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Annual Report
2015-16

ICAR-Indian Institute of Horticultural Research

Hesaraghatta Lake Post, Bengaluru - 560 089, India

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ICAR-Indian Institute of Horticultural Research
Hesaraghatta Lake Post
Bengaluru - 560 089, Karnataka, India

Tel. No. : +91-80-28466420-423
+91-80-28446140-143
Fax : +91-80-28466291
E-mail : director@iihr.res.in
Website : http://www.iihr.res.in

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Triple disease resistant tomato hybrid Arka Rakshak in farmer's field

Preface

Availability of food, nutritional security, sustainable livelihoods and health care are integral aspects contributing to inclusive growth of any developing economy. In this scenario, horticulture has emerged as one of the most important sub-sectors of agriculture in the country. The production of horticultural crops has outpaced the production of food grains since 2012-13. India has witnessed voluminous increases in horticultural production over the last few years. Significant progress has been made in the area expansion resulting in higher production. Over the last decade, the area under horticulture grew by about 2.7 per cent per annum and annual production increased by 7.0 per cent. During 2013-14, the production of horticultural crops was around 283.5 million tons from 24.2 million hectares area. Out of the six categories viz., fruits, vegetables, flowers, aromatic plants, spices and plantation crops, the highest annual growth of 9.5 per cent was seen in fruit production during 2013-14. The production of vegetables has increased from 58,532 thousand tons to 1,67,058 thousand tons since 1991-92 to 2014-15. India witnessed a sharp increase in the acreage of horticultural crops compared to food grains over the last five years (from 2010-11 to 2014-15) with the area under horticultural crops increasing to around 18 per cent as compared to an area expansion under food grains by a marginal 5 per cent during the stipulated period. The production of horticultural crops has outpaced the production of food grains since 2012-13. The percentage share of horticultural output in agriculture presently is more than 33 per cent. During 2014-15, the country exported fruits and vegetables worth Rs.7474.14 crores. Under the purview of agriculture and allied activities, the share of plan outlay for horticulture, which was 3.9 per cent during IX Plan, has increased to 4.6 per cent during the XII Plan, thus providing opportunities. The sub-sector has accomplished different milestones despite the challenges of low productivity, diminishing land resources, degraded production environment, energy crisis, significant post-harvest losses, low levels of value addition, climate change, global competition, weak knowledge sharing infrastructure, inadequate market linkages, sub-optimal factor productivity, harnessing of space and IT benefits.

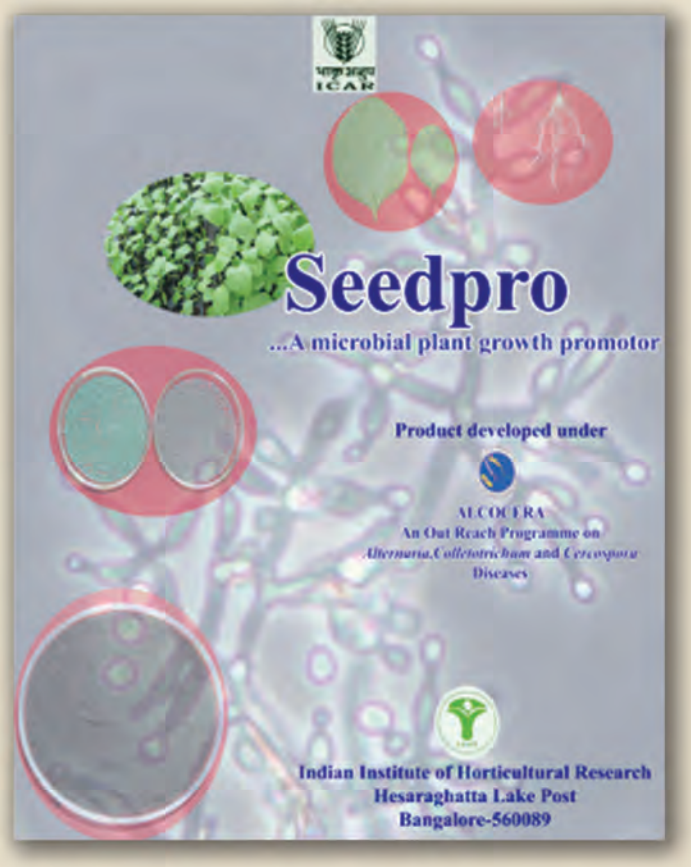
I feel utmost privileged to present the Annual Report 2015-16 of the ICAR - Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru. The institute along with its regional stations and Krishi Vigyan Kendras is playing a pivotal role in conducting research, education and knowledge management activities for boosting horticultural growth in the country through technology development in the areas of trait-specific varieties of fruits, vegetables, ornamentals, medicinal & aromatic crops and mushrooms focusing on water prudence, climate resilience and tolerance to different biotic and abiotic stresses supported by a range of farmer-friendly technologies for soil and plant health management, post-harvest management, value addition and farm mechanization. The institute takes pride in claiming that it is an innovative hub that has led to commercialization of a number of innovations in the area of seed and quality planting materials, diagnostics, bio-control agents, micronutrient formulations, microbial inoculants and gender mainstreaming technologies resulting in the mitigation of problems in real-time farming situations. The institute has also empowered the trainers, growers and other stakeholders through gap analysis, technology refinement and knowledge sharing mechanisms.

I take this opportunity to express my sincere thanks to all the staff of the institute for admirably raising to the occasion of challenges and harnessing the opportunities for optimizing the outputs. I am grateful to the Institute Management Committee and Research Advisory Committee, for reviewing the institutional activities and programmes from time to time and offering valuable suggestions for improvement.

I wish to place on record my deep sense of gratitude to Dr. S. Ayyappan, Former Secretary, DARE & Director General, ICAR, Dr. Trilochan Mohapatra, Secretary, DARE & Director General, ICAR, New Delhi and Dr. N.K. Krishna Kumar, Deputy Director General (Horticultural Science), ICAR, New Delhi for their continued support and guiding this institute towards the path of achieving excellence. The contributions of the publication committee of the institute in bringing out this publication in time, in an abridged form are greatly appreciated.

M.R. Dinesh
Director

Bengaluru
June 29, 2016



A few commercialized technologies of ICAR-IIHR

1. Executive Summary

Research work at the Institute is being carried out in 153 sub-projects under 25 in-house projects which include 133 sub-projects from the main station at Hesaraghatta, eight sub-projects from CHES, Chettalli and 12 sub projects from CHES, Bhubaneswar. Apart from this there are 77 externally funded projects, one international aided project, one national fellow project and eight All India Coordinated Research Projects under operation at the Institute. Apart from this, two Flagship Programs, three New Initiatives one Centre of Excellence and nine Consortia Research Platform projects have been sanctioned during the XII five year plan and work in these projects has been initiated. In the field of education, training and capacity building, the Institute has signed an MoU with IARI, New Delhi for initiation of Ph.D. program as an Outreach Program of PG School, IARI, New Delhi and the Post Graduate School of Horticultural Sciences has been established at Indian Institute of Horticultural Research, Bengaluru during August 2014 and has commenced the Ph.D. program in horticultural sciences at the Institute. On the capacity building front many staff members were deputed for advanced trainings in specific fields of their specialization, many staff members of the other institutes were trained in specialized fields of expertise available at the Institute, the scientists of the Institute were deputed to various national and international conferences, seminars, symposia, *etc.* to participate and present papers, get exposure to the recent advancements made in the field of horticultural research, interact with professional colleagues on topical issues and national problems in horticulture sector. On the transfer of technology front, a good number of training programs for extension personnel from state horticultural/ agricultural departments, KVKs, NGOs and interested farmers groups/entrepreneurs were conducted. On farm and off-farm demonstrations of the technologies and varieties/hybrids developed by the Institute were conducted apart from participating in many regional, national and international exhibitions/fairs/ *Kisan Melas etc.* and showcase the achievements and activities of the Institute. Many technologies/ varieties/hybrids developed by the Institute have also been commercialized for wider reach across the country. On the front of the physical and financial progress all the equipment and infrastructures approved under the XII plan have been procured to strengthen the research. The scope and 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. Summary of the research achievements in various projects under operation are presented below.

Management of plant genetic resources

Indian Institute of Horticultural Research, Bengaluru has been recognised as the nodal centre for management of horticultural plant genetic resources in the country in association with other horticultural crop institutions under the Council. In keeping with the fresh mandate, the institute carried out further exploration, collection, introduction, domestication, evaluation, characterization, conservation and documentation of horticulture plant genetic resources. Several germplasm accessions with novel features were added and with the new additions, the total germplasm collection of the institute, including regional stations stands at 10626.

Explorations conducted in Nagaland yielded 176 samples of vegetables, wild relatives of crop plants and land races belonging to 40 taxa and some unique collections like, *Abelmoschus tetraphyllus* var. *pungens* and *Momordica subangulata* subsp. *subangulata*. Apart from this, Hadagali Jasmine, three Jamun accessions, eleven mangosteen samples, two *Rubus sp*, three *Garcinia sp.* and *three* Orchid species were collected from Karnataka. Consequently, the total viable germplasm collection of major vegetable crops at the institute has been raised to 689 for tomato, 2000 for capsicum, 361 for brinjal, 334 for okra, 198 for cucumber, 103 for ridge gourd and 105 for bottle gourd.

Cryostorage of seed and pollen of two *Solanum* species, *Saraca indica* and *aonla* was successful. DNA fingerprints were generated for three released varieties of marigold viz. 'Arka Bangara', 'Arka Agni' and 'Arka Alankara' using SSR markers, two leafy amaranthus varieties 'Arka Varna' and 'Arka Samraksha' 39 jasmine genotypes and 19 pummelo accessions using SRAP and SSR/ EST markers. Association mapping and genetic diversity analysis

of 60 pomegranate accessions using microsatellite markers revealed good genetic diversity in the collections. The institute has developed distribution maps for 30 horticultural species of Eastern Ghats and 9 medicinal crops.

