual breeders of crop would be responsible for collection of information pertaining to their crop.
- Often processing industries say that our varieties are not suitable for processing and import huge quantities of tomato pulp. In the tomato breeding programme traits desired in a processing variety should be properly documented by interacting with the processors and develop varieties specifically for processing or fresh market.
- Work may be initiated on breeding tomato for resistance to insect pests (Pin worm-*Tuta absoluta*)
- Among the biotic stresses being studied in hot and sweet peppers (*Capsicum annuum* L), there is need to emphasize on nematode resistance.
- In brinjal, as bio-control agents have certain limitation like shelf life, non-availability on commercially scale and non-viability some other alternate methods needs to be explored.
- In brinjal, the thorny varieties are reported to have longer shelf-life/ keeping quality and tastier (in northern Karnataka)! The probable scientific reasons for this could be explored. Any traditional

knowledge available on this may be documented.

- Effort to be made to utilize native melon germplasm for improving variability and transferring resistance traits.
- Okra germplasm like long, thin and purple and light green types should be collected from south Canara for trait specific improvement.
- The yellow vein mosaic resistant lines identified in okra should be screened through artificial challenging.
- Rust resistant pole type photo-insensitive high yielding French bean to be developed.
- In Dolichos, bush type varieties have to be evaluated for screening of MYMV Resistance.
- In breeding onion varieties for resilience to soil moisture stress, focus needs to be given on the quantity of water saved by use of the resilient varieties.
- In backcrossing of advanced generations, superior performing lines for various traits can be selected as elite material for further using in the breeding of carrot.
- Cucumber green mottle virus is not a serious problem in India but in Southeast Asian countries and Japan. Tobacco streak virus is important in India and it needs to be addressed.
- Apart from vitamins, minerals like P, Zn, Fe, Ca may also be estimated from the wild vegetable *Momordica sahyadrica*.
- Exploitation of rootstock characters in summer squash should be studied.
- The BFSB resistant line developed by the interspecific F_1 hybrid between *Solanum melongena* and *Solanum macrocarpon* may be compared with the already published data of BT brinjal (Bangladesh). Edible quality & consumer acceptance of the fruits derived should also be tested.

4. Development and refinement of Production technology of Vegetable Crops

- Root stocks resistant to nematode may be tried under protected cultivation.

5. Genetic improvement of ornamental crops for improved productivity, quality and

resistance to biotic and abiotic stress

- More focus has to be given on concrete content in tuberose which increases the income of the farmers.
- Varieties developed by IIHR have to be multiplied in large number in the case of gladiolus and be given to the farmers and KVK for further multiplication and its spread should be documented.
- In gladiolus, novel hybrid selections have to be registered with NBPGR, New Delhi.
- In rose, emphasis should be given on mutation breeding for development of varieties with novel colour.
- In gerbera, novel colour varieties for open grown may be developed.
- In chrysanthemum, varieties which are day neutral and for pot culture may be developed.
- In crossandra, wilt resistant varieties may be developed.
- Anthurium varieties suitable for Pot culture may be developed.

6. Development and refinement of production technologies of ornamental crops

- In the experiments on enhancing water and nutrient use efficiency in flower crops under open field, instead of photosynthetic rate & evapo-transpiration rate, the WUE may be given in the results.

7. Genetic improvement of Medicinal Crops

- As wilt is a major problem in coleus, wilt screening has to be taken up.
- Nutritional aspect of different lines and polyploids should also be analysed in *Centella asiatica*.

8. Production, chemistry and related studies on plants of medicinal and agrochemical importance

- Change in nutritional and active principle content using organic inputs should be worked out.

9. Development, refinement and demonstration of post-harvest handling, storage and processing technologies for minimization of post-harvest losses and production of value added products

- Treatments like H₂O₂ and peroxyacetic acid alone and in combination and electrolyzed water, etc., may also be evaluated for enhancing the shelf life of selected fruits and vegetables.
- Scientific data on improved vase life using botanicals needs to be incorporated. Rationale behind better conduction of water in certain experiments needs to be elucidated.
- Fragrance profile analysis may be done for the standardized package for Jasmine flowers during their storage.
- One or two technical bulletins compiling all the scientific information on nutritional profiling, biochemical constituents, etc., in future fruits and vegetables must be brought out as early as possible.
- Efforts may be made to make more products from jackfruit and its waste, and information on its nutritional aspects in view of the crop gaining importance.
- Focus should be on development of one or two products in a year with a complete evaluation of the product during different storage intervals in case of fruit and vegetables based nutritious snacks and convenient products.

10. Development of machinery for production and processing of horticultural crops

- PI should visit NRCP, Solapur and MPKV, Rahuri to understand the design of the Pomegranate aril extractor conceptualized by the scientists from the two organizations, major bottlenecks and efficiency so as to ensure that the prototype conceived by the divisional scientists is different from those designs.

11. Diagnostics and Integrated management of Viral diseases of tropical horticultural crops

- The spread of Tomato Leaf Curl New Delhi Virus in cucurbits rather than Tomato needs to be understood.
- Monitoring system may be made for detection of viruses in seeds, special in the imported seed of vegetable crops in light of new viruses emerging.
- Host resistance may be explored for virus disease management.
- Let one crop specific approach involving all aspects

nutrition, pest management, disease management be made (probably Pomegranate in fruits; brinjal/ tomato in vegetables & gladiolus in ornamental crops).

- Management strategies of GBNV and PRSV to be prioritized in the new project proposed to be taken up.
- Focused targets may be taken for phytoplasma research and plasmid characterization based on pathogenicity, virulence and genetic diversity.
- In addition to border crop, effect of inter cropping also may be included in the disease management trials.

12. Integrated management of fungal and bacterial diseases of tropical horticultural crops

- The effect of individual weather parameters as well as combined effect on the grape rust spread may be presented as multiple regression model.
- Potential of root Endophytes as biological control agents for the wilt diseases of fruit crops may be explored.
- The pathogen mapping for guava wilt may be documented. The sample collection for guava and mango wilt may be attempted in freshly wilting plants. Sampling to be done during the start of the monsoon season.
- IDM package for pre and post-harvest management of mango anthracnose and fruit rots may be demonstrated at the Institute level.
- The failure of chemicals that are finding place in package of practices may be brought to the notice of concerned and efficacy of new chemicals may be documented at the earliest.
- Besides plasmids profile, the other genes (e.g.) Egl, rpf, hrp may be explored for characterization.

13. Integrated Insect Pest management in tropical horticultural crops

- Rootstocks in pomegranate and guava may be evaluated for its resistance / tolerance for Nematodes.
- Pollinators aspect is not appearing in any Institute Project. It should be focused and a Project may be made to study the role of pollinators in increasing the yield in various mandated crops.

- Crop wise IPM modules have to be developed than pest specific. This has been the recommendations of previous RAC meetings also.
- In Bitter gourd, the Aphids incidence is high resulting in spread of viral diseases. The formulations developed in this sub-project may be tested on vegetable crops grown by Vegetable Crops Division to control the pests.
- The field efficacy of the effective microbial agents may be studied.

14. Integrated Nematode Management in tropical horticultural crops

- Air layers of pomegranate accessions may be screened for nematode resistance.
- A demonstration plot with all the technologies should be put together for control of pomegranate wilt.
- Efficient EPN strains may be evaluated under field conditions for exploring efficacy.

15. Understanding the physiological and biochemical mechanism and their application for improving productivity and quality of mandate horticultural crop

- Morpho-physiological data in selected genotypes need to be correlated with yield and yield attributes for drawing useful conclusions in pea and rench bean.
- To concentrate on hormonal changes and mitigation strategies / aspects in the physiological studies carried on impact of low-moisture and high temperature in capsicum (*Capsicum annum* L.).
- Effects of current year defoliation in combination with induction treatments on flowering needs to be studied in Alphonso mango.
- Effects of pH, temperature and duration of storage on stability of the extracted antioxidants from pomegranate peel and flowers need to be studied.
- Final recommendations with respect to the crop stage and the level of stress for increasing the andrographallide can be tried on other genotypes instead of conducting the same experiment again with so many treatments in Kalmegh.
- A technical bulletin may be brought out on pesticide residues, MRLs and safe waiting periods in horticultural crops.

16. Soil, nutrient and water management in horticultural crops and cropping systems

- As studies on nanoparticles are in the infant stage, nanoparticles in agriculture applications and their safety is a matter of concern. Studies on nanoparticles may be focused on small scale using biological methods.
- Use of various diagnostic techniques / tools for the interpretation of leaf or plant analysis should be concomitant with practical utility so as to evaluate the nutritional requirements of horticultural crops.
- The benefit – cost ratio of conventional and speciality fertilizer under drip fertigation in horticultural crops need to be worked out rather than cost of fertilizers to income ratio for assessing the economic feasibility of fertilizers.
- Screening rose for salinity tolerance may be extended to Pot-culture studies so as to recommend the screened material for cultivation on saline conditions.

17. Addressing Environmental and Food safety in horticultural crops

- Actinobacteria may be isolated from pomegranate growing temperate regions like Himachal Pradesh, Jammu and Kashmir and Uttarakhand. This study may also be extended to pomegranate growing regions of Maharashtra.
- Soil dehydrogenase enzyme activity may be determined during different stages of plant growth.
- The P fixation capacity and release pattern of the soil may be evaluated

18. Improving knowledge and skill of stakeholders for improving productivity of horticultural crops and impact assessment of adopted technologies

- The external expert also made some valuable comments that a study on climate change and its impact on horticulture may be initiated. Indices may be developed for price forecasting. Studies on Big Data analysis may be taken up. The new methodologies are to be automated for easy applications. Studies on economics of farm mechanization may be initiated.
- The number of producer companies selected is much less (6 only). Efforts should be made to increase the number in future (at least upto 10) in the

studies carried on “Producer Company” model for providing Extension Services to Horticulturists.

- The sample size for evaluation of the videos and the mode of data collection should be specified in the studies on evaluation of Digitally Documented IIHR Technologies for its effectiveness and utility.
- The factors responsible for slower spread of IIHR technologies/varieties compared to those of private should be brought out and the kind of interventions required to spread it more and fast has to be suggested.
- Based on places where Arka Rakshak seeds have gone at least 5 states (not adjoining states) may be taken into study to see the communication behaviour of farmers which helped in its spread or otherwise.

19. Development and application of economic, statistical and ICT tools & strategies for improving and assessing productivity of horticultural crops

- Impact assessment studies on Arka banana special through KVKs and Arka Microbial Consortium through KVKs and private companies needs to be taken up.
- In studies on impact assessment, how many farmers were benefited by processing and value addition needs to be brought out, if the specific technology has a provision for processing.
- Results of risk Analysis for selected crops may be given in website for the benefit of the farmers.
- Conjoint Analysis may be used while developing new models.
- Mobile Apps has to be developed for more number of crops.

20. Plant Genetic Resources Management in Horticulture crops

- The technique / technology developed for identification (or) differentiation of zygotic and nuclear should be clearly brought out.
- Jamun IC numbers can be obtained for old collections also by writing “information not available” for missing data.

21. Development and refinement of efficient seed production and plant propagation technologies in key horticultural crops

- The external expert opined that since work on ultra-low and low moisture drying as a cost effective technique to extend seed longevity of horticultural crops under ambient storage is of great relevance to seed industry, a note on the results and technique may be given.

22. Development, refinement and use of biotechnological approaches for horticultural crop improvement and production

- All molecular markers’ projects need to focus on priority traits in specified crops.
- All transgenics’ projects need to focus and consolidate on important traits for which achievable results can be expected considering funding and biosafety issues.
- Fertile hermaphrodite papaya plants have to be propagated through tissue culture. Care should be taken to eliminate sterile hermaphrodites and female plants.
- RGA: Before testing F_2 population for wilt resistance in brinjal, parents must be tested for resistance by vacuum infiltration of the roots. Similarly, RNAi-based testing needs to be first tested in parents.
- Dr. G.K.Pillai may carry out the challenge inoculation of both transgenic brinjal developed by Dr. Vageeshbabu and intergeneric hybrids developed by Dr. Padmini for testing its resistance/ tolerance / susceptibility to shoot and fruit borer.
- Number of explants used for transformation needs to be increased so as to get many independent events.
- ECS culture technology to be commercialized after large scale demonstration in KVK, Hirehalli (or) CHES, Hirehalli.
- Mode of action (or) Nature of toxicity has to be known before testing / promoting as a strain (crystal solubilize / non-solubilize).
- A new project on micropropagation of intergeneric papaya hybrids to be proposed using shoot tip culture from the plants at CHES, Hirehalli.
- Biotic elicitors that can enhance forskolin production in both hairy roots and calli, especially from Coleus pathogens, may be tried.
- For more sensitive method of estimation, HoDs of Div. of Plant Physiology & Plant Pathology may be contacted

- Take only sibmated ones (selfed) and not half sibs.
- ERF family genes and downstream genes may also be taken.

23. Identification & utilization of small RNAs, genes and markers in the improvement of horticultural crops

- In plants, the resistance genes for *Xanthomonas* are different for different species, therefore, experiments with susceptible genotype Bhagwa is not going to yield any meaningful results.
- A program has been specially written to read all 100,000 plus EST sequences at one local PC, which has an advantage over programs that depend on internet connection, its speed and on the use of super computers."
- The computer program extracts useful EST sequences and generates text files and spread sheet files with necessary data in the files as per our requirement.

24. Development, refinement and popularization of cropping system models for improving productivity of horticultural crops in high altitude regions of Western Ghats of India

- Fruit set percent in Avocado is very low. Explore the possibility of increasing fruit set in Avocado. Samples of avocado may be given to Dr. Shamina for analysis.
- Promising under-utilised fruits may be registered with NBPGR.
- Quality and biochemical properties of only selected lines of all underutilized fruits should be studied instead of all the collections.
- The accessions of macadamia nut (*Macadamia integrifolia*) already collected may be evaluated for seed germination and other characters. Vietnam varieties & Florida var. should be evaluated.
- Mass production/rearing of Bio-control agents envisaged under sub-project objective should be revisited as no progress has been made on infrastructure/facilities required for the same in last 3 years.
- Intensification of pollination studies in Coorg region and emphasis should be given on role of wild pollinators as the region possess the maximum forest habitat.

- Suitable native trees and flowering plants could be identified to supplement the foraging plants for honey bees in the region
- Monitoring of Thai sac brood diseases has to be continued as said diseases is receding in recent years in the Coorg region.
- Chemical profiling of local vegetables of Coorg has to be done.
- Survey may be intensified for collection of the infected samples from different rainfall areas of Coorg mandarin growing areas.
- Integrated Package of practices has to be developed for management of Phytophthora and citrus greening.
- Seed transmission of other than begomo viruses associated with beans (Wild and cultivated) and chilli may be tested.