Crop improvement

In fruit crops, the jamun collection MP-2 which is a seedling progeny showed precocious flowering and fruiting during the second year of planting. Advanced inter-generic hybrid progenies between Arka Surya ×*V. cauliflora* attained stability for broad leaf trait and fruit shape similar to Arka Surya with field tolerance to PRSV and desirable fruit qualities by F_6 generation. Guava hybrid H-1314 from progenies of Purple Local × Allahabad Safeda with big sized fruits (300-325g), firm and thick white pulp (1.6 to 1.8 cm), medium seed hardiness (10.0-10.5 kg/cm^2) and good TSS (10.0-11.0^{o}B) was identified for table purpose. Guava varieties Arka Kiran and Arka Mridula as female parents were found to be cross compatible with the wild species *Psidium guineense* with about 75% fruit set. One promising hybrid of pomegranate H-4/2 that produces large reddish fruits weighing over 400g with thin rind and soft dark red sweet (TSS 17.6°B) arils was identified. A strawberry hybrid that produces large good quality fruits weighing over 20g with TSS 10.6°B was multiplied and evaluated.

In vegetable crops, two tomato lines (VRT-2-2-3 and VRT-8-6-1) were found resistant to ToLCBV. Seven hundred *Capsicum* sp. germplasm lines of NBPGR were characterized and regenerated. Among the *Capsicum* sp. germplasm lines evaluated, IHR 4561, IHR 3448, IHR 3024 and IHR 3575 were found immune to RKN; IHR 3580, IHR 3661 and IHR 3936 were found highly resistant to bacterial wilt; IHR 4582, IHR 4585 and IHR 4586 showed combined resistance to GBNV and ChLCV; and IHR 4503, IHR 3471 and IHR 500 showed combined resistance to CMV and ChiVMV. *Cucumber* wild species accession, IIHR 195 (*Cucumis metliferous)* was highly resistant to root knot nematode. Cucumber germplasm, IC-613485 was resistant to downy and powdery mildews. 150 watermelon gene bank accessions of NBPGR were regenerated and characterized. Bottle gourd germplasm, IIHR-124 had combined resistance to powdery mildew and CGMM virus. Two bitter gourd germplasm lines viz, BTG 166 and 167 were resistant to powdery mildew. Another bitter gourd germplasm, BTG-22 recorded highest momordicin and charantin contents.

Arka Samrat tomato was recommended at National level as a bacterial wilt resistant hybrid for zone VIII (Karnataka, Tamil Nadu, Andhra Pradesh and Kerala). In chilli, Arka Khyati (MSH-206), a CGMS based high yielding F_1 hybrid, two antioxidant rich vegetable amaranth varieties, Arka Samraksha and Arka Varna, one each of french bean variety, Arka Sharath , onion variety, Arka Bheem and yard long bean variety Arka Mangala were recommended for release for the state of Karnataka by SVEC. Three high yielding and bacterial wilt resistant brinjal varieties, viz., Arka Avinash, Arka Harshitha, Arka Unnathi; three pea early varieties viz., Arka Nirmal, Arka Harini and Arka Mayur; three pea varieties tolerant to high temperature viz., Arka Tapas, Arka Uttam and Arka Chaitra; six photoinsensitive pole type dolichos varieties, Arka Pradhan, Arka Krishna, Arka Adarsh, Arka Prasidhi, Arka Bhavani and Arka Vistar were identified for release at the Institute level. Rust resistant variety of French bean Arka Anoop is registered by PPV&FRA for protection.

Tomato hybrids, H-331 (48 t/ha) and H-329 (42 t/ha) were the top yielders and were triple disease resistant to ToLCV, bacterial wilt and early blight. Two tomato IPS *viz;* CLN 3125A × RF_4A F_2 - 177- 2-1-1-1 and F_2 - 22-1-1-1-1 and CLN 3125A × RF_4A F_2 - 22-1-1-1-1 were confirmed for drought tolerance through physiological studies. Two tomato introgressed lines *viz;* BC_1F_1 25-206-82-2 (15.6 mg/100g FW) and BC_1F_1 17-143-7-2 (13.5 mg/100g FW) with high β-Carotene and lycopene contents respectively, were developed. In chilli, an advanced breeding line, TR4 (2.5 kg/ plant) was found promising with combined resistance to CMV, ChVMV and thrips. In bell peppers, two advanced breeding lines viz., IHR 4033 (3.5kg/ plant) and IHR 3476 (3kg/ plant) were found heat tolerant under controlled conditions and recorded pollen germination of 12-16% at 40^{0}C. Brinjal IPS, IIHR 228 ×IIHR-571 -6-4-1-9-4 (1.86 kg/plant) was promising for fruit yield, quality and texture. Okra hybrid, GMS-4 × IIHR 299 (GMSH-7) was found superior for high yield (23.37t/ha) and was resistant to YVMV under natural field conditions. Three onion hybrids namely, PBR MS 318× PBRC 340, PBR MS 319 × PBRC 339 and PBR MS 317 × PBRC340 were found resistant to purple blotch disease and gave high bulb yield with good bulb qualities. In French bean, the maximum pod yield (16.2 t/ha) was recorded in (IC 525235 × Arka Anoop)-3 BS-1. French bean breeding line, IC 525224 × IC 525239-05-1-6 could withstand day temperature up to 35^{0}C with maximum

yield of 13.2 t/ha. Cucumber advanced breeding line, IIHR-381 recorded the highest fruit yield of 19 t/ha. Watermelon breeding lines, Line-283 (12.8% TSS), 298 (11.8% TSS) and 306 (13.2% TSS) in red flesh and Line-282 (11.0% TSS), 287 (11.0% TSS) and 29 (11.6% TSS) in yellow flesh backgrounds were found promising. A muskmelon selection, Sel-3 recorded an yield of 31.60 t/ha with elongated globe shaped fruits, golden yellow smooth rind, creamish white flesh and crisp and juicy texture. Three ridge gourd hybrids viz., RGH-66 (37.48 t/ha), RGH-64 (35.67 t/ha), RGH-63 (33.92 t/ha) were high yielding with good nutritional quality. Two MS sources in ridge gourd viz., RG-12*ms* and RG-28*ms* were characterized by the production of rudimentary male flowers and this male sterility is governed by cytoplasmic inheritance with restorer genes for fertility. Fifteen bottle gourd inbred lines viz., IIHR-3, 75, 77, 79, 81, 90, 94, 95, 97, 98, 105, 106, 108, 112 and 118 had combined resistance to CGMMV and gummy stem blight. Two bitter gourd inbred lines, BTG -144-2-1 (PDI-1.45), BTG - 80-5-1(PDI-2.98) were resistant to powdery mildew. Thirty one advanced breeding lines have been selected for resistance to brinjal shoot and fruit borer in F4 generation of interspecific cross between *Solanum melongena* and *Solanum macrocarpon* and forwarded to F5 generation.

In ornamental crops, inter varietal hybridization of tuberose was carried out involving Arka Sugandhi, IIHR-6, Mexican Single, Shringar, Vaibhav and Variegated. In gladiolus, two hybrid selections were identified for release at Institute level and named as 'Arka Manorama' and 'Arka Aayush'. In carnation, three genotypes viz., Charmant (24.13%), Bizet (22.73%) and Orange Vienna (23.62%) were tolerant to *Fusarium* isolates. In gerbera, two hybrids IIHR 3-34 and IIHR 8-45 were found promising for flower quality traits at the pre-release stage. In chrysanthemum, OP Seedlings 2-13, 2-16 and 5-9 were found to be early flowering with attractive flower. The OP line IIHR 4-8 was found promising for pot culture. In China aster, pure lines IIHRCC 5-1, IIHR G-13, IIHR J-3 and IIHR J3-2 were found promising for cut flower. In crossandra, highest mortality was recorded in 'Local' (66.6%) followed by 'Arka Kanaka' (22.2%) and 'Arka Shravya' (11.1%) against *Phytopthora* wilt after artificial inoculation. However, no mortility was recorded in 'Arka Ambara' and 'Arka Shreeya'. 'Arka Shravya' was found to be suitable for pot culture and landscaping. In marigold, a novel genetic stock IIHRMGYP-1 (INGR15036) was registered with NBPGR, New Delhi. Two apetaloid sterile lines were stabilized. IIHR10521AB and IIHR10572AB were the two male sterile lines of two-line system stabilized over six generations of intercrossing. Petaloid male sterile lines IIHRR 2_2(S) having cytoplasmic male sterility and an isogenic maintainer line IIHRR 2_2 (F) have been stabilized. In jasmine, seventeen different species have been collected and reconfirmed through *in vitro* pollen germination media. In Jasmine new compound of fragrance was recorded in *J.malbaricum*, which is ideal for commercial exploitation. In anthurium, seventeen hybrids of fragrant and non-fragrant hybrids were evaluated for their economical characters. *In vitro* leaves from 16 lines were used for callus induction on MS medium supplemented with auxin 2, 4-D.

In medicinal crops, promising selections of *Mucuna pruriens* with high seed yield and L-dopa content, IIHR PS 2 (310g, 5.38**%),** IIHR PS 14 (322g; 5.0 %) in long duration and in medium duration IIHR PS 6 (265g; 5.01%) showed superior performance over a period of three years. Among high L-dopa selections, IIHR 12-6 (173g/plant) and IIHR 12-12 (163g/plant) combined higher seed yield with high L-dopa contents (6.73, 6.03%).

Biotechnological approaches

Thirty four miRNAs were identified as potential indicators of *Fusarium wilt* infection in Banana. Forty defense related genes were found to have higher expression 3 DAI when challenged with *Fusarium* pathogen in resistant cultivar of banana, namely, Calcutta-4 when analysed by qRT-PCR. Analysis for cuticular wax in 87 F1 segregating populations between drought resistant and susceptible varieties showed that leaf water retention capacity (LWRC) and maintenance of hydration of the leaves was correlated to level of cuticular wax content. Occurrence of long noncoding RNAs (lncRNAs) was found to be tissue specific in its expression and was also species specific in banana. Transformation of embryogenic cells of banana cv. Rasthali with *Agrobacterium* strain AGL1 harboring pCAMBIA1305.2-Ace-AMP1 and-pflp for resistance to *Fusarium oxysporum* f.sp.*cubense* was carried out and forty PCR positive transformants were obtained. Cultivation based versus metagenomic profiling of endophytic bacterial diversity in banana (*Musa* sp.) shoot-tip tissue revealed the prevalence of immense and diverse microbial ecosystem intra-plant in a normally uncultivable form. Proteobacteria formed

the predominant phylum followed by Firmicutes, Actinobacteria, Bacteroidetes, Planctomycetes, Cyanobacteria and minor shares of 14 other phyla. The enormous endophytic bacterial diversity documented in the shoot-tip tissue of banana (covering 46 classes, 269 genera and 656 species) changes our present understanding about plant - endophyte association and interactions. A micropropagation protocol for the rapid multiplication of papaya 'Arka Surya' has been developed using immature seed-embryos as the starting material. Nine transgenic BC1T1 pomegranate plants derived from cultivar Bhagwa were shortlisted out of 65 events generated for resistance to *X.axonopodis* pv *punicae*. BC2T2 seeds were obtained. 569 conserved miRNAs and 139 novel miRNAs were isolated and sequenced by NGS technology from mango pulp with an intention to identify the fruit ripening process. Transgenic acid lime transformed with Xa21gene from rice for resistance to bacterial canker has set fruit. Ninty T1 seedlings were raised and were separated into zygotic and nucellar based on vigour one week after germination. Four RGA sequences were analysed from *Solanum torvum*, LRStRGA9 has 96% similarity to the PK34_210 RGA sequence of tomato, which showed clear resistance to bacterial wilt. A construct based on dsRNA for resistance to cucumber mosaic virus (CMV) in chilli has been generated.

Embryo rescue in interspecific crosses between *Lycopersicon esculentum* (15SBSB) and of *Solanum peruvianum*viz, IIHR-2809 was successful and one plant was hardened and transferred to the field. Transgenic ArkaVikas cultivar of tomato has been developed with 3 constructs one with a dsRNA for resistance to all known tospo viruses and the second with dsRNA construct for resistance to all known strains of Gemini viruses occurring on tomato in India and a third with dsRNA construct for combined resistance to PBNV and Geminivirus of tomato. Five mango leaf hopper species namely *I. clypealis*, *I. niveosparsus*, *A. brevistylus*, *I. nagpurensis* and *A. atkinsoni*, were found to share identical mitochondrial cytochrome oxidase-I (COI) genes. Study of two mitochondrial genes namely CO-I, CO-II and one nuclear gene sequences in EF-1α of 182, 146 and 186 taxa of aphids (Hemiptera: Aphididae) revealed that these genes are suitable for phylogenetic reconstruction. The miRNAome from *Thrips palmi* Karny and *Aphis gossypii* Glover was carried out using high-throughput sequencing. Genomic sequence assembly of *F. occidentalis* (Thripidae: Thysanoptera) was used as reference sequence to identify novel miRNAs, as no genomic information is available for *T. palmi* and similarly, *A. pisum* reference genome was used for comparing the *Aphis* genome. Miranalyzer pipeline identified a total of 10 novel miRNAs from *T. palmi* for the first time and Three novel miRNAs from *A. gossypii.* A total of 50 Bt isolates collected from various sources, were screened for the presence of nematicidal crystal protein genes with 2 primers pairs (Cry5 & Cry55) by PCR along with a reference strain which is positive for both *cry5* & *cry55* genes. 13 isolates were found to be positive with *cry5* specific primers and 23 isolates were found to be positive with *cry 55* specific primers. Further five PCR fragments were sequenced, two PCR products were found identical to *cry5B* and three were found identical to *cry55a* genes (99%). In another study, 10 isolates were screened for nematicidal activity against M*eloidogyne incognita* juveniles (J2), 5 isolates showed 100% mortality. *In vitro* nodal, leaf and root cultures have been initiated from *Coleus* IIHR-sel1. Callus has been generated from both roots and leaves for initiation of suspension cultures. Hairy roots from leaf cultures of Coleus IIHR-sel1, transformed with *Agrobacterium rhizogenes* have been obtained with a view for *in vitro* forskolin production.

Crop production

Fruit yield of nine years old Totapuri mango trees was higher on Turpentine (99.0 kg/tree) followed by Olour (83.3 kg/tree) rootstock. In Amrapali mango, a significant breakthrough was achieved in the understanding of the biochemical mechanism of jelly seed formation as due to the reduction of seed VLCFAs during fruit growth. A pre-harvest spray formulation was developed to prevent the disorder**.** Coir pith mulching for rainfed guava production resulted in better canopy spread and a yield advantage of 55% over no mulching. Treatment combination of berry thinning at 8-10 mm stage + ethrel application + basal leaf removal at veraison produced good quality bunches in Red Globe and Crimson Seedless grape varieties. Maximum fruitfulness in Crimson Seedless grapes was in the vines which were shoot pinched at 5th leaf. Pomegranate cv. Bhagwa plants tended to be dwarf when propagated on Daru rootstock. High density planting of fig varieties Poona and Deanna at 1000 plants/ha with annual pruning of previous season's shoots to the basal six nodes during September was promising for significant enhancement in fruit productivity by 2.5 times and 2.0 times respectively

during the initial six orchard years. Fruit yield varied from 6.2 to 13.0 t/ha in the initial cropping year for higher planting densities in guava cv. Allahabad Safeda. The geo-statistical parameters and semi-variogram models were developed for both essential and nonessential elements in soil and pomegranate plant samples for developing nutrient diagnostic norms. Application of the grapes micronutrient formulation improved the yield and TSS of grapes variety Bengaluru Blue. Treatment with endophytic growth promoting fungi *Piriformospora indica*, (10^8cfu/g) was beneficial in improving fruit number, and fruit quality attributes like carotenoids, flavonoids and ascorbic acid contents in papaya cultivars under salinity conditions.

Tomato hybrid, Arka Rakshak responded well upto 25 kg Mg as $MgSO_4$ per hectare in high Mg soils. The yield of cabbage and cauliflower was highly influenced by nano ZnO application irrespective of concentration used compared to $ZnSO_4$ application. Additional K application @10 ppm improved the growth parameters of onion varieties Arka Kalyan, Arka Niketan, Arka Bindu and Arka Pragathi grown under different water salinity levels of 0.6, 2.5, 5.0 and 7.5 dS m^{-1}. Ultra dry seeds of onion, papaya and China aster packed in moisture proof containers and stored at ambient temperature maintained higher germination and vigour up to 54, 50 and 48 months, respectively. Proteins regulating seed viability and vigour in French bean cv Arka Komal were isolated and characterized by comparing proteome of viable and non viable seeds. A total of twelve proteins involved in germination metabolism were identified.

In capsicum, Arka Mohini and CHT3-1 exhibited higher rate of pollen germination at high temperatures. Using Thermal Induction Response (TIR) technique, French bean genotypes, IC 525224 × IC-525239 IPS-1, IC-525224 × IC-525239-12 and Arka Anoop were identified as tolerant to high temperature stress.

The production technology for soilless cultivation of tomato hybrid Arka Rakshak on Arka Fermented Cocopeat under protected conditions has been standardized. A 5% (w/w) dose of the soilless Arbuscular Mycorrhizal (AM) fungal inoculants was found to be sufficient to achieve AM fungal colonization in protray raised seedlings of tomato (62.5%) and brinjal (54%). For onion seedling on raised beds an inoculum dose of 50 g/m^2 recorded AM fungal colonization of 76.5% compared to the conventional soil based inoculum applied at 100 g/m^2 (67%), which indicates a 50% reduction in the inoculum dose over the conventional mode of inoculation. The methodology for the production of mechanically aerated compost teas was developed.

In leather leaf fern (*Rumohra adiantiformis*), substrate combination of cocopeat, soil and vermicompost (1:1:1 v/v) + 2% Arka Microbial Consortium (AMC) along with application of 50% N and K to the substrate in two equal splits during June and January + 50% as foliar spray at fortnightly intervals @ 100:30:60 kg NPK/ha/year produced maximum number of cut foliage/plant/month (8.45). Photomorphogenic effect of colour shade nets on leather leaf fern indicated that plants grown under red shade net (light intensity range of 240.50 to 370 µ mol m^{-2} s^{-1}) recorded maximum production of cut foliage/plant/month (6.60), length of lamina (24.90 cm), frond width (17.77 cm) and number of pinnae (10.26). Plants of *Philodendron* 'Xanadu' grown under white shade net (light intensity range of 240.50 to 370 µ mol m^{-2} s^{-1}) recorded maximum production of cut foliage/plant/month (14.53) which was on par with green shade net (13.71). In rose, IIHR 7-1, IIHR 7-2 and IIHR 3-18-2 were found to be performing superior under polyhouse for yield and quality.