25. Development and refinement of technologies for improving productivity of fruits and vegetable crops in east coast regions of India (CHES- Bhubaneswar)

- Prediction models for mango Anthracnose should be developed under Institute Projects. Similarly, in Entomology also there are no prediction models. Based on the data generated prediction models should be developed.
- Local elite mango germplasm like Hamilton Sundari and some elite clones of Totapuri may be collected.
- Considering the potential of dragon fruit and ber, an objective on characterization and evaluation of dragon fruit (*Hylocereus spp.*) and ber in eastern tropical region of India
- *Oxalis corniculata* can be collected and included in the other leafy vegetables.
- Trellising in mango is a novel approach under HDPS. As the results are interesting, its evaluation may be continued for some more time. For this purpose a separate RPP-I in sub-project mode may be prepared and submitted by Dr. Kundan Kishore.

26. Studies on phyto-chemochemicals intervention involved in insect plant interactions of major horticultural pests: Deciphering chemical cues

- In integrated pest control, the focus should be crop specific and not pest specific. Efforts should be made to control multiple pests on the same

crop rather than control of one pest by different means.

12.3. Institute Management Committee

The 86th Meeting of the Institute Management Committee of ICAR-Indian Institute of Horticultural Research, Bengaluru was held on 23rd October, 2017 under Chairmanship of Dr. M.R. Dinesh and presence of following members and Special Invitees.

Chairman: **Dr. M.R. Dinesh**
Director, ICAR-IIHR, Hesaraghatta,
Bengaluru.

Members: **Dr. Markandey Singh**
Senior Scientist, Division of Floriculture
& Landscaping,
ICAR-Indian Agricultural Research
Institute, New Delhi.

Dr. Subhash Chander
Professor, Division of Entomology,
Indian Agricultural Research Institute,
New Delhi.

Dr. Smt. Neelima Garg
Head, Post-Harvest Management,
ICAR-Central Institute for Sub-tropical
Horticulture,
Rehmankhara, Kakori Post,
Lucknow.

Shri. S. George
Chief Finance and Accounts Officer,
National Academy of Agricultural
Research Management,
Rajendranagar, Hyderabad.

Member : **Shri. G.G. Harakangi**
Secretary Chief Administrative Officer &
Member-Secretary, IMC,
ICAR-IIHR, Bengaluru.

Special Invitees from IIHR, Bengaluru:

Dr. C.K. Narayana
Incharge, PME Cell,
ICAR-IIHR, Hesaraghatta,
Bengaluru.

Dr. R. Venkattakumar
Head, Division of Extension and
Training,
ICAR-IIHR, Hesaraghatta, Bengaluru.

Dr. Sudha Mysore
Chairperson, Institute Technology

Management &
Consultancy Processing Committee,
ICAR-IIHR, Hesaraghatta,
Bengaluru.

Dr. A.K. Chakravarthy
Head, Division of Entomology and
Nematology,
ICAR-IIHR, Hesaraghatta,
Bengaluru.

Dr. L.K. Bharathi
Incharge Chairman, Farm Management
Committee,
ICAR-IIHR, Hesaraghatta,
Bengaluru.

Dr. R.H. Laxman
Chairman (Works),
ICAR-IIHR, Hesaraghatta,
Bengaluru.

Dr. M. Sankaran
Chairman, Post-Graduation Cell,
ICAR-IIHR, Hesaraghatta,
Bengaluru.

Shri. S.K.C. Bose
Chief Finance & Accounts Officer,
ICAR-IIHR, Hesaraghatta,
Bengaluru.

Major Recommendations:

- 1. Progress of Engineering Works & Building:** The IMC suggested that the work may be done/completed as per rules and as per delegation of financial power following all codal formalities.
- 2. Disposal of buses of IIHR, Bengaluru:** The IMC suggested that this may be done as per rules and following all codal formalities. The matter may be referred to the Council for approval/concurrence of competent authority, wherever necessary.
- 3. Finance, Audit and Accounts matters:** The IMC suggested that the funds may be utilized as per allocation in BE/RE 2017-18 strictly adhering to the provisions in EFC and after following codal formalities.
- 4.** The IMC suggested that prior approval of the Council, wherever necessary, may be obtained for items concerning financial and administrative aspects before implementation of the approved recommendations of IMC.

13. Presentation of papers in Conferences/ Seminars/Symposia etc.

1. **Biology of Microbes Evolution along Technology, April 25, 2017, Mysuru, JSS University.**
 - Selvakumar G - presented a lead paper on Microbial Technologies for Horticultural Crop Production.
2. **Trends and innovations in Mushroom Science, April 27-28, 2017, DMR, Solan, HP.**
 - Meera Pandey- Mushroom technology as a social enterprise - The way forward.
3. **Second National Seminar-cum-Farmer's Fair, April 28–30, 2017, ICAR-NRCP, Solapur.**
 - Kanupriya and Murthy BNS - Molecular markers for pomegranate improvement, Status and future challenges.
 - Shivananda TN, Reddy PVR and Abraham Verghese - Management of pomegranate stem borer in field.
 - Usharani TR and Anjali - Recent advances in molecular breeding of pomegranate.
4. **National Symposium on Trends in Microbiology, May 12, 2017, Mysore University, Mysuru.**
 - Selvakumar G - lead paper on Microbial Innovations for Enhancing Horticultural Production
5. **National Seminar on Bio-resource Conservation and Utilization, May 13-14, 2017, UAS, Dharwad, College of Forestry, Sirisi, Karnataka.**
 - Ravishankar KV - Modern molecular tools for the assessment of diversity and characterization of bio resources.
6. **National conference on Horticultural crops of humid tropics diversification for sustainability, May 20-21, 2017, Madikeri, Kodagu.**
 - Aswath C - Orchids Anthurium and other ornamental crops for humid tropics.
 - Firoz H, Sampath Kumar P, Murthy BNS, Reddy MLN, Satisha J and Upreti KK - Use of chemicals to realize the productivity potential of pomegranate through increased flowering and fruiting.
 - Karunakaran G, Tripathi PC, Ravishankar H, Sankar V, Sakthivel T and Senthil Kumar R (2017) Scope and potential of rambutan cultivation in Western Ghats- Success story of farmers
7. **Third FAO–IAEA International Conference on “Area-wide Management of Insect Pests Integrating the Sterile Insect and Related Nuclear and Other Techniques”, May 22–26, 2017, IAEA Headquarters, Vienna, Austria.**
 - Karunakaran G, Ananthan M, Senthil Kumar R and Sankar V(2017) Improved technologies for Avocado cultivation.
 - Narayana CK, Shamina Azeez and Prakash Patil - Processing waste in jackfruit and the nutritional composition of its seeds.
 - Nimbolkar PK, Kurian RM, Upreti KK, Laxman RH and Varalakshmi LR - Seed germination and physio-biochemical changes in mango (*Mangifera indica*) seedlings under salinity.
 - Singh TH and Sadashiva AT -Vegetable crops and varieties suitable for humid tropics
8. **National Conference on Horticultural Crops of Humid Tropics: Diversification for Sustainability, May 25-26, 2017, Madikeri, Kodagu.**
 - Reddy PVR, Ashok Hadapad B, Shashank S, Soumya CB, Ramesh Hire S and Kamala Jayanthi PD - Pilot studies on the optimization of SIT through gamma radiation for the Oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae).
 - Bhuvanewari S and Varalakshmi B - Effect of drying on the quality of amaranthus leaves dried to different moisture levels.
 - Hebbar SS, Nair AK and Senthil Kumar M - Advances in production techniques for humid tropical vegetables.
 - Jayanthi Mala BR, Kamala Jayanthi PD, Shabharish Rai P, Raghava T and Reddy PVR - Occurrence of *Deudorix epijarbas* (Moore) (Lepidoptera: Lycaenidae) on Litchi (*Litchi chinensis* Sonn.) under humid tropics of South India.
 - Reddy PVR and Chakravarthy AK – Beekeeping a viable diversification option for ecosystem

services and economic returns.

9. International Conference on Recent trends in Agriculture, Biotechnology and Food Processing, College of Agriculture, July 5-7, 2017, Hassan.

- Usharani TR, Sunisha C, Sowmya HD and Saxena AK - Agrobacterium mediated transformation of banana (*Musa sp.*) cv. Neypoovan (AB) with plant ferredoxin-like protein (pflp) gene.

10. International Conference on Production, Value Addition and Marketing of jackfruit, August 9-14, 2017, RARS, Ambalavayal (KAU).

- Karunakaran G and Singh P (2017) Novel jackfruit selections with attractive coppery red flakes and high nutritive value for homesteads.
- Narayana CK, Prakash Patil, and Nagappa - Nutritional Enrichment of Indian Bread (Chapathi) using JFS Powder.
- Prakash Patil - Present status and future prospects of jackfruit in India.

11. Eighteen International Plant Nutrition Colloquium - Plant Nutrition for Global Green Growth, August 19-24, 2017, International Plant Nutrition Institute, University of Copenhagen at Department of Plant and Environmental Sciences, Faculty of Science, Copenhagen, Denmark.

- Satisha GC, Satisha J and Bansal SK - Effect of potassium fertilization on growth, yield and quality of sharad seedless grapes (*Vitis vinifera L.*)

12. Trends in Food Biotechnology, held at Defence Food Research Laboratory (DFRL), Aug 28 to Sep 01, Mysore.

- Meera Pandey - Mushrooms as source of nutrition and a compatible candidate for designer foods.

13. International Symposium on Horticulture Priorities & Emerging Trends, September 5-8, 2017, IISc Campus, Bengaluru, India.

- Aghora TS, Susmita C, Mohan N, Lakshmana Reddy, Tejesha and Raghu BR - Evaluation of soybean germplasm for vegetable types and molecular characterization for rust resistance.
- Alfia MA, Vasugi C and Linta Vincent - Studies on phenology of guava and wild species for crop

improvement.

- Anuradha Sane, Dinesh MR and Leela Sahijram - Using SSR markers and stomatal density for identification of clonal trees in polyembryonic mango variety Moreh.

- Anuradha Sane, Leela Sahijram, Madhusudhana Rao M and Dinesh MR - Using SSR markers and stomatal density for identification of clonal trees in polyembryonic mango variety Moreh.

- Anuradha Sane, Rekha A, Shamina A and Jasmin MR - Ethno-botanical and Phyto-chemical analysis of jamun (*Syzigium cumini*): a case study in tribal belt of Karnataka, India.

- Anushma PL, Linta Vincent and Rajasekharan PE - Freeze storage of pollen: Exploring the feasibility for pollen conservation and crop improvement in Passion flowers (*Passiflora spp.*).

- Aswath C - Advancement of Bioreactor technology in Horticulture crops

- Banoth Shiva, Murthy BNS, Dinesh MR and Rajasekharan PE - Effect of gamma ray irradiation and cryopreservation on pollen stainability, *in vitro* germination and fruit set in Pomegranate.

- Brinda R and Narayana CK - Effect of different extraction process on yield and quality of banana pseudostem fibre.

- Carolin Rathinakumari - Design and development of a power operated onion de-topper.

- Debi Sharma, Jyothi V Divakara and Prathiroopa - Residues of commonly used pesticides in exotic vegetables analyzed by LC-MS/MS for evaluation of waiting period.

- Debi Sharma, Uma Maheshwari, Jyothi V Divakara and Vasugi B - Efficacy and persistence of dazomet residues in poly house soil for control of root knot nematode.

- Deepa Pujar, Vasugi C, Dinesh MR, Krishna Reddy and Kanupriya - Studies on cross compatibility of Papaya with *Vasconcellea* species.

- Gajanana TM, Sreenivasa Murthy D, Saxena AK, Sudhakar Rao DV, Sudha M and

- Dakshinamoorthy V - Post harvest loss and marketing of fruits: economic analysis of pink flesh guava in local and distant markets.
- Ganga Visalakshy PN and Pillai KG - Promising microbial control agents for management of *Myllocerus subasciatus* Guerin infesting brinjal (*Solanum melongena* L.).
 - Ganga Visalakshy PN, Swathi C, Frenita Lewis, Krishnamoorthy A - A bio-intensive management strategy for thrips on bell pepper under polyhouse conditions.
 - Harikanth Porika, Satisha J, Sampath Kumar P, Upreti KK and Shivashankar - Effect of various viticultural practices for the improvement of fruit quality in coloured grapes cv. Red Globe.
 - Hemachandra Reddy P, Salil Jalali, Samuel DK and Krishna Reddy M - Biological and molecular detection of Turnip mosaic virus (TuMV) infecting radish in India.
 - Hemlata T, Manjunatha Rao, Leela Sahijram, Rajiv Kumar, Dhananjaya MV, Venugopalan R and Sriram S - Factors affecting aeroponics in horticulture crops.
 - Jayanthi Mala BR, Kamala Jayanthi PD, Shivashankara KS and David KJ - Behavioural responses of predatory gall midge, *Triommata coccidivora* (Diptera: Cecidomyiidae) to conspecific volatiles.
 - Kalaivanan D, Selvakumar G, Ganeshamurthy AN and Shankara Hebbar S - Growth Biomass and Yield of Zucchini as influenced by Nutrient Scheduling under Soilless Cultivation.
 - Kamala Jayanthi PD - Integrated Pest Management in Horticultural crops.
 - Kamala Jayanthi PD, Raghava T, Vivek Kempuraj and Jayanthi Mala BR – Semiochemicals an ecosystem approach to manage horticulture crop pests.
 - Kamala Jayanthi PD, Vivek Kempuraj and Saravan Kumar, Octopamine - Ecdysone rush: A trigger to wing development in padded aphids.
 - Kanupriya, Murthy BNS - Application of microsatellite markers in study of pomegranate germplasm resources.
 - Karunakaran G, Dinesh MR, Vasugi C and Krishna Reddy - Induced γ - irradiation on germination, sensitivity and survivability of papaya (*Carica Papaya* L.) cv. Arka Prabhat and Arka Surya.
 - Karunakaran G, Ravishankar H, Tripathi PC, Sakthivel T, Sankar V and Senthilkumar R - Potential and Promising Edible Future Fruit Crops for Western Ghats.
 - Krishna Reddy M - Diagnosis and management of virus diseases of Horticultural crops.
 - Krishna Reddy M, Akshata Gad and Pavithra BS - Computational prediction of potential MHC binding peptides and epitope mapping for the detection of Groundnut bud necrosis virus.
 - Kumar PC and Bhuvaneshwari S - Development of leaf powder and spray dried powder from *Moringa oleifera* as a potential source of phytochemicals.
 - Laxman RH, Hemamalini P, Geeta Biradar, Namratha MR., Bhatt RM., Sadashiva, AT - High throughput phenotyping of tomato genotypes through digital features using plant phenomics facility
 - Leela Sahijram B, Madhusudhana Rao, Kanupriya, Manamohan M, Methyloomics: DNA methylation modification - A novel approach to breeding crops.
 - Lekha, S, Mohapatra, S, Nagapooja, YM, Radhika, B, Uptake of spiromesifen in cabbage and tomato from soil application.
 - Linta Vincent, Vasugi C, Dinesh MR - Pollen Cryopreservation in *Vasconcellea* species: An approach for introgressing Papaya Ring Spot Virus resistant genes into *Carica papaya*.
 - Meera Pandey, Satisha GC, Jameel Mazhar, Bharathi and Punita Kumari - Mushrooms as a novel complimentary food to mitigate mineral malnutrition.
 - Meera Pandey, Satisha GC, Jameel Mazhar, Bharathi and Punitha Kumari - Mushrooms as a novel complimentary food to mitigate mineral malnutrition.
 - Mythili JB - Establishment of hairy root culture of *Coleus forskohlii* for the production of forskolin.
 - Nagapooja YM, Soudamini Mohapatra, Lekha S, Radhika B, Shambulinga G, Veena Rao U, Danish PR, Sampath KP, and Satisha J - Dissipation of fluopyram and tebuconazole on grapes and into soil.

- Nagesh GC, Sreenivasa Rao E, Pitchaimuthu M, Varlakshmi B, Rekha A, Lakshmana Reddy DC, Krishna Reddy M and Samuel DK - Genetic analysis for watermelon bud necrosis virus (WBNV) in watermelon [*Citrullus lanatus* (Thunb.) Matsum & Nakaj].
- Nandeesh P, Bharath V and Mahadevaswamy HS - Towards cloning nematocidal *cry* genes from Indian isolates of *Bacillus thuringiensis*.
- Nandeesh P, Bharath V, Umamaheswari R and Rao MS - Bio-evaluation of nematocidal *Bacillus thuringiensis* against *Meloidogyne incognita* infesting tomato roots.
- Narayana CK and Shamina Azeez - Quantification of juice yield and processing waste in pomegranate fruit and nutritional composition of its peels.
- Nimbolkar PK, Kurian RM, Upreti KK, Laxman RH, Shivashankara KS and Varalakshmi LR - Physio-biochemical responses of polyembryonic mango (*Mangifera indica*) genotypes to varying levels of salinity.
- Nitin KS, Sridhar V and Chakravarthy AK - Effect of elevated carbon dioxide and temperature on the growth of South American tomato moth, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae).
- Padmini K - Effect of pollen storage conditions and pollen storage period on fruit set and seed yield in hybrid seed production of watermelon under open field conditions.
- Pitchaimuthu M, Sandeep Kumar GM, Ravishankar KV, Chandrakala A, Chandrasekhar and Radhika Hegde - Screening for resistance to downy mildew caused by *Pseudoperonospora cubensis* (Berk. and Curt.) Rostov. in cucumber (*Cucumis sativus* L.).
- Pritee Singh and Rao VK - Water stress induced stage specific variation in andrographolide content in *Andrographis paniculata* (kalmegh).
- Pushpavathi Y, Satisha J, Shivashankara KS, Satisha GC and Sriram S - Variation in incidence of downy mildew disease on Sharad Seedless grapes as influenced by different sources of potassium and their method of application.
- Pushpavathi Y, Satisha J, Shivashankara KS, Satisha GC, Sunita Patil Sriram S - Different sources of potassium and their method of application influences growth, yield and quality of Grapes cv. Sharad Seedless (*Vitis vinifera* L.).
- R Venkattakumar presented a paper on Role of Farmers Producers Organizations (FPOs) in Promoting Horticultural Innovations: Experience of Selected FPO.
- Radha TK, Ganeshamurthy AN, Rupa TR and Srividya BR - Soil enzymes and microbial populations in mono and multi varietal Mango orchards of Chittoor district.
- Radhika V - An Epidemiological Model to study the Disease Development in Viral Diseases in Horticultural Crops.
- Radhika V, Rajasekharan PE, Kanupriya and Tripathi PC - An Online Information System for the Germplasm collection of IIHR.
- Radhika, B, Mohapatra, S, Lekha S, Nagapooja, YM, Shambulinga, G, Veena Rao U, Danish, PR - Uptake and translocation of flubendiamide in capsicum plant.
- Radhika, Rajasekharan VPE, Kanupriya and Tripathi PC - An Online Information System for the Germplasm collection of IIHR.
- Raghupathi HB and Shilpashree VM - Plant nutrient imbalance and interactions in pomegranate under a semi-arid region of Peninsular India.
- Rajasekharan PE - In vitro conservation of RET medicinal plants: challenges and prospects.
- Rao MS - Biopesticide interventions to manage nematode induced disease complex in protected horticulture.
- Rao TM, Aswath, C, Tejaswini, Dhananjaya, MV, Rajiv Kumar, Usha Bharathi T, Rao MS, Sriram S, Sridhar V and Umamaheshari R - Advances in breeding for biotic resistance in flower crops at ICAR-IIHR, Bengaluru.
- Reddy PVR, Varun Rajan V, Sudhagar S and Kavitha SJ - Impact of climate change on pollinators and their ecosystem services: Implications in horticultural crops.
- Renuka HM, Ganesh Naik and Krishna Reddy M - Survey and identification of Groundnut bud necrosis virus isolates infecting tomato in Karnataka.
- Rupa TR - Nutritional Status of Mango Orchards in Chittoor District of Andhra Pradesh, India.

- Saidulu Yeluguri, Tejaswini and Sriram S - Screening for black spot (*Diplocarpon rosae*) resistance in *Rosa* spp and identification of resistant source for rose breeding.
- Sakthivel T and Karunakaran G - Genetic Improvement of Annonaceous fruits.
- Satisha GC, T.N.V.K.V, Prasad, Bharathi K and Ganeshamurthy AN - Influence of zinc oxide nanoparticles on zinc uptake, biomass production and yield of cabbage (*Brassica oleracea* var. capitata).
- Saxena AK - Epidemiology and management of rust in grape var. Bangalore Blue.
- Selvakumar G - Microbes for Higher productivity in Horticultural Crops.
- Senthil Kumar R, Sankar V, Gowda IND, Karunakaran G, Tripathi PC and Sakthivel T - Evaluation of Avocado suitable for cultivation in Kodagu Region of South.
- Senthil Kumar R, Sankar V, Karunakaran G and Tripathi PC - Evaluation of Dragon fruit in Kodagu Region of Karnataka.
- Senthil Kumaran G - Development of a Mango Dipping Tool to Control Spongy Tissue.
- Shamina Azeez, Karunakaran G, Tripathi PC, Shivashankara KS and Roy TK - Nutrient composition of four promising avocado collections from India.
- Shivananda TN - Standardizing cultivation practices for *Mucuna Utilis* (L.) an important medicinal plant.
- Shivananda TN and Srivastava HC - Standardizing growth medium to *Plecrantus vettiveroides* – an endangered medicinal plant.
- Shwetha HK and Kanupriya - Analysis of genetic diversity in pomegranate using SRAP markers.
- Sridhar V, Gajalakshi M and Swathi P - Baseline susceptibility of South American tomato moth, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) to insecticides.
- Sridhar V, Onkara Naik S, Nitin KS, Ramesh K and Chakravarthy AK - Efficacy of Spinetoram 12 SC against South American tomato moth, *Tuta absoluta* (Lepidoptera: Gelechiidae) on tomato.
- Sriram S, Sandeepkumar GM and Kumawat MK - Management of black spot caused by *Diplocarpon rosae* in open cultivated rose using strobilurin and triazole fungicides S5016 A639.
- Subhash C, Rajasekharan PE and Kurian RM - Pollen viability and storability of sugar apple cv. Balanagar.
- Sudhakar Rao, Hebbar SS and Anand SK - CFB box wrapping of vegetables - A new shrink wrapping technology.
- Sunita Patil, Satisha J, Pushpavathi Y, Sampath kumar P and Upreti KK - Improving bunch and berry quality of Red Globe grapes through application of alternate flower berry thinning chemicals.
- Sunita Patil, Satisha J, Pushpavathi Y, Sampath kumar P and Upreti KK - Standardization of GA₃ concentration for reducing bunch compactness by improving rachis elongation in Crimson Seedless grapes (*Vitis Vinifera* L.).
- Suveditha S, Hema Chandra Reddy P, Salil Jalali and Krishna Reddy M - Identification and diagnosis of Tomato mottle mosaic virus in Tomato.
- Swathi P, Das SB and Ganga Visalakshy PN - In vitro evaluation for compatibility of additives with *Beauveria bassiana* (Balsamo) Vuillemin.
- Swathi, Ganga Visalakshy PN and Das SB - Potentiality of *Beauveria bassiana* isolates against South American tomato leaf miner, *Tuta absoluta* (Meyrick) through laboratory bioassay.
- Thomas P - Feasibility of commercial scale micropropagation of papaya (*Carica papaya* L.).
- Thomas P and Pitchaimuthu M - Micropropagation of Triploid Seedless Watermelon: A Feasibility Assessment.
- Tiwari RB - Developments in osmotic dehydration technique for value-addition in fruits and vegetables.
- Tripathi PC, Ganeshan S and Sakthivel T - Characterization of *bael* accessions for morphological and fruit characters.
- Tripathi PC, Ganeshan S and Shetti DL - Identification of thornless lines of Governor's plum (*Flacourtia indica*) from a segregating population.
- Umamaheswari R - Bioefficacy of Entomopa-

thogenic Nematodes on Insect Pests of Horticultural Crops.

- Umamaheswari R - Rhizospheric interventions with biopesticides to manage root knot nematode, *Meloidogyne incognita* in tomato (*Solanum lycopersicum* L.)
- Umamaheswari, Rao MS and Ganga Visalakshy PN - Bio-efficacy of Entomopathogenic Nematodes on Insect pests of Horticultural crops.
- Usha Bharathi T and Kirthishree SP, Cut style pollination - A method to temporarily suppress self-incompatibility in tuberose (*Polianthes tuberosa* L.).
- Usharani TR, Meenakshi S, Sunisha C, Sowmya HD, Poovarasan S, Mohandas S - Loop-mediated isothermal amplification for rapid and sensitive detection of *Xanthomonas axonopodis* pv. *Punicae* infecting Pomegranate.
- Varalakshmi B and Deepak GC - Identification of male sterility, its inheritance and fertility restoration in Ridge gourd [*Luffa acutangula* (Roxb.) L.].
- Varalakshmi LR - Effect of conventional and water soluble fertilizers on NPK content in rhizosphere and on growth and yield of papaya.
- Veere Gowda R, Madhavi Reddy K, Pitchaimuthu M, Varalakshmi B, Tejaswini, Lakshmana Reddy DC, Padmini K and Anuradha Sane - Development of male sterility based F1 hybrids in Horticultural Crops for doubling the farmers income.
- Yogeesh HS and Bhanuprakash K - Ultra dry seed storage as a cost effective technique for germplasm conservation of horticultural crops.

14. National symposium of Indian Phytopathological Society (South zone), September 12-13, 2017, College of Horticulture, UHS campus, GKVK, Bengaluru.

- Venkataravanappa *et al.* - Detection, characterization and *In-silico* analysis of *Candidatus Phytoplasma australasiae* associated with big bud disease of tomato in India.
- Venkataravanappa *et al.* - Recombinant Tomato leaf curl new Delhi virus is associated with yellow vein mosaic of okra in India.

15. National symposium on Emerging trends in plant

health management in relation to climate change, September 12-13, 2017, College of Horticulture, Bengaluru, UHS, Bagalkot, IPS, New Delhi.

- Duleep Kumar Samuel M, Krishna Reddy M, Hema Chandra Reddy P, Salil Jalali, Sriram S, Saxena AK and Pavithra BS - Ultrastructural Imaging and Analysis of Plant Pathogens Using Scanning and Transmission Electron Microscopy.
- Krishna Reddy M - Recent advances in plant pathogen diagnosis in the genomic era.
- Kumawat MK, Chandran NK, Sriram S - Identification of alternate fungicides for the management of carbendazim resistance in *Fusarium* species causing wilt in gladiolus and marigold.
- Mahesha B - Development of sap transmission method for onion (*Allium sativum* L.) infecting *Iris yellow spot virus* (G: Tosspovirus, F: Bunyaviridae).
- Praful MV, Anjaneya Reddy B, Krishna Reddy M, and Ramachandra RK - Molecular diagnosis of ChiVMV causing mosaic in Capsicum (*Capsicum annuum* var. *grossum*).
- Praful MV, Anjaneya Reddy B, Krishna Reddy M, Anjanappa M and Ramachandra RK - Epidemiology and loss assessment of Chilli veinal mottle virus causing mosaic in Capsicum (*Capsicum annuum* var. *grossum*).
- Rajeshwari R and Krishna Reddy M - Molecular characterization of begomovirus associated with bitter melon yellow mosaic virus disease in Kerala.
- Rajeshwari R and Krishna Reddy M - Genetic diversity of secondary endosymbionts of whitefly, *Bemisia tabaci* in Karnataka, India.
- Swarnalatha P, Ashwathappa KV, Salil Jalai and Krishna Reddy M - Molecular characterization of *Phytoplasma* associated with French bean (*Phaseolus vulgaris*).