In *Coleus forskohlii*, planting during September and harvesting at 180 DAP produced maximum dry tuberous root yield of 1633.75 kg/ha, total forskolin yield of 22.37 kg/ha with a B: C ratio of 2.625. Hy 08-129 and Hy 08-53 recorded significantly higher root yield (76.7 and 66.66 g) over check K8 (59.533g). Higher total forskolin was recorded in CF 75 (1.769%), Hy 08-53 (1.550%), Hy 12-5 (1.395%) Hy 08-129 (1.361%). Hy 08-129 and, Hy 08-53 recorded higher forskolin yield. In *Withania somnifera* (Aswagandha) the advance breeding line F7-1 was distinctly superior for dry root yield (10.2 q/ ha to currently cultivated varieties). It is one of the potential hybrid derived lines with high dry root yield, withanolide content and field resistance to diseases and pests. In *Andrographis paniculata* (Kalmegh) studies revealed that variation was present for different andrographolides in stem and leaves and the content differed based on genotype and stage of harvest.

Crop protection

Pest surveillance in mango indicated that fruit borer (*Citripestis eutraphera)*, thrips (*Scirtothrips dorsalis)* gall midge (*Erosomyia* sp.), mite (*Oligonychus mangiferus)* and root mealybug (*Formicococcus*

mangiferacola) were the emerging pests. On pomegranate, severe incidence of tea mosquito bug, *Helopeltis antonii* was observed. For the management of mango hoppers and thrips, four sprays of *Metarhizium anisopliae* oil formulation @ 0.5ml/L resulted in > 80 % reduction in hopper (*Idioscopus* spp.) population and 71 % reduction in thrips population. Modelling for the progress of rust of grapes in Bengaluru Blue variety has been developed. Studies showed that soils with more silt or loam did not support the survival of the pomegranate wilt pathogen, *Ceratocystis fimbriata* for long indicating that soil with more of silt or loam should be used to fill the pits for fresh planting or refilling after removal of the dead plants. Occurrence of both mating types (MAT 1 and MAT 2) were recorded in Karnataka which is likely to pose a serious problem in future. IDM practices were demonstrated for the management of papaya ring spot virus and pomegranate bacterial wilt. The IDM package for PRSV included border cropping with castor and *Sesbania*, silver mulching and spraying of neem oil and micro nutrients while IDM for pomegranate blight included sequential spraying of different copper fungicides along with streptocycline based antibiotics. Infection of tissue culture derived plants of Grand Naine variety of banana by *Pyricularia angulata*, and occurrence of bacterial canker in bael by *Xanthomonas campestris* pv. *bilvae* were observed in Bhubaneswar.

Among the 19 brinjal germplasm/varieties screened, *Solanum macrocarpum* showed resistant reaction whereas *S. ethiopicum* and *S. indicum* showed moderately resistant reaction to root knot nematodes. Biopesticide formulations viz., *Bacillus subtilis* 1% A.S., *B. subtilis* 1% W.P., *B. pumilus*1% A.S., *Pseudomonas putida* 1% A.S. were found effective in controlling *Meloidogyne incognita* and *Radopholus* in banana. Substrate treatment with *B. subtilis* or *B. amyloliquefaciens* @ 5 ml/ kg of cocopeat in protrays and soil application of 5 tons of FYM / 2 ton of vermicompost enriched with either of them at 5 L /ha recorded significantly higher yield (28.48 to 29.41 % increase over control) and lower nematode population in soil and roots of tomato (63.94 to 64.41 % decrease). Two native strains of entomopathogenic nematodes (EPN) *Heterorhabditis indica* were isolated from mango orchards and cucumber. The bacterial symbiont associated with *H. indica* was identified as *Photorhabdus luminescens* subsp. *laumondii*.

Field distribution pattern of thrips was studied using distribution indices on chilli. The variance to mean ratio (>1), Lyold's mean crowding index (X*>1) and patchiness index (X*/X >1) indicated the aggregated distribution of thrips. Mass production of parasitoid, *Encarsia transvena* for the management of whiteflies on gerbera in polyhouses was carried out and tomato and tobacco. Biology of the invasive pest, South American tomato moth, *Tuta absoluta* was studied on three solanaceous hosts and tomato was found as the most preferred host followed by potato and egg plant. Having realized the marked impact of plant diseases in the production of horticultural crops, ICAR-IIHR had focussed its efforts in precise diagnosis, understanding of disease progression and integrated disease management practices. Begamoviruses infecting chillies and Phytoplasmas infecting vegetable crops were characterized using molecular tools that would help in proper diagnosis of these pathogens.

At CHES, Bhuabneswar, screening studies yielded sources resistant to downy mildew and leaf curl in gourds, bacterial wilt in brinjal and anthracnose in chilli. Fungicide evaluation trials revealed that chlorothalonil was effective against chrysanthemum rust while combination product of trifloxystrobin and tebuconazole was effective against black spot of rose. Post-harvest management of mango anthracnose using generally regarded as safe (GRAS) fungicides and botanicals had been standardized. Besides, ICAR-IIHR has supported the plant quarantine efforts of the country by making post-entry quarantine inspections and involving in the seed certification for export or import of seed or planting materials with respect to horticultural crops.

Crop utilization, postharvest management and farm mechanization

Among different surface coatings on mango fruits, methyl cellulose and poly vinyl alcohol were found to be beneficial in delaying ripening rate of Alphonso fruits. A process was developed for utilization of raw mango fruits (Neelum) into snack food by blending with Alphonso mango pulp. Okra pods could be stored in marketable condition for 3 days at RT (27-33°C) and 11 days at 13°C by modified atmosphere packing (MAP) in non-perforated PD-961 film. In yellow and red coloured capsicum, packed in CFB boxes and shrink wrapped with semi-permeable films could be stored for 11 and 8 days, respectively at ambient temperature (26-32°C). The storage life could be further extended to 5 weeks by storing these

shrink wrapped boxes at 8°C without any shrivelling and with a weight loss of < 5% in both cultivars.

Bitter gourd juice with acceptable taste and reduced bitterness was developed by blending the juice with cucumber, coriander and lime juice. Active principles responsible for health benefits in bitter gourd were characterized. In *amla* blended juice the blend consisting of 70% amla and 30% bottle gourd was judged best with acceptable taste and overall acceptability. Corrugated fibre board of non telescopic type having bursting strength 20 kg/cm^2 were found suitable for packaging, storage and road transportation of guava.

The pomegranate peel extract was suitable for fortification of fruit juices like pomegrante, banana, and noni or their blends. Packing of 2% calcium chloride treated cabbage shreds in Cryovac ® PD 961 to obtain an equilibrium modified atmosphere with 10- 12% O_2 and 6-8% CO_2 extended the shelf life of the produce upto 16 days at 8 °C. Market samples of betel leaves were found to harbour *Salmonella, E. coli* and *Listeria* spp. Solar tunnel dried moringa leaf powder possessed higher level of antioxidants compared to hot-air and shade dried leaf powder. Antioxidant activity of herbal tea of *R. damascene* dried petals stored at RT (26-29°C) decreased by about 50% during storage for 12 months.

Among the essential oils tried, patchouli oil at 250 ppm was effective in extending the vase life by 3-4 days in cut flowers of tuberose var. Local Double and chrysanthemum var. White Reagan. Single ply CFB sheet (10×45cm) was suitable for prevention of stem bending and breakage during storage at RT. A mango dipping tool was developed to treat the Alphonso mangoes with Arka Saka Nivarak in the tree itself for control of spongy tissue. Solar tunnel dryer of 6 × 3 × 2.7 m was developed to dry cut slices of onion and amla with a capacity of 300 kg per batch. A motorized watermelon seed extractor was developed with the capacity of extracting 70-80 fruits (1.98 kg of seeds/h). A manually operated onion grader was developed for grading of rose onions based on size with a capacity of 1 tonne/ h.

Economics, statistical modelling and computer applications

The economic impact of adoption of Arka Prajwal tube rose hybrid evaluated at individual farm level and at the aggregate level (district/state) indicated high profitability to the growers with net realisation of Rs. 3.86 to 8 lakhs/ha and a BCR of 1.87-2.97. Based on the two year cycle of the crop, with over 50% adoption rate of Arka Prajwal between the period 2011 to 2015, the total discounted net benefit accrued to the state was estimated at Rs 640 crores. The aggregate total economic impact in terms of discounted net benefit accrued to the economy based on sample survey and data collected from Tamil Nadu, Uttar Pradesh and West Bengal, is around Rs.880 crores, thus justifying the investment into breeding better hybrids/ varieties in flower crops.

Export of mango pulp grew at an annual growth rate of 5.67 % in quantity and 10.43 % in value (2005-2016). Major importing countries, Saudi Arabia, UAE, Netherlands, Yemen, UK, Germany and Canada reflected this trend as well. UAE, Kuwait and USA recorded positive growth in value but registered negative growth in quantity. An instability analysis of export performance indicated higher instability index (CV> 25%) in case of UK, Germany, UAE, Kuwait and Netherlands. Irrespective of the variety used for pulping, cost of the raw material accounted for major share (>60%) of export cost. Frequent fluctuations in exchange rate, payment defaults by merchant exporters and increasing cost of export such as higher duties were identified as the constraining factors impeding export performance of processed products from India.

Efforts at analyzing the factor productivity and production efficiency in papaya revealed that labour use and nitrogen application are the key factors having positive effect on yield. Only 53% of the farms were found to perform at optimum production scale while the average production efficiency of all farms was 0.79. The rest of the farms could be advised to remain at the same level of efficiency even if they reduce their input use by 20%. The average allocative efficiency score achieved was only 0.439. Only 7% of the farmers achieved the allocative efficiency score of 0.9 or above. The average economic efficiency is 0.355, which suggests that farmers producing papaya are yet to achieve the economic efficiency.