- Venkataravanappa V and Krishna Reddy M - Recombinant Tomato leaf curl New Delhi is associated with yellow vein mosaic of Okra in India.
 - Venkataravanappa V, Swarnalatha P and Krishna Reddy M - Detection, characterization and In silico analysis of *Candidatus Phytoplasma australasiae* associated with big bud disease of tomato in India.
- 16. National Conference on Rural Resources Management for Climate Smart Sustainable Agriculture, September 13, 2017, Barapani, Meghalaya.**
- Saxena AK, Thilaka Rani R and Rathnamma K - Disease dynamics and mitigation of anthracnose in mango in view of Climate Change.
- 17. Project launch of Mainstreaming Jackfruit, Custard apple & Jamun diversity through Custodian Farmers, September 23, 2017, HC & RI, Periyakulam (TNAU), Tamil Nadu.**
- Prakash Patil - Jackfruit – a versatile potential minor.
- 18. National Workshop on Developing a Roadmap for Agricultural Knowledge Management in India, September 27-28, 2017, NASC Complex, New Delhi.**
- Sridhar Gutam - Open Access to Agricultural Sciences through Community Platforms.
- 19. National Seminar on Nanotechnology for Evergreen Revolution, October 5-6, 2017, Tamil Nadu Agricultural University, Coimbatore, India.**
- Satisha GC and T.N.V.K.V. Prasad - Synthesis of ZnO Nano-particles and its positive effect on Cole Crops.
- 20. Asian conference on remote sensing, October 23-27, 2017, New Delhi, India.**
- Mohammed Ahamed J, Raghupathi HB, Gowri UN, Shilpashree VM, Ganeshamurthy, AN Hebbar, Uday Raj - Retrieval leaf chlorophyll and nitrogen content of mango leaf from leaf level hyperspectral measurements.
 - Mohammed Ahamed, Bharath Kumar J, Reddy K, Raghupathi HB, Hebbar R, Ganesha Raj, Uday Raj - Varietal discrimination of mango (alphonso and totapuri) using leaf spectra from ground based hyperspectral measurements.
- 21. International conference and Expo on Agriculture and Veterinary Sciences: Research and Technology, October 23-25, 2017, PJTSAU, Hyderabad.**
- Deepa Samant - Effective anti-browning treatment for ready to cook (RTC) tender jackfruit.
- 22. International Symposium on Tropical Fruits 2017 (ISTF 2017), October 23-25, 2017, Nadi, Fiji.**
- Prakash Patil - Ensuring a Sustainable Tropical Fruit Industry in the Midst of Climate Change - The India Story.
- 23. Seventh International Conference on Silicon in Agriculture, October 24-28, Bengaluru, University of Agricultural Sciences, GKVK, India.**
- Satisha GC, Saxena Ak and Ganeshamurthy AN - Effect of silicon and Micronutrients on Plant Growth, yield and disease incidence in Chilli (*Brassica oleracea* var. capitata).
- 24. UNESCO-NDL India International workshop on knowledge engineering for digital library design, New Delhi, India. October 25-27, 2017.**
- Sridhar Gutam - Communities of practices for Open Access in South Asia.
- 25. Potential Impact of Pesticides on Environment and Human Health, November 2-4, 2017, Dayanand sagar College, Bangalore, Karnataka.**
- Nagapooja, YM, Mohapatra, S, Lekha S, Veena Rao U, Shambulinga G, Danish PR, Dissipation of tebufenpyrad on tomato and its risk assessment.
 - Veena Rao U, Mohapatra S, Nagapooja YM, Lekha S, Shambulinga G, Danish PR - Dissipation of imidacloprid on chilli and its risk assessment.
- 26. Knowledge Sharing Workshop on Tropical Fruits-Banana and Pomegranate, November 5, 2017, Anantapuramu, Andhra Pradesh.**
- Sudhakar Rao DV - Post harvest management of banana.
- 27. Agricultural, Allied Sciences & Biotechnology for Sustainability of Agriculture, Nutrition & Food Security, November 25-26, 2017, Banaras**

Hindu University, Varanasi.

- Mohapatra, S, Lekha, S, Radhika B and Nagapooja YM - Effect of environmental factors on the persistence of imidacloprid, indoxacarb and thiamethoxam in/on pomegranate.
- 28. Challenges of mechanization in Onion and Garlic, Directorate of Onion and Garlic, Pune, December 2, 2017.**
- Senthil Kumaran G - Current status and future prospects of mechanization in Onion and Garlic.
- 29. National Conference on New Vistas in Vegetable Research towards Nutritional Security under Changing Climate Scenario, Tamil Nadu Agricultural University, Coimbatore, December 6-9, 2017**
- Carolin Rathinakumari A - Automatic protrait conveying and dibbling unit for vegetable nursery.
- 30. Twenty sixth Annual conference of Indian Virological Society Virocon 2017 on Viruses in Health and Disease, December 7-9, 2017, Mangaluru, India.**
- Akshata Gad, Hema Chandra Reddy P and Krishna Reddy M - Computational prediction of Epitope based peptides for immuno-diagnosis of *Chilli veinal mottle virus*.
- Ashwathappa KV, Swarnalatha P, Jalali S and Krishna Reddy M - Identification of Tomato leaf curl Gujarat virus infecting *Xanthium strumarium* a new host for begomoviruses.
- Krishna Reddy M - Emerging Plant viruses : A threat for future.
- Suveditha S, Swarnalatha P, Jalali S and Krishna Reddy M - Identification and molecular diagnosis of viruses infecting Cucumber.
- 31. National Academy of Sciences, India (NASI) Eighty Seventh Annual Session and the National Symposium on “Basic Research - its role in national development”, December 8-10, 2017, Savitribai Phule University, Pune.**
- Thomas P - Endophytic Microbiology as a Significant Emerging Area for Basic Research in Plant Biology.
- 32. National conference on food and Nutritional Security through Vegetable crops in relation to Climate Change December 9, 2017, IIVR, Varanasi.**
- Sadashiva AT, Veere Gowda R, Madhavi Reddy K, Singh TH, Pitchaimuthu M, Varalakshmi B, Shankara Hebbar, Rao ES, Bharathi LK, Senthil Kumar M, Nage gowda NS and Lasya Bhat - Doubling the farmer's income through adoption of F1 hybrids in Vegetable Crops.
- 33. National Seminar on “Developments in Soil Science 2017” during the Eighty Second Annual Convention, December 11-14, 2017, Amity University, Kolkata.**
- Raghupathi HB, Srinivas S and Shilpashree VM - Establishing relationship between plant nutrient and diseases incidence by spatial analysis in pomegranate.
- Satisha GC, Ganeshamurthy AN and Mazhar Jamil - Effect of different sources of calcium on the incidence of blossom-end rot, marketable yield and fruit quality of Tomato (*Lycopersicon esculentum* Mill.).
- 34. International Conference on Climate Change and Sustainable Development, December 14, 2017, Annai Fatima College, Madurai**
- Selvakumar G - A lead paper on Role of Microbes in Climate Resilient Agriculture.
- 35. Mega Horticulture Fair 2017, December 22, 2017, University of Horticultural Sciences, Bagalkot,**
- Shivananda TN - How to double the farmers income in mango cultivation by adopting advance technologies?
- 36. CAFT course on Exploitation and conservation of Plant Genetic Resources in Major, minor and Underexploited Fruits, December 23, 2017, COH, Mysore.**
- Prakash Patil - Conservation and utilization of PGR in jackfruit and sapota.
- 37. National Symposium on Recent Advances on Floriculture and Urban Horticulture in Global Perspective, BCKV Floriculture & Landscape Architecture, January 04-05, 2018, Mohanpur, Nadia, West Bengal.**
- Leela Sahijram and Nandeesh P - GM and non-GM

biotechnologies in the improvement of floriculture.

- Manjunatha Rao T - Advances in breeding for disease resistance in flower crops.
- 38. National Conference on improving income of farmers through Agriculture and aquaculture through development interventions, January 5-7, 2018, Society of Krishi Vigyan and Association of Aqua culturists at CIFA Bhubaneswar.**
- Saju George - Arka Microbial Consortium Technology: Helping Black Pepper Farmers Increase Farm Income in an Eco friendly Way.
- 39. National Symposium on Doubling the Farmers Income through Technological Interventions, January 6-8, 2018, Anand Agricultural University, Anand.**
- Carolin Rathinakumari A - Design and development of a square shaft twisting machine for developing onion de-topping tool.
- 40. International seminar on Agricultural and Food for Inclusive Growth and Development, January 14-15, 2018, CSIR-NBRI, Lucknow.**
- Venkataravanappa *et al.* - Diversity and Phylogeography of begomviruses and their satellites associated yellow vein mosaic and enation leaf curl disease of wild and cultivated species of okra,
- 41. Current trends in Biosciences, January 23, 2018, Sri Sathya Sai Institute of Higher learning, Anantapur campus, Andhra Pradesh.**
- Meera Pandey - Nutrition and medicinal potential of Mushrooms.
- 42. International Conference on Biocontrol and Sustainable Insect Pest Management, Jan 29-31, 2018, Killikulam, Tamil Nadu.**
- Sridhar V and Swathi P - Compatibility of pesticides with entomopathogenic fungi, *Metarhizium anisopliae* (Metchnikoff) Sorokin infecting *Tuta absoluta* (Meyrick).
- Sridhar V, Onkara Naik S, Nitin KS and Swathi P - Integrated Pest Management components against *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) on tomato.
- 43. National Seminar on Innovation, IPR and Entrepreneurial opportunities in BT, January 29-31, 2018, Sir M Visvesvaraya Institute of Technology, Bengaluru.**
- Usharani TR, Sowmya HD, Anjali PC, Manamohan M and Krishnareddy M – RNAi- Mediated Resistance to cucumber Mosaic virus (CMV) in Tomato cv Arka Vikas.
- 44. XVI AZRA International Conference, February 9-11, 2018, BHU, Varanasi.**
- Reddy PVR and Varun Rajan V - Ecosystem services of multi-varietal mango orchards through crop associated biodiversity with special reference to insects.
- Swathi P, Das SB and Sridhar V *Tuta absoluta* – an invasive pest: A brief Review.
- Sridhar V, Kamala Jayanthi PD and Nitin K- Climate change mediated impact of elevated temperatures and carbon dioxide on major pests of tomato.
- 45. National Conference on Floriculture for Rural and Urban Prosperity in the Scenario of Climate Change, February, 16-18, 2018, Ranipool, Sikkim.**
- Raja Babu K, Sumangala HP and Rupa TR - Effect of fertigation, irrigation and mulching on growth and nutrient uptake pattern in African marigold.
- 46. National conference on Specialised Ayurvedic and Innovative Foods and Nutrition, February 16-17, 2018, Sri Sathya Sai Institute of Higher Learning, Anantapur.**
- Meera Pandey - Mushrooms as novel source of nutrition.
- 47. National Seminar and Banana Festival, February 17-21, 2018, Kalliyoor, Thiruvananthapuram, Kerala.**
- Bhuvanewari S and Narayana CK - Development of value added fruit tray cushions from banana pseudostem for packaging of fruits.
- 48. Workshop on Crop Management and Precision farming in guava and Jasmine, February 26, 2018, Swarna Bhartha Trust Akuru, Vijayawada.**
- Tiwari RB - Value addition in guava
- 49. National Conference on Digital and Engineering Technologies for Precision Agriculture and Value Addition, February 26-27, 2018, College of Agricultural Engineering, ANGRAU, Bapatla, Andhra Pradesh.**

- Venu SA - Investigation on Energy Utilization for Rose Onion (*Allium Cepa L.*) Cultivation by adopting Conventional and Selected Mechanized Practices.
- 50. International conference on sustainable business practices for rural development, February 28 to March 1, 2018, Jammu University, Jammu.**
- Tiwari RB- Role of Agro-industry on sustainable development.
 - Tiwari RB -Structural Challenges for Rural Development with reference to Agriculture.
- 51. National seminar on wild edible fruits of Western Ghats, March 2-3, 2018, College of Forestry, Ponnampet, Karnataka.**
- Kanupriya, Tripathi, PC and Swati Sahu - Diversity analysis in *Garcinia* species using SRAP markers.
 - Karunakaran G, Tripathi PC and Sankar V - Status of wild edible fruits and their ethno-botanical knowledge in western ghats.
 - Tripathi PC, Karunakaran G, Sankar V and Kanupriya - Exploration, collection and characterization of native fruits of Western Ghats.
- Tripathi PC Kanupriya and Shetti DL - *Ex-situ* Characterization and evaluation of wild edible species of Western Ghats.
 - Yogeesha HS, Ganeshan S and Tripathi PC - Fruit and seed morphology, seed germination and storage studies in *Flacourtiamontana graham* an underutilized fruit crop of Western Ghats of India.
- 52. Seminar on Eco-Physiological Approaches in Stress and Post - Harvest Management, March 06, 2018, Regional Agricultural Research Station, KAU, Kumarokom.**
- Narayana CK - Recent Advances Post- Harvest Management in Fruits and Vegetables.
- 53. International Conference on Invigorating Transformation of Farm Extension towards Sustainable Development: Futuristic Challenges and Prospects (INTFES – 2018), March 9, 2018, Tamil Nadu Agricultural University, Coimbatore.**
- Venkattakumar R -Strategies for doubling the farmers' income: A case of FPOs.

14. Symposia / Seminars /Other Events

14.1 The National Horticultural Fair, 2018

The National Horticultural Fair 2018 (March 15-17, 2018) was held at ICAR-IIHR where knowledge was shared by the scientists and other stakeholders on recent innovations in tools and technologies in the area of horticulture besides addressing emerging challenges of climate change, abiotic and biotic stresses, energy crisis, value chain management and markets through showcasing and interactions between subject matter specialists, model farmers (experience sharing) and other farmers. The Fair was inaugurated on March 15, 2018 by Dr D. L. Maheshwar, Vice Chancellor, University of Horticultural Sciences, Bagalkot, Karnataka. The fair had overwhelming response from the stakeholders, especially, the farmers. More than 2500 farmers and other stakeholders representing Karnataka, Andhra Pradesh, Telangana, Maharashtra, Kerala and Tamil Nadu participated.

During the inaugural session, Smt. Kamala, Narasipura, Tarabanahalli, Bengaluru, a progressive mushroom cultivator, Mr. Mahaboob, KMC Biotech, Chitradurga, a progressive grower of medicinal crops; Sri. Murthy, Nanjangudu, Chamrajanagar district, a progressive polyhouse farmer and Sri. Kempanna, Doddaballapur, a progressive onion grower were felicitated for their achievements. These progressive farmers shared their success stories of adopting ICAR-IIHR technologies.

Live demonstrations of fruits, vegetables, ornamental crop cultivars, recommended production technologies for plant nutrient management as well as pest and disease management were put on display at exhibition (100 stalls) by the organizations of NARES. On the first day a scientists-farmers interface session on the theme "Horticulture for promoting rural entrepreneurship" was chaired by Dr. A.T. Sadashiva, Principal Scientist and Head, Division of Vegetable Crops and Co-Chaired by Dr. Reju Kurian, Principal Scientist and Head, Division of Fruit Crops. Heads of Divisions of ICAR-IIHR was held.

On the 2nd day, there was a farmers-scientists interaction on "Handholding of members of Farmers Producer Organizations (FPOs) and HOPCOMS". This session was chaired by Dr. Harinder Singh Oberoi, Head, PHT&AE and Co-chaired by Dr. Sudha Mysore, Principal Scientist & Chairperson, BPD, IIHR. All Heads of Divisions of

ICAR-IIHR were the panelists during the interaction. The queries of farmers on production technology, processing, value addition, marketing and export of horticultural crops were addressed. The 2nd day of event had more than 3600 visitors representing Karnataka, Pondicherry, Telangana, Andhra Pradesh, Orissa.

On the 3rd day, there was live webcast of speech of Shri Narendra Modiji, Honorable PM of India delivered at the inaugural function of Krishi Unnati Mela and Biennial KVK Conference, New Delhi from 11.30 AM to 1.30 PM for the benefit of local farmers. The Honorable Prime Minister was addressing 681 KVKs, reaching out to seven lakh progressive farmers, agricultural scientists of ICAR institutes, state agricultural universities (SAUs) and officials of development departments. More than 1000 farmers, students, representatives of development departments, private industry, members of NGOs, FPOs representing Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Telangana, Orissa, Bihar, West Bengal, Maharashtra etc. Watched live telecast. The live telecast covered the scintillating and thought-provoking speech of Hon'ble Prime Minister about the innovative and need based agricultural developmental schemes and programmes of the Government of India.

In the afternoon, there was an interaction session on mango cultivation. Shri. C. D. Nagaraju, Managing Director, Karnataka State Mango Development Corporation (KSMD), Govt. of Karnataka participated as Chief Guest and delivered talk on programmes and schemes implemented by KSMD. This programme was followed by a valedictory session during which Dr. K. Narayana Gowda, Former Vice Chancellor, UAS, Bengaluru participated as Chief Guest and distributed certificates to the best Exhibition stalls. In his valedictory address, Dr. Narayana Gowda appreciated the efforts of ICAR-IIHR of organizing such event in order to disseminate the technologies developed by ICAR-IIHR and suggested that such events should be conducted regularly. Dr. M.R. Dinesh, Director, ICAR-IIHR stated that the fair was an opportunity for the farmers to observe live demonstrations, learn technologies through exhibition stalls and interact with the scientists and other progressive farmers. The 3rd day of the event had more than 2500 participants from Karnataka, Tamil Nadu, Telangana, Andhra Pradesh, Orissa and Bihar. Over all, the event had participation of 9000 farmers representing ten states of the country.



National Horticultural Fair – 2018 – glimpses

14.2 Conferences / Seminars / Symposia / Meetings

National Conference on Horticultural Crops of Humid Tropics - Diversification for Sustainability

National Conference on Horticultural Crops of Humid Tropics Diversification for Sustainability was organized by CHES, ICAR-IIHR, Chettalli at Gandhi Maidhan, Madikeri, Coorg on May 20-21, 2017 in collaboration with Society for Promotion of Horticulture (SPH), Bangalore. The conference was aimed to create a platform for exchange of ideas and thoughts among the scientific fraternity, entrepreneurs, farmers, growers, students etc. From ICAR institutes, SAUs, KVKs and other Govt. and Non - Govt. Organizations from different parts of the country who have been associated with humid tropical horticultural crops. The Inaugural session was chaired by Dr. M R Dinesh, Director, IIHR, Bangalore, Guest of Honour, Sri. Bose Mandanna, Progressive Planter & Ex-Chairman, Coffee board. Chief guest of the programme was Dr. A K Singh, DDG (Horticultural Science), ICAR, New Delhi, Dr. Janakiram, ADG (Horticultural Science) ICAR, New Delhi, Dr. VA Parthasarathy, Ex-Director IISR, Calicut and Dr. Doreyappa Gowda, Head, CHES, ICAR-IIHR, Chettalli, Coorg. On this occasion,

a souvenir and abstracts of National conference, CD-ROM of lead papers and abstracts, Indian Horticulture – a Special issue of IIHR and a technical bulletin on "Management of diseases and pests of coorg mandarin" were also released. Honorable DDG (Hort.) Dr. A K Singh emphasized on conservation and utilization of these less known fruits for food and nutritional security of the common people. Dr. M R Dinesh, Director, IIHR, Bengaluru described the achievements of the station and about research and development of the underutilized fruits particularly Rambutan, Mangosteen, Avocado, Passion fruit etc. He emphasized for more work on production and post harvest technologies of these crops. Dr. V A Parthasarthy, emphasized the role of underutilized fruits and tree spices in the livelihood security of rural and tribal people. He opined on farm conservation of the indigenous underutilized fruits and tree spices. Dr. Janakiram, ADG (Horticultural Science), ICAR, New Delhi spoke about scope of various underutilized horticultural crops in future markets. More than 1000 scientists, farmers/ planters, progressive growers, processors, entrepreneurs, government officials and marketing experts from all over the country viz. Karnataka, Tamil Nadu, Maharashtra, Andhra Pradesh, Kerala and Goa participated during the two days conference.



National Conference on Horticultural Crops of Humid Tropics

XXXV Group meeting of AICRP on Vegetable Crops

XXXV Group Meeting of Vegetable research workers of 'All India Coordinated Research Project on Vegetable Crops' was held from 24 -27th June, 2017 at ICAR-IIHR, Bengaluru. Important delegates included Dr. Kirti Singh, Dr. G.Kaloo, Dr.A.K.Singh, Dr. T. Janakiram, Dr. B Singh, Dr. A B Rai and Dr. M R Dinesh. More than 250 delegates including all the scientists of the Division of Vegetable crops participated in the Group meeting. Dr. Manmohan Attavar, Chairman, Indo-American Hybrid Seeds Pvt. Ltd, Bengaluru was felicitated for his significant contributions for the development of vegetable seed industry in the country. Exhibition stalls by ICAR- IIHR and private seed companies were also put up to display their technologies.



Group meeting of AICRP

International Symposium on Horticulture: Priorities & Emerging Trends

An International Symposium on 'Horticulture: Priorities & Emerging Trends' jointly organized by ICAR – Indian Institute of Horticulture Research, Bengaluru, Society for Promotion of Horticulture (SPH) and International Society for Horticultural Sciences (ISHS), Belgium was held at JN Tata Auditorium, National Science Symposium Complex, IISc, Bengaluru during 4th - 8th September, 2017 to commemorate the Golden jubilee year of inception of the Institute. His Excellency Shri Vajubhai Rudabhai Valaji, Hon'ble Governor of Karnataka State of India inaugurated the Symposium on 4th September, 2017. Shri Ananth Kumar, Hon'ble Union Minister for Chemicals & Fertilizers and Parliamentary Affairs, Govt. of India graced the occasion as the Chief Guest. Dr. M. R.

Dinesh, Director, ICAR-IIHR extended warm welcome to the dignitaries, delegates and the participants. Dr. A. K. Singh, Deputy Director General (Horticultural Sciences), ICAR, New Delhi, highlighted the growth of horticulture in the country and mentioned that horticultural production has touched 300 million tonnes from an area of 25 million ha during 2016-17. Shri. Ananth Kumar appreciated the contribution of the Institute in supporting the horticulturists through development and dissemination of farmer-friendly technologies. His Excellency Shri. Vajubhai Rudabhai Vala mentioned that agriculture supports the livelihood of 65 percent of the country's population. He called upon the scientists to help the farmers in doubling their income. The symposium was attended by more than 500 delegates including 26 foreign delegates from 11 different countries. The symposium comprised of 8 key note addresses, 7 technical sessions and 4 workshops spread over 4 days from 5th to 8th September, 2017. About 51 invited talks, 174 oral papers and 400 posters were presented during the symposium under seven thematic sessions. There were two exclusive sessions for students where more than 40 students presented oral papers. More than 400 posters were presented as e- posters. The symposium concluded with an open session of feedback from various stakeholders followed by recommendations and awards ceremony.



International Symposium on Horticulture: Priorities & Emerging Trends

Consultative Meeting with ATARI Directors on Dissemination of ICAR-IIHR Technologies

ICAR-Indian Institute of Horticultural Research organized "Consultative Meeting with ATARI Directors on Dissemination of ICAR-IIHR Technologies" on July 7, 2017. This is an unique programme initiated by ICAR-IIHR with the purpose of augmenting dissemination of

ICAR-IIHR technologies through Krishi Vigyan Kendra's (KVKs) of eleven Agricultural Technology Application Research Institute (ATARI) Zones of the country. The ATARIs are actively engaged in the transfer of technology to the stakeholders, mainly the farmers. Hon'ble Deputy Director General (Agricultural Extension), Dr. A.K. Singh, and Directors of ATARIs representing ten zones of the country participated as delegates. Dr. A. K Singh in his introductory remarks appreciated the efforts of ICAR-IIHR to develop many farmer-friendly technologies. M.R. Dinesh in his introductory remarks mentioned that ICAR-IIHR is very keen to partner with eleven ATARI zones of the country, so that the benefits of horticultural technologies that are viable and have potential to double the income of farmers, reach the horticulturists through KVKs. During the deliberations, the DDG (AE) and ATARI Directors expressed their interests towards technologies that are suitable for their respective zones and areas of interests for collaboration such as technology assessment, technology demonstration, capacity building and seed production programmes. Potential areas for further collaboration were arrived-at based on the interests of the ATARI Directors and modalities for way forward were worked out. It was decided that the programmes of ICAR such as ARYA, Farmers First, Farmers Producers Organizations (FPOs) etc, may be utilized for application of ICAR-IIHR technologies by the KVKs, so that the income of horticulturists can be doubled. Nodal Scientists from the Division of Social Sciences and Training were identified for follow-up action towards technology dissemination of ICAR-IIHR technologies identified by the ATARIs.



Consultative Meeting with ATARI Directors

Seminar on Avocado in association with CHES, Chettalli

A one day Seminar on Avocado was conducted on 12th July 2017 at KVK, Gonikoppal, Kodagu in association with CHES, Chettalli. Seventy farmers from Puthari Farmers Producer Company Ltd., Gonikoppal and Dept. of Agriculture, ATMA, Wyanad, Kerala participated in the seminar. During the seminar an exhibition on avocados was also arranged. The programme was inaugurated by Dr. I.N. Doreyappa Gowda, Principal Scientist & Head, CHES, Chettalli who spoke about the post harvest processing technologies at CHES and IIHR available for licensing and commercialization. Scientists from CHES, Chettalli, Dr. Senthil Kumar and Dr. V.Shankar explained about the production technology of Avocado. Dr. Saju George, Head, KVK spoke about the health benefits of "Avocado and why it is now being referred to as a Super food". Mr. Prabhakar, SMS (Horticulture) coordinated the programme. At the end a farmer -scientist interaction session was arranged.

XXVI group meeting of AICRP on Floriculture

The 26th group meeting of AICRP on Floriculture was jointly organised by ICAR-IIHR and DFR, Pune at ICAR- IIHR, Bengaluru during August 3-5, 2017. Dr. K.V. Prasad, Director, ICAR-DFR, Pune welcome the delegates of 26 centres and presented Project Coordinator's Report followed by remarks from the guest of Honour, Dr. D.R. Singh, Director, ICAR-NRC Orchids, Pakyong. Release of publications, unveiling of DFR logo, release of rose variety & flower seed box was carried out by the chief guest and dignitaries. Later, Dr. T. Janakiram, ADG (HS-II), ICAR, New Delhi addressed the gathering and the presidential address was delivered by Dr. M.R. Dinesh, Director, ICAR-IIHR, Bengaluru. At the end of the inaugural session, Dr. T.M. Rao, Head, Division of Floriculture and Medicinal Crops, ICAR-IIHR, Bengaluru proposed vote of thanks. There were nine technical sessions during three days of deliberations. There was a session on interaction with the industry.



AICRP- Release of Arka Savi

The Quinquennial Review Team (QRT)

The QRT to review the work done at ICAR-Indian Institute of Horticultural Research, Bangalore and ICAR-AICRP on Fruits during 1st April, 2011 to 31st March 2018 has been constituted by the ICAR under the chairmanship of Padma Shri Dr. K.L. Chadha [Former DDG (Hort.) ICAR & President, HSI]. The other members are Dr. B.M.C. Reddy (Former VC, Dr.YSRHU), Dr. V.S. Thakur (Former VC, YSPUHF), Dr. Satyabrata Maiti (Former Director, ICAR-DMAPR), Dr. H. K. Senapati (Ex-Dean, PGF cum DRI, OUAT), Dr. D. S. Khurdiya (Former HOD, PHT, IARI) and Dr. Prakash Patil - Secretary, QRT [PC (Fruits)]. The team had preliminary meeting on 24th August 2017 at Horticultural Science Division, ICAR, New Delhi. In the first phase, the team reviewed the programmes of ICAR-IIHR, Bengaluru, along with visit to experimental fields and laboratories (27th to 29th November 2017). The team also visited three Regional stations of ICAR-IIHR viz., CHES, Chettalli, and Hirehalli (16th to 18th January 2018) and Bhubaneswar (29th to 30th January 2018). In all the reviews, the team had interaction with all categories of the employees for eliciting their views. The team also reviewed the recommendations of various stake holders' events organized by the ICAR-IIHR during the review period. Accordingly, the team has drafted the report for drawing the future action plans of ICAR-IIHR.



QRT Team at ICAR-IIHR

Consultative Workshop for Promotion of Horticulture technologies in Karnataka

ICAR-IIHR Organized a Consultative Workshop on 16.8.2017 with officials of Department of Horticulture, Government of Karnataka and Vice-Chancellors of SAUs in Karnataka for “Promotion of Horticulture technologies in Karnataka”. At the outset, Dr. C. K. Narayana, Chairman, PME Cell, ICAR-IIHR extended a warm welcome to the delegates. Dr. M.R. Dinesh, Director, ICAR-IIHR, in his introductory remarks highlighted the viable technologies of ICAR-IIHR, their impact under real farm situations, and the opportunities for replication of such impact by the extension mechanism of the

Department of Horticulture. Shri. Maheshwara Rao and Shri. P.C. Ray briefly expressed the technological needs in horticulture in Karnataka and the modalities through which, ICAR-IIHR and Department of Horticulture may have pragmatic partnership for technology transfer. The delegates appreciated the purpose of the workshop and desired that such deliberations are to be organized regularly, so that horticulturists of Karnataka will be supported with viable technologies, keeping in view the vision of Shri. Narendra Modi, Hon'ble Prime Minister of India in doubling the income of farmers by 2022.



Consultative Workshop

Indo-German bilateral workshop

Indo-German bilateral workshop on 'Principles of DUS Testing of Rose Varieties and Vegetables according to UPOV System' was organised at ICAR-IIHR on Dec 14-15 in association with PPV&FRA, New Delhi. Ms. Friedhilde Trautwein, expert on rose and vegetable DUS testing from BSA, Germany deliberated on DUS testing procedures and Plant Breeders' rights in Germany. Representatives of South Indian Floriculture Association as well as commercial rose growers and exporters participated in the workshop and discussed about the issues related to 'Plant variety protection' in rose. Scientists and research staff of Directorate of Floriculture, Pune, AICRP-NARP-Pune, UHS- Bagalkot participated in the workshop besides the crop breeders and DUS workers from ICAR-IIHR. DUS guidelines in rose and vegetables were discussed in detail and visits were organized to fields where DUS testing was in progress.



Discussion during DUS meeting

14.3 Other Events

Visit of Parliamentary committee on Agriculture

Parliamentary committee on Agriculture under the chairmanship of Shri. Hukmdev Narayan Yadav along with 16 MP's visited ICAR-IIHR, CHES, Chettalli on 27th April 2017.