M-estimation**,** a methodology for attaching the desired weights to multiple outlier observations / replications while analyzing designed experimental data on brinjal showed that the probability of type I error decreased from 7.22-2.51%, coupled with an increase in confidence level from 92.78 to 98.99%. The robust analysis of variance for Huber's M-estimation

for eight different traits in brinjal experiments resulted in reduction of 38 to 42% EMSS and confidence level increased from 92.78 to 97.57%. Use of Andrew's M-estimation for the same characters resulted in reduction of 54.22 to 56.55% EMSS and increase in confidence level from 92.78 to 98.99%.

A logistic mechanistic growth model developed along with biological measures of intrinsic growth rate and carrying capacity indicated that the severity of grapes yellow rust disease could be predicted to an extent of 91%. A non-linear logistic model used to estimate the area under disease progression curve for describing population dynamics for yellow rust in grapes showed a range of 27.5 to 48.5 for the year 2015, when plants were pruned in April. A Decision Support System on pomegranate was developed as web application with graphical user interface for general crop information, disease management, plant protection and disorder identification modules to provide diagnosis and solutions for pomegranate cultivation. A web application has been developed for onion production with solutions for farmers and other stake holders on disease diagnostics, disorder identification and crop management modules and general crop profile.

Extension and Transfer of technology

Latest cultivars of vegetables and ornamental crops were demonstrated under real farm situations. Rate of adoption of two technologies were assessed. Issues of litchi growers were documented. Training needs of agricultural officers of Kerala and International delegates from Kenya, Malawi and Liberia were assessed. ICAR-IIHR interventions for knowledge and economical empowerment of farm women were assessed under real farm situations. Study on understanding dynamics of women interest groups was initiated. More than 30 on-campus training programmes were organized for extension personnel and farmers. More than 10 off-campus training programmes and interface meetings were organized. More than 1600 stakeholders benefitted through these programmes. Through participation of ICAR-IIHR in various exhibitions, more than 9 lakh farmers were benefitted. More than 8500 farmers, who visited the institute were imparted awareness on ICAR-IIHR technologies, through orientation and agro-advisory services including that of ATIC. ICAR-IIHR products worth of Rs. 47 lakhs were distributed through ATIC. More than 30 research and extension publications were brought out.

Women Empowerment

With an idea of empowering women by bringing them into the mainstream of agriculture and rural development, farm women from Rajanakunte Gram Thana and nearby villages were provided with kits containing ICAR-IIHR developed vegetable seeds for taking up horticulture as a source of livelihood. The institute has developed women friendly farm equipments/tools and machineries to reduce drudgery and several skill development training programs were organized exclusively for farm women so as to encourage more and more women to takeup horticultural activities.

Tribal sub-plan

Promotion of horticulture for tribal livelihood was taken up at CHES, Bhubaneswar under tribal sub-plan. Critical inputs like pesticides, farm tools, sprayers, fertilizers, etc. were provided to 450 farmers in Kashipur to promote mango cultivation in the region. Besides, training and demonstrations were organized for effective dissemination of technologies. The concept of nutritional kitchen gardening was introduced with the participation of 250 tribal households of seven villages of Mohana block of Gajapati district of Odisha for ensuring nutritional security at household level and to generate supplementary income for the farm women. Interventions to promote underutilized cucurbits like teasel gourd, ivy gourd and pointed gourd were initiated with 50 farmers' households by providing seedlings to selected farmers. Farmer's self-help groups were trained to produce planting material of these crops in the polyhouse nursery and in processing of jackfruit into ready-to-cook products for local and urban marketing. Under the Mera Gaon Mera Gaurav (MGMG) project of the Council, awareness camps, farmer advisory services through mobile service, providing literature, and *Kisan Gosthis* were organized for the benefit of the farming community.

CHES, Chettalli organized an off-campus training programme followed by input distribution at Balegundi and Thyagathur villages of Somwarpet Taluk, Kodagu for skill up-gradation of farmers. This training on coconut and vegetable cultivation benefitted 90 tribal beneficiaries from both the tribal villages, to whom 1000 six months old coconut seedlings of West Coast tall variety and 100 vegetable seed kits were distributed.

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. Popularly known today as IIHR, Bengaluru, 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. The Institute was initially established at the ICAR headquarters and subsequently shifted to Bengaluru in Karnataka on February 01, 1968. Dr. G.S. Randhawa was the Founder Director with whose vision and dynamism, the Institute made rapid progress. 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 its sphere of 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 ICAR-IIHR, Bengaluru has three Central Horticultural Experiment Stations at Bhubaneshwar in Odisha and Chettalli and Hirehalli in Karnataka and two Krishi Vigyan Kendras located at Gonikopal and Hirehalli. The Institute also 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 centre 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 and sustainability to achieve food, nutritional and livelihood security. Towards this end, the ICAR-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, notwithstanding the present day needs and demands of horticulture sector. Achieving the projected growth rate of 12% to 15% in agriculture for sustainable development without disturbing the socio-economic and ecological balance, the research programs of the Institute are designed to develop sustainable technologies to achieve food and nutritional security. Reducing the cost of production, improvement of soil health and biosphere for increased productivity, maintenance of high crop productivity under adverse conditions, evaluation and mitigation of undesirable effects of climate change, biotechnological interventions to increase productivity and minimizing post-harvest losses and value addition to horticultural produce are the other priority areas.

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 ICAR-IIHR technologies.

Main Station, Hesaraghatta, Bengaluru

The main station is located at Hesaraghatta, 25 kms towards north of Bengaluru city. During the initial years, the Institute functioned from its administrative office located in Bengaluru city with the laboratory complex and research farm at Hesaraghatta until an independent administrative office was built at Hesaraghatta campus in 1994. Today, the entire laboratory complex with the experimental farm, administrative unit and staff quarters are located at Hesaraghatta campus spread over 263 ha land. Recently the Institute has also taken over 24 acres of land of ICAR-IVRI at Yelahanka, Bengaluru and also about 2 acres of land in UHS, Bengaluru campus.

Growth

The physical growth of the Institute could be viewed in two phases. The first phase was from 1970 to 1990, wherein emphasis was laid on development of land and infrastructure. During this phase, the blueprint of the entire farm area for carrying out experimental trials and laboratories for research and administrative office buildings was prepared. Accordingly, 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. The second phase of development was from 1990 to 2005 during which period, stress was laid on developing state-of–the–art facilities for basic and applied research. Currently, the research activities are being carried out by 11 divisions and four sections viz., Divisions of Fruit Crops, Vegetable Crops, Ornamental Crops, Post-Harvest Technology, Plant Pathology, Entomology and Nematology, Soil Science and Agricultural Chemistry, Plant Physiology and Biochemistry, Plant Genetic Resources, Biotechnology, Agricultural Extension and Training and Sections of Medicinal Crops, Seed Science and Technology, Economics and Statistics and Agricultural Engineering with more than 65 purpose oriented laboratories having state of art equipments like electron microscope, ultra-centrifuge, LC-MS, HPLC, UPLC, GLC, liquid scintillation counter *etc.* Field facilities include poly houses, net houses, growth chambers and mist chambers. Other facilities like, cold storage chambers, gene banks, seed processing, nursery units and communication channels like, local area network with video conferencing facilities, *etc.* are available The temperature gradient chambers and phenomics facility are the latest additions, built to study the effects of climate change and to promote protected cultivation. The Institute has also created cryopreservation facilities for the long-term preservation of germplasm of crop genetic resources. Apart from this, the Institute houses an ultra-modern library, a conference hall, auditorium, training hostel, bank, post office, hospital, essential quarters and facilities for the PG School for research in horticultural sciences.

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

The Station was established in 1972 at Chettalli, with its 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 with effect from 01.01.1992. 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 planting material, *Trichoderma* cultures and other planting materials. 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. The objective of the station is 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. The station has a strong unit for 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 ICAR-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 ICAR-IIHR released vegetable varieties and research work on fruit crops, particularly maintenance of 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

Krishi Vigyan Kendra was sanctioned in the year 2009. Apart from the activities of Krishi Vigyan Kendra, it has taken up popularization of ICAR-IIHR developed technologies and production and distribution of seeds and planting material and technological products developed by ICAR-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 ICAR-IIHR, Bengaluru on February 1, 1972 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. All the research work on citrus has now been shifted to Chettalli. 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 implements, monitors all the activities of the Institute. Considering the importance given to horticultural research and development in the country, ICAR-IIHR has the mandate to serve various stake-holders of horticultural sector. In order to meet these needs, the Institute has established various service-oriented units.

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 constitute at the Institute level would maintain a close watch on the functioning and performance of the Institute at different levels especially 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 Head of the Institute in all administrative, financial and vigilance matters for the overall improvement of the organization. The Vigilance Cell website link, mail ID has been created in the Institute website for the benefit of the 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.

Human Resources Development

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 ICAR-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 to farmers and development personnel on various advanced technologies in the horticultural sector.

Post Graduate School in Horticultural Sciences

A Post Graduate School in Horticultural Sciences has been established by signing an MoU with ICAR-IARI, New Delhi for initiation of Ph.D. Program as an Outreach program of PG School, ICAR-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.The second batch of Ph.D. degree program in Horticulture and Post-Harvest Technology of Horticultural crops as an out-reach campus of ICAR-IARI, New Delhi, commenced on 08.08.2015 with a total of 16 students (three in Fruit & Horticulture Technology, six in Vegetable Science, four in Post Harvest Technology and three in Floriculture & Landscape Architecture). Board of studies meetings were conducted thrice to monitor and review the course work and research program of the students. A total of 61 courses in Horticulture (Fruits Science, Vegetable Science and Floriculture & Landscape Architecture), Post-Harvest Technology, Genetics, Biotechnology, Plant Pathology, Plant Physiology, Microbiology, Extension, Statistics, Agronomy, Soil Science, and PGR were offered.