Visit of Parliamentary committee

Celebration of World Soil Day

World Soil Day was celebrated at ICAR- IIHR on 5th December 2017 in coordination with Krishi Vigyan Kendra, Hirehalli. On this day, about 50 farmers from Tumkur, Bangalore (Rural), Chikkaballapur District and from nearby villages attended the celebration. A Special lecture by Dr. Ramamurthy, Retired Principal Scientist & Head, NBSSLUP was arranged to expose the farmers to advanced technologies developed at ICAR-IIHR and Soil Health Cards were distributed to the farmers by the dignitaries. Tenth standard students of 60 numbers from nearby St Ann's School, Hesaraghatta, attended the lecture and they were educated on improving soil health through the technologies developed at the Division of Soil Science and Agricultural Chemistry, ICAR-IIHR. World Soil day event was also conducted at KVK Gonikoppal on 5th December 2017, in association with Department of Agriculture, Shri Kshetra Dharmasthala Rural Development Project, Puthari and Bhagandeswara Producer Company limited. About 200 farmers and departmental officials participated in the programme. Soil health cards were distributed to selected 50 farmers of the district.



World Soil day at ICAR-IIHR



World Soil day at KVK Gonikoppal

Jack fruit diversity fair

The two days Jackfruit diversity fair was organized by ICAR-IIHR from 24-25 June, 2017. In the programme, more than 120 Jackfruit diversities representing the accessions maintained at NAGS of ICAR-IIHR and farmer's collections were exhibited. The fair was inaugurated by Dr. Keerti Singh, Ex- Chairman, ASRB, New Delhi. Other dignitaries included Dr. A. K. Singh, DDG (HS), ICAR, Dr. Janakiram, ADG (HS), ICAR, Dr. Narayana Gowda, Ex-Vice Chancellor, UAS, GKVK, Bangalore, Dr. G L Kaul, Former DDG (HS). The event included exhibition of fruits and farmer's-scientists interface meeting on the first day. The highlight of the fair was creating awareness among the farmers about the importance of the crop on the health benefits of jack fruit and its revenue generation potential in the fruit crop based cropping system. The farmer's-scientists interface meeting was coordinated by Dr. H. Ravishankar, In charge Head, Division of Fruit crops in which outside experts, Dr. Narayana Gowda, Shri. Sree Padre, Editor, 'Adike Patrike' and crusader of Jackfruit promotion among the farming community besides scientists of ICAR-IIHR and GKVK, UAS also participated and responded to the grower's queries. The main issues that were prominently articulated during the interaction included : availability of genuine, vegetative propagated and quality planting materials of elite types especially orange flaked ones; possibility of year-round production; processing and value addition; marketing ; utilization of Jackfruit seed ; vegetable types etc. About 150 farmers participated in the interaction. On 25 June, 2017, the fair was open to the public.



Jack fruit diversity fair

Mango diversity exhibition

Mango diversity exhibition has been organized for three days at ICAR-IIHR, Hesaraghatta, Bengaluru during 26-28 May, 2017. A total of 329 varieties which includes the hybrids, indigenous varieties, polyembryonic, coloured / exotic varieties, pickling (appemidi) and farmers varieties have been displayed. This exhibition was inaugurated by Dr. Tejaswini, Anantkumar, Managing Trustee, Adanya Chethana Foundation, Bangalore. Shri. Maheshwar Rao, IAS, Secretary, Department of Agriculture, Horticulture and Sericulture, Government of Karnataka and Dr. D.

L. Maheshwar, Vice-Chancellor (VC), University of Horticultural Sciences (UHS), Bagalkot visited the mango diversity exhibition on 27.5.2016. Both the dignitaries had congratulated the Scientists for displaying an excellent variability collected from various parts of the country and abroad. This exhibition has attracted 1100 visitors from all walks of life and visitors have shown interest in knowing the variety name, place of its origin and its importance. Mango fruits of selected varieties were sold to the visitors and some of them have shown interest on procuring the grafted plants of traditional varieties of mango.'



Mango diversity exhibition

15. Women Empowerment

15.1.1. Celebration of Mahila Kisan Divas

ICAR-Krishi Vigyan Kendra, Hirehalli organized “Mahila Kisan Diwas” in collaboration with DHAN foundation, Tumakuru, at Kodihalli Village of Tumakuru Taluk on October 15, 2017. In this program, totally 57 farm women had participated. Dr. Loganandhan, Senior Scientist & Head, ICAR-KVK Hirehalli briefed about the KVK activities which can strengthen the social economic status of the women and stressed upon the role of women in Agriculture. A lecture was given on the importance of kitchen garden, use of bio agents for chemical free vegetable to maintain the overall health of the family by Dr. Somashekhar, SMS Plant Breeding and later Ms. Radha R Banakar, SMS Home Science briefed the participants on importance of nutrition, processing and value addition to agriculture and horticulture crops for income generation activities which can be taken by women self help groups.



Mahila Kisan Diwasat Kodihalli Village

A training programme on Bakery was arranged on October 15, 2017 at ICAR-KVK, Gonikoppal on the occasion of Mahila Kisan Divas for the benefit of 35 farm women. A method demonstration on different bakery product by Mrs. Savitha, Resource person cum practitioner, demonstrated a home scale preparation of cakes, pastries and biscuits as an additional income to the farm families.

13.1.2 Celebration of International women’s day

International Women’s Day was celebrated at ICAR-IIHR on March 23, 2018 where a Guest Lecture was arranged, following by lunch to the woman-labourers of the Institute. The programme commenced with a Welcome Address by Dr. Leela Sahijram, Chairperson, CCSHWW who gave a brief account of the historical background and the need for celebrating Women’s Day. This was followed by an introduction of the Chief Guest and her

multiple achievements by Dr. Narayanaswamy, Principal Scientist, Division of Social Sciences & Training and former associate of the Distinguished Guest.

The Chief Guest, Dr. T. C. Poornima, Indian Information Services (IIS), Director at the Directorate of Field Publicity (Mysore Division), Ministry of I & B, is a distinguished woman of several achievements in Kannada literary circles. She holds the distinction of being the first woman to be recruited into Indian Information Service and she coordinates directly between Prime Minister’s Office and the State on all official Central Govt. events. She spoke on the contribution of and progress made by women in the agricultural sector and about their struggles in overcoming prejudices regarding women in various domains. She spoke on women’s empowerment and the critical importance of financial literacy/ independence. She expressed that it is indeed a sad scenario where the country is still grappling with such issues at a basic level, despite the law of the land having no gender bias. Literacy of women would be one of the solutions in the rural areas. There is need, felt Dr. Poornima, for women-only judiciary in courts to improve their lot. Self-expression was a core need in women to help them live a life of dignity. Besides, she strongly pitched for women to take an active part in decision-making, instead of being dependant on the family for it. Director, ICAR-IIHR, Dr. M. R Dinesh, gave the presidential address highlighting inner strength of womenfolk in facing hardships. He spoke about the powerful women in India’s history, their contribution to the society in general, and agriculture sector in particular, rural women being the backbone of the family and the community.



Dr. T.C. Poornima, being felicitated by Dr. M.R. Dinesh

International women's day was celebrated on 8th March 2018 at KVK, Gonikoppal. Smt. Pravi Monnappa, Ex President Gram Panchayath, Gonikoppal inaugurated the programme and suggested all women to cooperate and help each other to progress themselves also their families without any differences. The Programme was presided by Dr. Saju George, Senior Scientist & Head, KVK, Gonikoppal. On this occasion he highlighted the importance of the Day and disparities in the gender have to be minimised to over all progress of the country and also emphasized on the contribution of women in the construction of robust Society. On this occasion, Cookery training cum demonstration was arranged to the participants.



International women's day at KVK, Gonikoppal

16. Official Language Implementation

The Official language implementation committee of the Institute carried out the following activities for the effective implementation of Official Language Policy of Govt. of India during 2017-18. During the year four meetings of the Official Language Implementation Committee were convened.

16.1. Main Station, ICAR-IIHR, Hesaraghatta, Bengaluru

Hindi Workshops

The Institute organised the following Hindi Workshops during 2017-18:

- A table workshop on “How to work in Hindi on Computer?” was conducted on 27.06.2017 for the staff members of Establishment Section.
- A special training-cum-workshop on “Spoken Hindi” was conducted during 18-25 September 2018.
- Table workshop on “How to install Unicode in computer” was conducted on 25.11.2017 and 14.02.2018.

Hindi Fortnight Celebration

The Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru observed Hindi Fortnight during September, 14-28, 2017. Various competitions viz., Hindi Recitation, Hindi Reading, Hindi Terminology and Noting, Antakshari, Hindi Conversation, Hindi Song, Pre-written Hindi Essay and Extempore were organized for the benefit of the staff members of the Institute. Dr. Ashok Kumar Bhatia, Advisor, DRDO inaugurated the Hindi fortnight on September 14, 2017. The Hindi fortnight was concluded on October 03, 2017 with Dr. Mangal Prasad, Former Deputy Director, Kudremukh, Bengaluru as Chief Guest, who distributed prizes to winners of various competitions organised



Inauguration of Hindi Week



Address by Chief Guest Dr. Ashok Kumar Bhatia



Hindi Terminology Competition



Address by Chief guest of valedictory function

Special Training-Cum-Workshop on “Spoken Hindi”

A special training-cum-workshop on which Dr. P.C. Tripathi, Dr. A.K. Saxena and Dr. Rajiv Kumar have trained the participants on how to speak Hindi

effectively.

Dr. S.N. Mahesh, CAIR, DRDO, Bengaluru on “Hindi Computing”. Forty five participants from different ICAR institutes were participated in this conference.



Participants of the training-cum-workshop



National Conference in Hindi

National Conference in Hindi on “Enhancing Efficiency and Effectiveness in Institutional Administration/ Management and Effective Implementation of Official Language Policy of Govt. of India in ICAR System”

ICAR-Indian Institute of Horticultural Research, Bengaluru has organized a Golden Jubilee National Conference in Hindi on “Enhancing Efficiency and Effectiveness in Institutional Administration/ Management and Effective Implementation of Official Language Policy of Govt. of India in ICAR System” on 11th August, 2017 at its campus. This national conference was inaugurated by Shri Sunil Kumar Singh, Additional Secretary, DARE and Financial Advisor, ICAR, New Delhi.

This conference was divided into two sessions with two theme areas. The theme of the first session was “Enhancing Efficiency and Effectiveness in Institutional Administration / Management in ICAR System”. The presentations in this session were made by Shri Pushpanayak, CAO, ICAR Research Complex for Eastern Region, Patna, Bihar, Shri G.P. Sharma, CFAO, ICAR-CAZRI, Jodhpur and Shri G.G. Harakangi, CAOICAR-IIHR, Bengaluru, on “Delegation of Financial Powers”, “Financial and Accounts Management” and “General Administrative Issues” respectively.

The theme area of second session was “Effective Implementation of Official Language Policy of Govt. of India in ICAR System”. In this session also there were three presentations, in which Shri Anil Kumar Dubey, Former Director (OL), ICAR, New Delhi made a presentation on “Implementation of Official Language Policy: Problems and Solution”; Dr. P.S.R. Murthy, Joint Director (SG), CSIR-NAL, Bengaluru on “Role of higher officials in Implementation of Official Language Policy” and

Hindi Publications

Annual Official Language Magazine “*Bagwani*”, Annual Report (Hindi) 2016-17, Extension folders on “Arka Prajwal”, “How to grow F₁ Chilli hybrids”, “Commercialization of technology through licensing – A success story” and Brochure of National Horticultural Fair 2018 were some publications that were brought out in Hindi.

Hindi Incentive Scheme

Hindi incentive scheme was implemented at the Institute for working in Hindi originally and during the year, out of the total 10 participants 02 secured first, 03 secured second and 05 secured third prizes. The prizes and certificates for the participants were distributed during the valedictory function of Hindi Week Celebration.

16.2. CHES, Chettalli

Hindi Week Celebration

Central Horticultural Experiment Station, ICAR-IIHR, Chettalli, Coorg celebrated “Hindi Week (Sapthaah)” during 16-21st September, 2017. Mr. Arjun Singh, Principal, Kendriya Vidyalaya, Madikeri, inaugurated the Hindi Saptah programme on 16th September, 2017 at seminar hall, CHES, Chettalli. Dr. I.N. Doreyappa Gowda, Principal Scientist and Head i/c, CHES, Chettalli welcomed the guest and addressed the staff about importance and necessity of Hindi language in our daily life. Dr.V.Sankar, Principal Scientist (Hort), CHES, Chettalli and Chairman - Hindi Saptah Programme introduced the guest and briefed the events to be carried out during Hindi Week. During this period, Dr. Priti Sonavane, Scientist, CHES, Chettalli and Member Secretary - Hindi Saptah Programme, organized several competitions viz.,

Dictation in Hindi, Reciting Hindi poem, Hindi meanings, Copy writing and Hindi Aksharmala writing for all scientific, technical, administrative, supporting staffs and SRFs. Valedictory function of the week-long event was organized on 21st September, 2017. Shri Subramanya, Programme Executive, All India Radio, Madikeri and Dr. Shridhar Ramkanth Hegde, Associate Professor and Head of Department (Hindi), Field Marshall Cariappa College, Madikeri, graced the function as chief guests. The speakers emphasized on the importance of Hindi week celebration and role of Hindi in everyday life. At the end of programme, prizes were distributed to the winners of various competitions and encouragement prizes were also distributed to all participants.

Acharya, Head I/c gave a brief account of office activities being adopted for promotion of Hindi. During the Hindi Week various competitions like extempore, essay writing Hindi terminology, and quiz completion were organized by Dr. P Naresh, Dr. S Mandal, Dr. P Srinivas and Dr. Kundan Kishore, respectively. Interestingly these events were organized by using LCD projector and most of staff participated with great enthusiasm. The valedictory function of week-long event was organized on September 20, 2017 which was graced by Sh. Pradeep Rath, Former Deputy Chief Labour Commissioner, Govt. of Odisha. Dr. Laxminarayan, CTCRI, Bhubaneswar, Dr. Manish Kumar, IMMT, Bhubaneswar and scientist from CIWA also participated in the function. In his address, Sh. Rath put emphasis on the importance of language in linking society and people of the country. He told that we should treat different languages equally for the development of society. Dr. Kumar highlighted the need of amalgamation of science with Hindi and *vice versa*. Dr. G C Acharya welcomed the guests and congratulated all the staff for their active participation in different events. At the end of the program, prizes were distributed to the winners.



Inauguration of Hindi Week



Inaugural function



Prize distribution



Winners of competitions

16.3. CHES, Bhubaneswar

Hindi Week Celebration

Central Horticultural Experiment Station (ICAR-IIHR), Bhubaneswar celebrated 'Hindi Week' from 14th – 20th September, 2017 to promote Hindi in office activities and to foster friendship and understanding among staff through learning process. Sh. Shubransh Mishra, Zonal Deputy Commissioner, BMC, Bhubaneswar inaugurated the Hindi Diwas and highlighted the significance of Hindi in national integration and development of society. Dr. G C

17. Distinguished Visitors

17.1 IIHR, Hesaraghatta, Bengaluru

- ❖ Dr. Tejasvini Ananth Kumar, Chairperson, Adanya Chetana Foundation, Bengaluru
- ❖ Mr. S. K. Singh, IAS, Financial Advisor, DARE
- ❖ Shri. Chhabilendra Roul, Addl. Secretary, DARE & Secretary, ICAR, Ministry of Agriculture, New Delhi.
- ❖ Mr. C. Ramesh Rao, DGM, NSFD, New Delhi
- ❖ Sanjay Prasad IAS, Principal Secretary, Agriculture Farmers Welfare & Co-operation Department, Government of Gujarat.
- ❖ Mr Friedhilde Trautwein, Expert on Rose and Vegetables from BSA, Germany.
- ❖ Dr. D L Maheshwar, Vice-Chancellor, UHS, Bagalkot, Karnataka
- ❖ Mr C D Nagaraju, MD KSNMDC, Karnataka
- ❖ Dr. K Narayana Gowda, Former Vice chancellor, UAS, Bangalore.

17.2 CHES, Chettalli

- ❖ Dr. P G Chengappa Ex Vice-Chancellor, UAS, Bangalore visited CHES, Chettalli.
- ❖ Parliamentary Committee on Agriculture under the chairmanship of Shri. Hukumdev Narayan Yadav along with 16 MP's
- ❖ Shri. Chhabilendra Raul, Addl. Secretary, DARE & Secretary, ICAR, Ministry of Agriculture, New Delhi.
- ❖ Dr. K. Nirmal Babu, Director, Indian Institute of Spices Research, Calicut.
- ❖ Dr. S. J. K. Annamalai, Head, ICAR-Central Institute of Agricultural Engineering, Regional Centre Coimbatore.
- ❖ Dr. K. S. Varaprasad, Former Director, IIOSR, Hyderabad, Telangana.

17.3 KVK, Gonikoppal

- ❖ Shri. Chhabilendra Raul, Additional Secretary, DARE & Secretary, ICAR
- ❖ Dr. Nirmal Babu, Director, ICAR-IISR, Calicut
- ❖ Dr. Chandre Gowda, Principal Scientist, ATARI, Bengaluru

- ❖ Dr. S. Aiyappan, Former Director General, ICAR and Secretary DARE
- ❖ Dr. P. G. Chengappa, Former Vice Chancellor, UAS, Bengaluru
- ❖ Mr. M.C. Nanaiah, District Development Manager, NABARD, Kodagu District
- ❖ Dr. Ramamurthy, Rtd Soil Scientist and Deputy Director Coffee Board
- ❖ Dr. Narasimhan, Organic practitioner of Virajpet
- ❖ Shri Kurubur Shanthakumar, Chairman, Raithamithra Farmer Producer company Ltd., Mysore

17.4 CHES, Hirehalli

- ❖ Dr. N Kumar, Former Dean (Hort.), HC and RI, Tamil Nadu Agricultural University, Coimbatore-3
- ❖ Dr. D.L. Maheswar, Vice Chancellor, University of Horticultural Science, Bagalkot
- ❖ Dr. B. N. S. Murthy, Horticulture Commissioner, GOI, New Delhi.
- ❖ Dr. P. Rethinam, Former Chairman, CBD, Former Executive officer, APCC, Jakarta

17.5 KVK, Hirehalli

- ❖ Dr. M. R. Dinesh, Director ICAR- IIHR, Bengaluru
- ❖ Dr. Sri. Sri. Sri. Shivakumara Swamiji, Head, Shri Siddaganga Math, Tumkur
- ❖ Sri Shankar Mahadev Bidari Former Director General and Inspector General of Police (DG&IGP), Karnataka.
- ❖ Dr. B.K. Srivastava, Director, DOD, Hyderabad
- ❖ Dr. Sreenath Dixit, Director, ICAR-ATARI, Zone XI, Bengaluru,
- ❖ Dr. M. S. Nataraj, Director of Extension, UAS, Bengaluru
- ❖ Dr. M. J. Chandre Gowda, Director, ICAR – ATARI, Bengaluru
- ❖ J. S. Veerabadram, DDM, NABARD, Tumakuru

18. Personnel

DIRECTOR

Dinesh, M. R. Ph.D.

SCIENTIFIC STAFF

ICAR-IIHR, Hessaraghatta, Bengaluru, Karnataka

Division of Fruit Crops

Srinivas Murthy, B.N. Ph.D.

Principal Scientist (Horticulture)

Upto 27.05.2017

Reju M. Kurian, Ph.D.

Principal Scientist (Horticulture) I/c Head

w.e.f. 2.11.2017

Sampath Kumar Pamu, Ph.D.

Principal Scientist (Horticulture)

Manjunath, B.L. Ph.D.

Principal Scientist(Agronomy)

Rekha, A. Ph.D.

Principal Scientist (Genetics & Cytogenetics)

Anuradha Sane, Ph.D.

Principal Scientist (Horticulture)

Sakthivel, T. Ph.D.

Principal Scientist (Horticulture)

Satisha, J. Ph.D.

Principal Scientist (Horticulture)

Sankaran, M. Ph.D.

Principal Scientist (Horticulture)

Vasugi, C. Ph.D.

Principal Scientist (Horticulture)

A.C.Madhav, M.Sc.

Scientist (Fruit Sci)

Upto 3.12.2017

Linta Vincent, M.Sc.

Scientist (Fruit Sci.)

Anushma P.L. M.Sc.

Scientist (Fruit Sci.)

Division of Vegetable Crops

Sadashiva, A.T. Ph.D.

Principal Scientist (Horticulture) & Head

Veere Gowda, R. Ph.D.

Principal Scientist (Horticulture)

Madhavi Reddy, K. Ph.D.

Principal Scientist (Horticulture)

Aghora, T.S. Ph.D.

Principal Scientist (Horticulture)

Pitchaimuthu, M. Ph.D.

Principal Scientist (Horticulture)

Varalakshmi, B. Ph.D.

Principal Scientist (Horticulture)

Shankar Hebbar, S. Ph.D.

Principal Scientist (Agronomy)

Singh, T.H. Ph.D.

Principal Scientist (Horticulture)

Anil Kumar Nair, Ph.D.

Principal Scientist (Agronomy)

Dhananjaya, M.V. Ph.D.

Principal Scientist (Plant Breeding)

w.e.f. 20.10.2017

Sreenivasa Rao, E. Ph.D.

Principal Scientist (Horticulture)

Padmini, K. Ph.D.

Principal Scientist (Horticulture)

Bharathi, L.K. Ph.D.

Principal Scientist (Hort. Veg.Sci)

Upto 21.01.2018

Raja Shankar, Ph.D.

Sr. Scientist (Veg. Science)

w.e.f. 10.07.2017

Senthil Kumar, M. Ph.D.

Scientist (Veg. Science)

Smaranika Mishra, Ph.D.
Scientist

Raghu, B.R. PhD
Scientist (Pl. Breeding)
w.e.f. 27.6.2017

Ramya, P. Ph.D.
Scientist (Pl. Breed)
Upto 05.06.2017

Susmitha Cherukuri, M.Sc.
Scientist (Gen. & Plant Breed)
Upto 15.06.2017

Division of Floriculture & Medicinal Crops

Manjunatha Rao T. Ph.D.
Principal Scientist (Horticulture) & I/c Head

Aswath, C. Ph.D.
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Tejaswini Ph.D.
Principal Scientist (Plant Breeding)

Sujatha A. Nair, Ph.D.
Principal Scientist (Horticulture)

Hima Bindu, K. Ph.D.
Principal Scientist (Plant Breeding)

Sujatha, S. Ph.D.
Principal Scientist (Agronomy)

Suryanarayana, M.A. Ph.D.
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Rajiv Kumar, Ph.D.
Principal Scientist (Horticulture)

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Smitha, G.R. Ph.D.
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Rohini M.R. M.Sc.
Scientist (Hort- PSMA)

Division of Post Harvest Technology & Agriculture Engineering

Harinder Singh Oberoi, Ph.D.
Principal Scientist & Head

I.N. Doreyappa Gowda, Ph.D.
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w.e.f. 15.03.2018

Narayana, C.K. Ph.D.
Principal Scientist (Horticulture)

Sudhakara Rao, D.V. Ph.D.
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Tiwari, R.B. Ph.D.
Principal Scientist (Horticulture)

Sangama, Ph.D.
Principal Scientist (Horticulture)

Senthil Kumaran, G. Ph.D.
Principal Scientist (FM&P)

Carolina Rathina Kumari, Ph.D.
Principal Scientist (FM&P)

Bhuvaneshwari, S. Ph.D.
Senior Scientist (AS&PE)

Ranjitha. K. Ph.D.
Scientist (Microbiology-Agricultural Science)

Pushpa Chethan Kumar, M.Sc.
Scientist (Food & Nutri.)

Division of Plant Pathology

Krishna Reddy, M. Ph.D.
Principal Scientist (Plant Pathology) & Head

Meera Pandey, Ph.D.
Principal Scientist (Plant Pathology)

Saxena, A.K. Ph.D.
Principal Scientist (Plant Pathology)

Sriram, S. Ph.D.
Principal Scientist (Plant Pathology)

Samuel, D.K. Ph.D.
Principal Scientist (Plant Pathology)

Sandeep Kumar, G.M. M.Sc. (Ag)
Scientist (Plant Pathology)

Chandrashekhara, C. Ph.D.
Scientist (Plant Pathology)

Mahesha, B. Ph.D.
Scientist (Plant Pathology)
w.e.f. 04.07.2017

Priti Sonavane, Ph.D.
Scientist (Plant Pathology)
w.e.f. 21.03.2018

Rangaswamy, E. M.Sc. (Ag)
Scientist (Plant Pathology)
Upto 15.06.2017

Division of Entomology and Nematology

Chakravarthy, A.K. Ph.D.
Principal Scientist (Agricultural Entomology & Head)
Upto 31.10.2017

Sreenivas Rao, M. Ph.D.
Principal Scientist (Nematology) & I/c Head
w.e.f. 1.11.2017

Ranganath, H.R. Ph.D.
Principal Scientist (Agricultural Entomology)
Upto 30.04.2017

Shivarama Bhat, P. Ph.D.
Principal Scientist (Agricultural Entomology)

Gopalakrishna Pillai, K. Ph.D.
Principal Scientist (Agricultural Entomology)

Ganga Vishalakshy, P.N. Ph.D.
Principal Scientist (Entomology)

Venkat Rami Reddy, P. Ph.D.
Principal Scientist (Agricultural Entomology)

Sridhar, V. Ph.D.
Principal Scientist (Entomology)

Kamala Jayanthi, P.D. Ph.D.
Principal Scientist (Agricultural Entomology)

Uma Maheshwari, Ph.D.
Scientist (Nematology)

Prasanna Kumar, N.R. Ph.D.
Scientist (Agricultural Entomology)

Jayanthi Mala, B.R. M.Sc. (Ag)
Scientist (Agricultural Entomology)

Division of Plant Physiology and Biochemistry

Shivashankara, K.S. Ph.D.
Principal Scientist (Plant Physiology) & Head

Shivashankar, S. Ph.D.
Principal Scientist (Biochemistry)
Upto 30.06.2017

Bhatt, R.M. Ph.D.
Principal Scientist (Plant Physiology)

Debi Sharma Ph.D.
Principal Scientist (Agricultural Chemistry)

Ravindra, V. Ph.D.
Principal Scientist (Plant Physiology)

Upreti, K.K. Ph.D.
Principal Scientist (Organic Chemistry)

Soudamini Mohapatra Ph.D.
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Laxman, R.H. Ph.D.
Principal Scientist (Plant Physiology)

Shamina Azeez, Ph.D.
Principal Scientist (Plant Biochem.)

Keshava Rao, V. Ph.D.
Principal Scientist (Organic Chemistry)

Partha Choudhury, P. Ph.D.
Principal Scientist (Agril. Chemicals)
w.e.f. 01.07.2017

Preeti Singh, Ph.D.
Scientist (Agril. Biochemistry)

Division of Soil Science & Agricultural Chemistry

Ganeshamurthy, A.N. Ph.D.
Principal Scientist & I/c Head

Raghupathi, H.B. Ph.D.
Principal Scientist (Soil Science)

Shivananda, T.N. Ph.D.
Principal Scientist (Soil Science)

Rupa, T.R. Ph.D.
Principal Scientist (Soil Sci.)

Sathisha, G.C. Ph.D.
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Varalakshmi, L.R. Ph.D.
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Selvakumar, G. Ph.D.
Principal Scientist (Agril. Microbiology)

Kalaivanan, D. Ph.D.
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Radha, T.K. Ph.D.
Scientist (Agril. Microbiology)

Rajendran, S. Ph.D.
Scientist (Soil Sci.)
w.e.f. 27.06.2017

Division of Social Sciences and Training

Venkattakumar, R. Ph.D.
Principal Scientist & Head

Ravishankar, H. Ph.D.
Principal Scientist (Horticulture) & I/c ATIC
Upto 31.10.2017

Gajanana, T.M. Ph.D.
Principal Scientist (Agricultural Economics)
ATIC in-charge w.e.f. 1.06.17

Sudha Mysore, Ph.D.
Principal Scientist (Agricultural Economics)

Sreenivasa Murthy, D. Ph.D.
Principal Scientist (Agricultural Economics)

Nita Khandekar, Ph.D.
Principal Scientist (Agricultural Extension)
Upto 06.06.2017

Venugopalan, R. Ph.D.
Principal Scientist (Agricultural Statistics)

Balakrishna, B. Ph.D.
Principal Scientist (Agril. Extn)

Narayanaswamy, B. Ph.D.
Principal Scientist (Agril. Extn)

Senthil Kumar, R. Ph.D.
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Achala Paripurna, Ph.D.
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Chandra Prakash, M.K. Ph.D.
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Reena Rosy Thomas, MCA.
Scientist (SS) (Computer Application)

Reddy, T.M. Ph.D.
Scientist (Agrl. Extn.)

Atheequlla, G.A. M.Sc.
Scientist (Agrl. Extn.)

Division of Plant Genetic Resources

Tripathi, P.C. Ph.D. I/c Head
Principal Scientist (Horticulture)

Yogeesha, H.S. Ph.D.
Principal Scientist (Seed Technology)

Rajashekharan, P.E. Ph.D.
Principal Scientist (Economic Botany)

Radhika, V. M.Sc.
Scientist (SG) (Computer Application)

Kanupriya, C. Ph.D.
Scientist (Hort.)