Library

Due to technological developments, the availability and access of information has changed the complexion of information seekers. Of late, the trend is moving towards the e-contents than the browsing of physical documents. The library has a total collection of 31143 documents: 11446 books, 15552 back volumes, 119 theses, 1737 reports, 1986 bulletins and 344 other documents and proceedings, which includes 36 books added this year. 294 newsletters, which are received *on gratis* or complimentary this year. Acta Horticulturae which are the wealth of international information for scientists working on horticulture crops, are procured and have been consulted by people across the country. The review literature which is being published serially as Advances and Annual Reviews (28 titles) in the form of books were also procured on standing order for reference purpose. A good number of international and 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 36 foreign Journals and 156 Indian journals for its main station, Regional Stations and KVK libraries. Apart from this, 8 Indian Journals and 10 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 proposal for the digitization of rare and old books, research reports, bulletins and research articles etc. had been received from NAIP under e-granth project: a list of research articles published by the scientists since 1969 to 2010 was prepared for digitization and sent. 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 CeRA (Consortium for e-Resources in Agriculture). The CeRA – 'Consortium for e-Resources in Agriculture' also provides a lot of enhanced features of online access to full text articles of journals from the following participating publishers viz., Springer, Elsevier, Taylor & Francis, Oxford University Press, American Society of Agronomy journals, Annual Reviews, CSIRO (Australia), Indian journals, ICAR & SAU Libraries subscribed Journals and the new version of 'Open J-Gate plus'.

Linkages

The Institute has established linkages with many national and international organizations in the field of research and training. Collaborative research program with international organizations like ADB, AVRDC, DFID, IPGRI, SAVERNET, UNU-KIRIN, ICUC, World Bank, FAO, *etc.* are in progress in specific subjects in horticulture. Many collaborative research programs are being carried out under the aid of national organizations like DST, DBT, CSIR, APEDA, KAPPEC, ISRO, DRDO, NSC, NHB, NHM, CWC, Ministry of Agriculture and Cooperation, State Departments of Horticulture etc. Many inter-institutional multidisciplinary projects of the ICAR are also under operation at the Institute in Network mode with IIHR as the lead center. Apart from these IIHR, Bengaluru is a leading Institute for training of international personnel, particularly from Africa, Middle East, South East Asian countries and SAARC countries.

Human Resources

The Institute (including its regional stations) has a sanctioned staff strength of 607 staff members (153 scientific, 226 technical, 83 administrative and 145 supporting). The Institute is headed by the Director supported by 11 Heads of Divisions and four Heads of Sections. The Central Horticultural Experiment Stations at Chettalli, Bhubaneswar and Hirehalli and the Krishi Vigyan Kendras are managed by the Station Heads and Program Coordinators respectively under the overall control of the Director of the Institute. All the staff of administrative, finance and accounts wings of the Institute are managed by the Chief Administrative Officer heading the Administrative

Wing who also functions as Head of the Office and the Assistant Finance and Accounts Officer heading the finance, accounts and audit wing under the control of Director of the Institute. The Research Advisory Committee and the Institute Management Committee constituted by ICAR review the progress and advice on all research, development and extension activities of the Institute from time to time.

Awards and Recognitions

The Institute is an ISO 9001:2008 certified organization and the quality policy of the Institute is well defined and functions as per the defined quality standards. The Institute had been adjudged as "The Best Institute" by Indian Council of Agricultural Research, New Delhi and awarded Sardar Patel Best Institute Award twice during 1999 and again in 2010. The other achievements of the Institute are; the Institute is recognized as the main center for production and supply of breeders' seeds of vegetable crop varieties, the Institute nursery has been rated Four Stars by National Horticulture Board, the pollen Cryo-Bank of the Institute features in the Limca Book of Records 2001, recognized as the Team of Excellence in Biotechnology and Post-Harvest Management with a Product Development Laboratory to up-scale technologies, centre for entrepreneurship development for lower middle level technical personnel, a centre of DBT-ICAR National Facility for virus–diagnosis and quality control of tissue culture plants and Sanitary and Phyto-sanitary Certification Agency for seeds and planting materials and NABL accredited Pesticide Residue Research Laboratory in accordance with the standard ISO/IEC 17025:2005 for chemical testing of pesticides in fruits, vegetables, water, cereals and pulses.

Research and Development

In the first few years of its inception, the main research agenda of the Institute was to increase the production and productivity of horticultural crop varieties by developing high yielding varieties of fruits, vegetables, ornamentals, medicinal and aromatic plants and mushrooms and to develop advanced production technologies to increase the productivity of horticultural crops. With changing times and emergence of new challenges in the fields of crop improvement, crop production, crop protection and crop utilization, emphasis was laid on breeding varieties for biotic and abiotic stresses, breeding F1 hybrids, production and utilization of edible and medicinal mushroom, development of integrated pest and disease management technologies, developing integrated water and nutrient management protocols aimed at optimum utilization of resources. Standardization of post-harvest management practices to reduce post-harvest losses, processing for value addition, production of vegetables under protected conditions, precision farming, information technology, biotechnological interventions to increase yields, evolving non-conventional methods for protection of crops from insect pests, diseases and viruses, and extension of shelf life of horticultural produce, biological control, disease diagnostics, pesticide residue management, evaluation and mitigation of adverse effects of climate change in horticultural crop production and frontier research areas like hi-tech horticulture became priority areas with changing research agenda at the national level.

Accomplishments

Research work carried out during the last four decades has paid rich dividends in terms of release of 220 varieties and hybrids and development of a number of sustainable production, protection and post-harvest management technologies. One of the important objectives of the Institute is collection, characterization, evaluation, conservation and maintenance of germplasm of horticultural crops for utilization in crop breeding and for posterity. The Institute maintains a wealth of varied collection of germplasm reflecting considerable genetic biodiversity that includes potential sources of resistance to various biotic and abiotic stresses and also those with high nutritional, health care and medicinal values and quality traits. At present, the Institute has the largest collection of 10626 germplasm in various horticultural crops. The main station at Hesaraghatta, Bengaluru holds 8580 germplasm in its fold comprising of 1360 in fruits, 5787 in vegetables, 874 in ornamentals and 465 in medicinal plants apart from 94 in mushroom and betel vine. The CHES, Chettalli and CHES, Bhubaneswar have a collection of 1538 and 508 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 100 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 and long term cryo preservation of Nuclear Genetic Diversity (NGD) apart from low cost techniques for storage of vegetable seed germplasm. A pollen cryo pollen bank was established for the first time in the country at the Institute in 1983 in which nearly 6045 collections of various horticultural crops are cryo preserved.

Most of the varieties/ hybrids developed by the Institute are intended for obtaining higher yields, resistance to moisture stress, high temperature stress, resistance to multiple pests and diseases, off season production and export. So far, the Institute has developed over 235 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 it released a high yielding pink fleshed papaya hybrid Arka Prabhat, a red fleshed hybrid guava Arka Kiran, and Arka Sahan a hybrid of annona with large globules and less seeds. These hybrids hold excellent promise and are gaining in popularity within the country and abroad.

In vegetable crops, the Institute has so far developed and released 93 high yielding open pollinated varieties and 19 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, ivy 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 Komal, 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 80 improved varieties having high yield, attractive colour, novelty and improved shelf life in gladiolus, chrysanthemum, bougainvillea, hibiscus, tuberose, rose, China aster, carnation, gerbera and crossandra. Many of the gladiolus varieties, China aster varieties - Poornima, Kamini, Violet cushion and Shashank, tube rose cultivars - Shringar, Suvasini, Prajwal and Vibhav and crossandra varieties -Arka Kanana and Arka Ambara have gained high popularity among the farmers.

In the field of medicinal and aromatic plants, the Institute has developed six varieties, two each in *Diascoria floribunda*, *Solanum viarum* and *Mucuna pruriens* having higher content of active principles and three varieties of aromatic plants, jasmine having higher percentage of essential oils. Work on RET of medicinal plants and other important herbal plants is in progress.

In the field of mushrooms, a sporeless mutant of oyster mushroom, milky mushroom, Jews ear mushroom, a medicinal mushroom with export potential and an ornamental mushroom have been developed.

In the field of production technologies, the Institute has concentrated its work on increasing productivity by standardizing high density orchards, using 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.
- Integrated water and nutrient management schedules like, drip irrigation and fertigation.
- Application of fertilizer in the active root feeding zone, etc., for optimum utilization of resources for various fruits, vegetables and ornamental crops
- Standardized leaf and petiole diagnostics for recommendation of optimum fertilizers for respective crops.
- Technology for foliar nutrition of micronutrients 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.
- Arka Microbial Consortium, Arka Fermented Cocopeat and Arka Actino-Plus for use in horticultural crop production.
- Technology to boost seed yield in China aster (powder puff type)
- The causative factor for the formation of jelly seed, a major physiological disorder in Amrapali mango has been established and a nutrient formulation developed for its management.
- Technology for production of tomato, colored capsicum, cucumbers and melons under protected conditions.
- Refined 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 upto 90% crop loss by insects like *Helicoverpa* or epidemic diseases like *Phytophthora* have been reported. The Institute, in the initial stages worked out management practices for control of major insects, nematodes and diseases using chemical pesticides. Pesticide spray schedules were worked out for control of major pests in fruits, vegetables and ornamental crops. These spray schedules 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, pesticide residue analysis in horticultural produce, safe waiting period for pesticides, decontamination of pesticide residue from horticultural produce, biodegradation of pesticides, suitability of pesticides for inclusion in integrated pest management *etc.* have also been worked out. 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. IPM technologies for management of mango fruit fly and stone weevil, sapota seed borer, citrus leaf miner, borer in tomato, brinjal, chilli, DBM in cabbage and cauliflower, okra, onion, leguminous vegetables and various other vegetables and 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 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.