Division of Biotechnology

Akella Vani, Ph.D.
Principal Scientist (Genetics & Cytogenetics) & Head
Upto 31.05.2017

Leela Sahijram, Ph.D.
Principal Scientist (Plant Physiology) & I/c Head
w.e f. 01.06.2017

Mythili, J.B. Ph.D.
Principal Scientist (Plant Physiology)

Pious Thomas, Ph.D.
Principal Scientist (Horticulture)

Ashokan, R. Ph.D.
Principal Scientist (Agril. Entomology)

Ravishankar, K.V. Ph.D.
Principal Scientist (Plant Physiology)

Manmohan, M. Ph.D.
Principal Scientist (Plant Physiology)

Vageesh Babu, H.S. Ph.D.
Principal Scientist (Biotechnology)

Lakshmana Reddy, D.C. Ph.D.
Scientist (Biotechnology)

Nandeesh, P. Ph.D.
Scientist (Biotechnology)

Usha Rani, T.R. Ph.D.
Scientist (Biotechnology)

Project Coordinator's Cell (Tropical fruits)

Prakash Patil, Ph.D.
Principal Scientist (Plant Physiology)

Sridhar Gutam, Ph.D.
Sr. Scientist (Plant Physiology)

Central Horticultural Experiment Station, Chettalli

Senthil Kumar, R. Ph.D.
Principal Scientist (Horticulture) & I/c Head
Upto 27.11.2017

Doreyappa Gowda I.N. Ph.D.
Principal Scientist (Horticulture) & I/c Head
From 28.11.2017 to 13.03.2018

Bharathi, L.K. Ph.D.
Principal Scientist (Hort. Veg.Sci) & I/c Head
w.e.f 14.03.2018

Sankar, V. Ph.D.
Principal Scientist (Veg. Sci.)

Venkataramanappa, V. Ph.D.
Scientist (Plant Pathology)

Vaisakhi K.C. M.Sc.
Scientist (Soil Science)

Mahendran, Ph.D.
Scientist
Upto 06.06.2017

Muralidharan.B.M. M.Sc.
Scientist
Upto 15.06.2017

Priti Sonavane, Ph.D.
Scientist (Plant Pathology)
Upto 20.03.2018

A.C. Madhav, M.Sc.
Scientist (F.S)
w.e.f. 04.12.17

Central Horticultural Experiment Station, Bhubaneswar

Gobinda Chandra Acharya, Ph.D.
Principal Scientist (Horticulture) & I/c Head
w.e.f. 25.6.2017

Sudhamoy Mondal, Ph.D.
Principal Scientist (Plant Pathology)

Kundan Kishore, M.Sc.
Principal Scientist (Horticulture)

Sangeetha, G. Ph.D.
Principal Scientist (Plant Pathology)

Petikam Srinivas, Ph.D.
Principal Scientist (Plant Pathology)

Deepa Samant, Ph.D.
Scientist (Hort.)

Ponnamm Naresh, Ph.D.
Scientist (Vegetable Science)

Meenu Kumari, M.Sc.
Scientist (Horticulture)

Kishor Kumar Mahante, M.Sc.
Scientist (Fruit Science)

Central Horticultural Experimentation Station, Hirehalli

Karunakaran, G. Ph.D.
Principal Scientist (Horticulture- Fruit Science)

Krishi Vigyan Kendra, Hirehalli, Karnataka
Loganandhan, N. Ph.D.
Principal Scientist & Programme Coordinator, KVK

Krishi Vigyan Kendra, Gonikoppal, Karnataka
Saju George, Ph.D.
Senior Scientist and Head

TECHNICAL STAFF

Division of Fruit Crops

Prakash, B. M.Sc. (Org. Chem.)
CTO (Lab.)
Upto 31.01.18

Parashuram, H.D.

TO (Lab.)

w.e.f 22.04.2017

Jayaramaiah.N

TO (Field/Farm)

Division of Vegetable Crops

Umashankar, B.E. B.Sc. (Ag)

ACTO (Lab.)

Nage Gowda, N.S. M.Sc. (Ag)

STO (Farm)

Lakshmipathi, Ph.D.

ACTO (Field/Farm)

Idiya, H. K.

TO (Field/Farm)

Sanna Manjunatha

TO (Field/Farm)

Ramamurthy.B

TO (Field/Farm)

Division of Floriculture and Medicinal Crops

Cheluvvaraju, V.

TO (Field/Farm)

Vamana Naik, D.

TO (Field/Farm)

Muniraju. M.

TO (Field/Farm)

Division of Post Harvest Technology & Agriculture Engineering

Reddappa, K. B.Sc., PGD (FT)

ACTO (Lab.)

Ravindra Kumar, Ph.D.

ACTO (Lab.)

Mahanthesh, P.T.

TO (Mech.)

Dayananda, P.

TO (Mechanic)

Division of Social Science and Training

Nagappa

ACTO (LAB)

Lakshmisha, R. M.Sc. (Ag)

STO (Field/Farm)

Venkateshwar Rao, R.

TO (Projection)

Division of Plant Genetic Resources

Shetti, D.L. M.Sc. (Agril. Ento.)

ACTO (Lab.)

Division of Plant Pathology

Salil Jalali, M.Sc.

CTO (Lab)

Balasubramanian, K.

STO (Lab.)

Puttamadashetty

TO

Upto 31.07.2017

Division of Entomology and Nematology

Rajanna T.S.

TO (Field/Farm)

Lokesh, C.

STO upto (25.08.2017)

Saroja, S.

TO (Lab)

Division of Plant Physiology and Biochemistry

Bujji Babu, C.S. M.Sc. (Biochem.)

CTO (Lab.)

Tapas Kumar Roy, M.Sc.

CTO (Lab.)

Jyothi V. Divakar, M.Sc.

STO (Lab.)

Qazi, S.M. B.Sc.

STO (Lab.)

Upto 30.06.2017

Loksha A.N.

TO (Field/Farm)

Nataraju, M.S.

TO (Field/Farm)

Division of Biotechnology

Chandrashekhara, S.C. M.Sc.
ACTO (Lab.)
Upto 30.04.17

Madhusudhana Rao, B. M.Sc.
STO (Field)

Venkateshaiah, S.
TO (Field)

AKMU

Jayashankar N
STO (Computer-Lab)
Till 15.06.2017

Krishananda, S.
TO (Computer Lab)

Library

Shankara Prasad, K.V. M.Sc.
ACTO (Lib.Sci.)

Artist Cell

Rajendra Astagi M.F.A.
STO (Artist)

Photography Cell

Chandrashekaraiyah, K. B.Com.
STO (D.R.A.)

Farm Management

Pandey, R.N. M.Sc. (Ag.)
CTO (Farm) Upto 31.01.2018

Nagaraj E. Kodekal
TO (Mech.)

Annu M.
TO (Field)

Jagadeesh Kumar, D.N.
TO (Elect.)

Siddaveeraaradhaya, H.C.
TO (Field)

Ramesh V
TO(Lab)

Prioritization, Monitoring and Evaluation Cell

Janmay JaiDeveshwar. M.Sc. (Plant Physiology)
CTO (Field/Farm)

Thippeswamy, S. MCA
ACTO (Computer Lab)

Medical and Paramedical

Mandakrantha Bhattacharya, MBBS, DLO
CTO (Medical)

Transport Section

Siddaram G. Kalashetty, B.E. (AE)
STO (Transport)

Sunder Raj, G.
TO (Driver)

Finance and Accounts

Chandra Kumar Chitralla. M.Sc. (Computer Sci.)
STO (Lab. Tech- Computer)

Cash & Bill

Jyoti Appu Naik
TO (Computer-Lab)
w.e.f 13.06.2017

Works Unit

Bhanu, A. M. Tech. (Const. Tech.), PGDBA
CTO (Engg.)

Harish, K.M. B.E.
STO (Civil)

Mahishi V.K
STO (Elect-Workshop)

Narendra, S.
TO (Elect.)

Lakshmana Kanthan
TO (Tuner-Workshop)

Manjunath.R
TO (Welder-Workshop)

Jayakumar. T.N
TO (Elect-Workshop)

Central Horticultural Experimentation Station, Bhubaneswar

Manoj Kumar Pattnaik,
STO

Singray Majhi
TO (Lab)

Central Horticultural Experimentation Station, Chettalli

Swathy, P.B.
Upto 30.06.2017

Central Horticultural Experimentation Station, Hirehalli

Varadarajacharya K.V.
TO (Mech-Workshop)

Paramesha H.C.
TO
Upto 31.12.2017

Krishi Vigyan Kendra, Gonikoppal, Karnataka

Devaiah, K.A. M.Sc., (Hort.)
CTO (Field)

Somashekhar, Ph.D
ACTO (Field)
w.e.f 01.11.2017

Prabhakara, B. M.Sc. (Ag.)(Hort.)
ACTO (Field)

Veerendra Kumar K.V
ACTO (Pl.Path-Field/Farm)

Suresh, S.C. Ph.D
ACTO (Field)

Padmavathy, M.K. M.Sc.
STO (Lab)

Krishi Vigyan Kendra, Hirehalli, Karnataka

Ramesh P.R.
ACTO (Soil-Science-Field/Farm)

Jagadish K.N.
ACTO (AG.Extension-Field/Farm)

Prashanth J.M
ACTO (Horticulture-Field/Farm)

Hanumanthe Gowda
ACTO (Plant Prot-Field/Farm)

Radha R.Banakar
ACTO (Home Science-Field/Farm)

Jayashankar N
STO (Computer-Lab)
w.e.f 16.06.2017

Somashekhar, Ph.D
ACTO (Field)
Upto 31.10.2017

Parashuram, H.D.
TO (Lab.)
Upto 21.04.2017

Jyoti Appu Naik
TO (Computer-Lab)
Upto 12.06.2017

ADMINISTRATION AND ACCOUNTS

ICAR-IIHR, Hessarghatta, Bengaluru

Administration

Harakangi, G.G.
Chief Administrative Officer

Ramesh R.G.
Administrative Officer

Malay Bisht
Administrative Officer

Mohana, G.
Assistant Administrative Officer
Upto 28.02.18

Anasuya, N.
Assistant Administrative Officer

Lokanatha, B.
Assistant Administrative Officer

Tittu Kumar, K.B.
Assistant Administrative Officer

Hemaprabhu, R.
Assistant Administrative Officer
Upto 19.11.2017

Shailaja R. Prasad
Assistant Administrative Officer

Manjula A.C.
Assistant Administrative officer
w.e.f. 01.03.18

Official Language Cell**Jagadeesan, A.K.**

Assistant Director (Official Language)

Finance and Accounts**S.K.C.Bose**

Chief Finance & Accounts Officer

w.e.f. 02.08.2017

Bharathi P.S.V.

Finance & Accounts Officer

w.e.f. 21.04.2017

Krishi Vigyan Kendra, Gonikoppal, Karnataka**Administration****Mohan, C.M.**

Assistant Administrative Officer

w.e.f. 08.12.2017

**Central Horticultural Experimentation Station,
Bhubaneswar****Administration****Rina Pattnayak**

Assistant Finance & Accounts Officer

**Central Horticultural Experimentation Station,
Chettalli, Karnataka****Administration****Mohan, C.M.**

Assistant Administrative Officer

Upto 07.12.2017

Hemaprabhu, R.

Assistant Administrative Officer

w.e.f. 20.11.2017.

19. Meteorological data

19.1 ICAR-IIHR, Hesaraghatta, Bengaluru

Month	Temperature (°C)		Relative Humidity (%)		U.S.W.B. Class 'A' Pan Evaporation (mm)	Mean wind speed (km/h)	Rainfall (mm)
	Max	Min	07.30 hrs	14.00 hrs			
April 2017	34.9	20.3	70.4	30.0	6.50	3.71	33.75
May 2017	33.0	21.2	75.6	48.7	4.05	2.69	294.25
June 2017	28.4	20.9	77.1	64.4	4.45	5.14	59.00
July 2017	28.9	20.2	75.1	60.4	4.46	6.09	41.50
August 2017	28.5	20.9	82.9	64.2	3.41	4.82	244.55
September 2017	28.5	20.4	85.9	65.4	2.64	3.86	359.10
October 2017	28.7	19.5	82.5	61.9	2.75	2.64	241.95
November 2017	27.6	17.5	77.7	56.4	3.37	3.00	11.65
December 2017	27.2	14.2	79.7	45.3	3.57	3.92	5.60
January 2018	28.4	12.7	78.5	36.4	4.25	2.70	0
February 2018	30.2	12.7	67.5	27.8	5.59	3.37	0.5
March 2018	32.6	16.2	66.4	27.3	6.45	3.68	54.15

19.2 CHES, Chettalli

Month	Temperature (°C)		Relative Humidity (%)		Mean wind speed(km/h)	Rainfall (mm)
	Max.	Min.	Max.	Min.		
April 2017	33.4	13.6	97.9	34.3	5.83	49.20
May 2017	31.4	9.8	97.8	44.8	5.13	47.0
June 2017	27.3	14.2	97.6	62.5	2.72	76.80
July 2017	24.9	19.4	99.4	78.8	6.96	260.10
August 2017	25.8	19.0	100.0	75.3	5.68	282.70
September 2017	27.1	18.8	99.9	67.8	4.83	211.50
October 2017	27.9	17.6	100.0	61.5	4.46	20.80
November 2017	28.1	16.4	99.7	53.2	4.78	0
December 2017	27.2	15.6	100.0	56.3	5.15	12.70
January 2018	28.4	11.5	99.9	36.9	4.62	0
February 2018	30.1	12.5	98.4	33.3	4.82	1.70
March 2018	32.4	15.6	99.4	30.3	5.85	12.79

19.3 CHES, Bhubaneswar

Year	Mean Temperature (°C)	Mean Relative Humidity (%)	No of raindays	Rainfall (mm)
2017	27.2	77.2	135	1500

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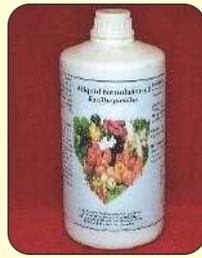
ICAR-IIHR Technologies released during 2017-18



Technology for shelf life extension of fresh-cut vegetables



Portable vegetable dicing tool



Liquid formulation of *Bacillus pumilus*



Osmotic dehydration of guava



osmotically dehydrated aonla segments



Papaya fruit bar



Power operated onion size grader



High humidity storage box for shelf life extension of green leafy vegetables



Vegetable vending van



Minimally processed onion



**International Symposium on Horticulture: Priorities & Emerging Trends
September 4 - 8, 2017, Bengaluru**