- 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. Similarly, integrated disease management protocols and diagnostic kits for viruses have also been developed.
- Sealer and healer for management of stem borer.
- 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 the horticultural commodities. ICAR-IIHR, Bengaluru has been recognized as the Center of Excellence in Post-Harvest Technology with excellent infrastructure facilities. The Institute has standardized the technology to extend the storage life 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, ultra centrifuge, micropropagation 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 micropropagation 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) nucleocapcid gene of PBNV and planty 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, export promotion and import restriction, 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, impact analysis and assessment of technologies, 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. The results of these studies have facilitated to refine the package of practices of

cultivation of various horticultural crops, reduction in cost of cultivation by efficient use of inputs, time and placement of horticulture produce in the domestic as well as overseas markets for higher profit margins, technological interventions and refinement of technologies based on farmer's needs, development of innovative extension and communication methods for timely and accelerated dissemination of information, redesigning and modification of training programs and as per the needs of the trainees etc.

ICAR-IIHR is involved in first line transfer (or demonstration) of technology for dissemination of information and technologies developed by the Institute. This is being carried out by conducting on farm and off farm demonstrations, FLDs, various media and publicity activities, radio and television programs, publishing popular literature, video films, conducting field days, participating in national and international exhibitions, first line training programs for development functionaries, need based training programs to entrepreneurs and corporate/ private agencies and also to the needy farmers. So far the Institute has organized more than 35 subject matter workshop cum seminars for officers of different states organized more than 480 training programs on various aspects of horticulture and trained more than 10,000 personnel, apart from training a huge number of farmers, farm women and private entrepreneurs. 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 a good number of demonstrations on 16 innovative IIHR technologies on farmers' fields in 10 different states to popularize the technologies. More than 60 field days on IIHR developed technologies and varieties have been organized both at the Institute and on farmers' fields. About 350 radio and 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. Under the Lab to Land program the Institute adopted 760 small and marginal farm families from 65 villages in and around Bengaluru and Kolar to popularize the vegetable varieties developed by the Institute through distribution of seeds and other inputs. 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 the field of research and development worldwide, playing a greater role in the economy. Identifying IPR's in the field of agriculture, protect and further commercialize them competitively has become one of the major issues in agriculture. Realizing the importance of IPR and recognizing the need for becoming competitive in the Intellectual Property Rights regime so as to ultimately bring the Indian farmers away from subsistence with the transfer of IPR enabled technologies through commercial, cooperative and public route, the ICAR-IIHR, Bengaluru took up protecting 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 designed and registered a trade mark, 'ARKA' 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 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.

Livelihood, nutritional and health security through all round development of horticulture sector in the country is the main thrust of the Institute. This is

envisaged to be achieved through basic, strategic and applied research and development in a mission mode with bifocal vision. Sustainable and economic growth of the farmers in particular and the country at large will be the ultimate goal.

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 2015-16 including regional stations under plan and non-plan was Rs.1738.82 and Rs.16.44 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. 169,92,596.

Staff Position

Category	Sanctioned	Filled	Vacant
Scientific	152+1*	145	07
Technical	226	157	69
Administration	83	62+1$	21
Skilled Supporting Staff	145	127	18
Total	606+1	489+1	115

* Director; $ SAO

Station-wise budget allocation 2015-16 (Rs. in lakhs)

PLAN

Heads	ICAR-IIHR Bengaluru	CHES Chettalli	CHES B'war	CHES Hirehalli	Total
Capital	515.25	20.00	90.50	6.35	**632.10**
Total	**515.25**	**20.00**	**90.50**	**6.35**	**632.10**
Revenue					
Establishment charges	0	0	0	0	0
Wages	0	0	0	0	0
Overtime allowance	0	0	0	0	0
Travelling expenses	12.20	0	0.0	0	**12.20**
Research & Operational	25.85	9.75	13.50	1.40	**50.50**
Administrative expenses	140.55	0	0	3.20	**143.75**
Miscellaneous (HRD)	11.43	0.32	0.25	0	**12.00**
Pension & Retirement	0	0	0	0	**0**
Loans & Advances	0	0	0	0	**0**
Total Plan Revenue	**190.03**	**10.07**	**13.75**	**4.60**	**218.45**
Total Plan (Capital + Revenue)	**705.28**	**30.07**	**104.25**	**10.95**	**850.55**
Plan Schemes (ORP's, NI, NEH & TSP)	**853.95**	**15.00**	**19.40**	**0**	**888.35**
Total	**1,559.23**	**45.07**	**123.65**	**10.95**	**1,738.90**

Station-wise expenditure incurred 2015-16 (Rs. in lakhs)

PLAN

Heads	ICAR-IIHR Bengaluru	CHES Chettalli	CHES B'war	CHES Hirehalli	Total
Capital	515.57	19.74	90.45	6.34	**632.10**
Total –Plan Capital	**515.57**	**19.74**	**90.45**	**6.34**	**632.10**
Revenue					
Establishment charges		0	0	0	0
Wages	0	0	0	0	0
Overtime allowance	0	0	0	0	0
Travelling expenses	12.20	0	0.00	0	**12.20**
Research & Operational	26.05	9.66	13.42	1.39	**50.52**
Administrative expenses	140.53	0	0	3.20	**143.73**
Miscellaneous (HRD)	11.43	0.32	0.25	0	**12.00**
Pension & Retirement	0	0	0	0	**0**
Loans & Advances	0	0	0	0	**0**
Total Plan Revenue	**190.21**	**9.98**	**13.67**	**4.59**	**218.45**
Total Plan (Capital + Revenue)	**705.78**	**29.72**	**104.12**	**10.93**	**850.55**
Plan Schemes (ORP's, NI, NEH & TSP)	**853.87**	**15.00**	**19.40**	**0**	**888.27**
Total	**1,559.65**	**44.72**	**123.52**	**10.93**	**1,738.82**

Station-wise budget allocation 2015-16 (Rs. in lakhs)

NON-PLAN

Heads	ICAR-IIHR Bengaluru	CHES Chettalli	CHES B'war	CHES Hirehalli	Total
Capital	37.45	2.00	2.50	1.05	**43.00**
Total – Non-Plan Capital	**37.45**	**2.00**	**2.50**	**1.05**	**43.00**
Revenue					
Establishment Charges	3759.96	183.50	235.00	65.00	**4243.46**
Wages	119.69	27.40	0	0	**147.09**
Overtime allowance	0.45	0	0	0	**0.45**
Travelling Expenses	26.90	2.65	5.25	0.20	**35.00**
Research & Operational	325.90	45.60	36.75	21.75	**430.00**
Administrative Expenses	532.50	25.50	29.00	13.00	**600.00**
Miscellaneous	30.63	1.72	1.00	0.65	**34.00**
Pension & Retirement	2353.00	91.00	6.00	0	**2450.00**
Total Non-Plan Revenue	**7149.03**	**377.37**	**313.00**	**100.60**	**7940.00**
Total Non-Plan (Capital + Revenue)	**7186.48**	**379.37**	**315.50**	**101.65**	**7983.00**
Loans & Advances	15.06	1.38	0	0	**16.44**

Station-wise expenditure incurred 2015-16 (Rs. in lakhs)

NON-PLAN

Heads	ICAR-IIHR Bengaluru	CHES Chettalli	CHES B'war	CHES Hirehalli	Total
A. Capital	37.62	1.97	2.35	1.05	**42.99**
Total – Non-Plan Capital	**37.62**	**1.97**	**2.35**	**1.05**	**42.99**
B. Revenue					
Establishment Charges	3760.86	183.46	234.30	64.83	**4243.45**
Wages	119.69	27.40	0	0	**147.09**
Overtime allowance	0.43	0	0	0	**0.43**
Travelling Expenses	26.93	2.64	5.23	0.20	**35.00**
Research & Operational	326.02	45.61	36.73	21.64	**430.00**
Administrative Expenses	531.98	25.09	29.00	12.93	**599.00**
Miscellaneous	30.63	1.84	0.90	0.63	**34.00**
Pension & Retirement	2351.97	91.05	5.80	0	**2448.82**
Total Non-Plan Revenue	**7148.51**	**377.09**	**311.96**	**100.23**	**7937.79**
Total Non-Plan (Capital + Revenue)	**7186.13**	**379.06**	**314.31**	**101.28**	**7980.78**
Loans & Advances	**15.06**	1.38	0	0	**16.44**

Station-wise revenue realised (Rs. in lakhs)

NON-PLAN

Heads	ICAR-IIHR Bengaluru	CHES Chettalli	CHES B'war	CHES Hirehalli	Total
Sale of Farm produce	2227861	5271971	1287330	121534	**8908696**
Sale of Publication	222400	0	0	0	**222400**
Licence Fee/Guest House	948525	294866	0	1850	**1245241**
Interest earned on Loans & Advances	2216075	40877	85	0	**2257037**
Leave Salary & Pension Contribution	0	0	0	0	**0**
Analytical Testing fee	565250	0	0	0	**565250**
Application fee from candidate	244200	0	0	0	**244200**
Receipts from Service rendered	0	0	0	0	**0**
Fee/Subscription	449360	0	91600	0	**540960**
Consultancy Service	192000	0	0	0	**192000**
Misc. receipts	2704244	81768	30800	0	**2816812**
Total	**9769915**	**5689482**	**1409815**	**123384**	**16992596**

3. Research Achievements

3.1. Crop Genetic Resources

3.1.1. Germplasm Exploration & Collection

- Countrywide exploration for trait specific germplasm in fruit crops led to collection of 104 germplasm comprising mango (28), guava (2), jamun (3), *Annona atemoya* (1), passion fruit (1), strawberry (5) and seven underutilized fruit species. Fifty seven accessions of pomegranate were introduced from USDA. Variants of apple guava and Allahabad Surkhi were collected from Lucknow.
- Exploration in Phek, Tuensang and Mokokchung districts of Nagaland and adjoining border areas for various vegetables, wild relatives and land races yielded 176 collections including 40 taxa of targeted crops and their wild relatives (Dimapur-01; Kiphire-12; Kohima-06; Mokokchung-13; Phek-93; Tuensang-35; Wokha-17). *Gymnopetalum chinense*, *Herpetospermum operculatum*, *Abelmoschus tetraphyllus* var. *pungens*, *S. torvum*, *S. aculeatissimum* and *S. aethiopicum* were the wild species collected. *Cucumis sativus* (JRPH/15-58) with mild sweetness, extra long fruited (90cm) yard-long bean (JRPH/15-68), Raj -mash (JRPH/15-122) with white small grains, *Solanum indicum* without spines (JRPH/15-39) and a rare species of *Momordica* viz., *M. subangulata* subsp. *subangulata* were some unique collections. In land races of French beans, variability for seed size, colour, mottling pattern and culinary traits were observed.

Cucurbita ficifolia (Fig leaf gourd), Roots stock for cucumber drought tolerance and fruits of M. subangulata subsp. subangulata

Abelmoschus tetraphyllus var. *pungense* and mild sweet type *Cucumis sativus* JRPH/15-58

- Collections of Hadagali jasmine, three jamun accessions from Rajanukunte, Bengaluru, eleven mangosteen samples from FRS, Burliar and Kallar (Tamil Nadu), *Rubus sp* (2), *Garcinia sp* (3) and orchid species (3) from the Western Ghats region were made.
- Details of vegetable germplasm collections are furnished below:

Crop species	No. of collections made	Place of collection	Total viable germplasm
L. esculentum	2	IIVR, Varanasi	689
S. cheesmanii, S. chmielewskii and *S. pimpinellifolium*	7	University of Hyderabad	
Cucumis sativus	50	NBPGR, New Delhi	198
C. hardiwickii	1	A.P	
Luffa acutangula	3	Kerala, Tamil Nadu and Nagaland	103
Benincasa hispida	5	Kerala	105
M. charantia var charantia and *M.c. var. muricata*	2	NBPGR, New Delhi and IARI, New Delhi	138
Capsicum sp.	750	NBPGR, New Delhi, AVRDC, Taiwan, NE, Madhya Pradesh, Maharastra	2000

- Distribution map documentation of 30 horticultural species in Eastern Ghats and nine medicinal crops was completed.
- Fifteen chrysanthemum genotypes from Kashmir and three local types were collected and multiplied.

3.1.2 Germplasm Conservation and Domestication

Field Gene Bank (FGB)

- The status of fruit germplasm maintained in the field gene bank is as follows.

Crop	Number of accessions
Mango	675
Papaya	32
Guava	60
Pomegranate	178
Strawberry	132
Passion fruit	12
Pummelo	25
Grape fruit	8
Grapes	55
Annona	24
Underutilized fruits	38
Jamun	66
Sapota	46
Jack Fruit	72

- A new block of twenty nine underutilized fruit crops comprising rose apple, avocado, longan, rambutan, bilimbi, mangosteen, langset, milk fruit, star apple, karonda, ber, passion fruit, *A. muricata, A. cheromola, A. reticulate, A. atemoya, A. squamosa*, tamarind, etc. was established at CHES, Bhubaneswar.
- As ICAR-IIHR is a recognized NAG (National Active Germplasm) centre, six accessions of sapota were deposited from Fruit Research Station, Gandevi, Gujarat. Also, 55 varieties/ hybrids/accessions of grapes were multiplied and maintained in CHES, Hirehalli.
- In the biodiversity block of Western Ghats plants, leguminosae species were maximum in number followed by Meliaceae (5), Apocyanaceae (5) and Moraceae (5). Among them, three tree species viz., *Pterocarpus santalinus, Moringa concanensis and Madhuca insignis* are red listed. There are 10 threatened and 20 potential fruit species.
- In crossability tests of guava, the fruit set percentage in direct and reciprocal crosses of *P. guajava* and *P. guinense* were 34% and 4% respectively.
- Flowering and fruiting data from FGB of *Saraca asoca, Embelia ribes, Embelia tsjeriamcottam, Oroxylum indicum and Holotemma adakodien* were recorded and correlated with the weather data.
- One genotype of *E. ribes* in the FGB for RET medicinal plant exhibited flowering and fruiting throughout the year and seeds were deposited to ICAR-NBPGR for obtaining the IC number.

Fruiting in E. ribes genotype

- A field gene bank of 60 betelvine germplasm and a separate block of its 50 hybrids were established on *Sesbania* supports at CHES, Hirehalli.

In vitro Conservation

- In *Bael*, multiple shoots were induced using embryonic axes cultured in WPM supplemented with BAP (0.5 and 1.0mg/l. In *Saraca asoca*,

Multiple shooting of Bael embryonic axes in WPM+ BAP (1.0mg/l)

regeneration from embryonic axes was observed in WPM supplemented with BAP (0.5 and 1.0 mg/l). In 2 accessions of jackfruit, embryonic axes cultured in MS media supplemented with 0.1 mg/l BA regenerated after 5 days under SCC in dark.

Cryopreservation

- 100 percent germination in seeds of *Solanum aethiopicum*, *S. gilo* and *S. mammosum* was obtained after four months of cryostorage.
- Pollination with 3 months cryostored pollen of the above species on same parent resulted in 80 per cent fruit set in *S. mammosum* and 100 per cent in both *S. aethiopicum* and *S. gilo*.
- In jamun, cryostored pollen of five accessions retained viability up to 6 months of storage.
- In *Saraca asoca*, the optimum time for pollen collection for cryopreservation was found to be between 3.00 and 4.00 am.
- Thirty two per cent of cryostored aonla pollen germinated on 15% sucrose supplemented with Brewbaker's salts.
- Seed and pollen collections made during the earlier years were continued to be maintained under cryogenic conditions in the cryogenebank.

3.1.3. Germplasm Characterization

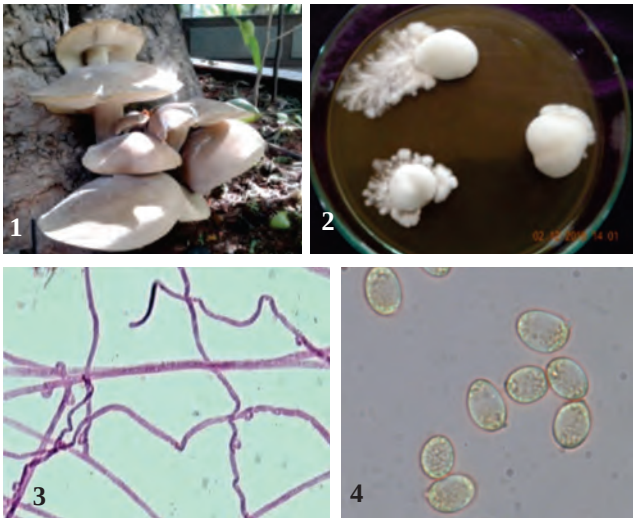
Morphological characterization

- Morphological characterization of mangosteen collected from State Horticultural Farm, Burliar and leaf samples of 7 accessions from FRS, Kallar revealed variability for aril thickness, number of seeds/fruit, seed weight, seed shape and seed colour. Genotype T.N. 41 recorded highest TSS of 21.6^{o} B.
- Fourteen accessions of jamun that were morphologically characterized for tree growth, leaf and flowering parameters using NBPGR minimal descriptors showed no significant difference among the genotypes.
- Morphological characterization of mango seedlings established from fruits procured from Andaman and Nicobar Islands, seedlings/grafts from NBPGR, Thrissur and seedling progenies of polyembryonic varieties from FGB, IIHR was carried out.
- Vegetative and reproductive characters were recorded in strawberry as per IBPGR guidelines.
- Thirty two underutilized fruits were characterized as per the minimal descriptors for tropical fruits developed by Bioversity International.
- IC numbers were obtained for 10 custard apple and 15 bael germplasm.
- One hundred and fifty watermelon gene bank accessions of NBPGR were regenerated and characterized as per NBPGR minimal descriptors during *Rabi*, 2015-16.
- Among the 99 indigenous collections of *Amaranthus*, variability was observed for plant height (125 cm to 9.50 cm), stem thickness (9.5 to 3.1 cm), petiole length (12.8 to 1.0 cm), leaf length (22.5 cm to 3 cm), leaf width (9.5 to 1.0 cm), inflorescence length (155 to 1.4 cm) and inflorescence girth (55 to 5.8 cm)
- Thirty nine accessions of jasmine across four commercially cultivated species viz., *Jasminum sambac, J. auriculatum, J. grandiflorum, J. multiflorum* and six other species viz., *J. rigidum, J. nitidum, J. flexile, J. malabaricum, J. humile* and *J. primulinum*) were characterized as per minimal descriptors.
- Nineteen tuberose genotypes were characterized for growth, flower yield parameters and resistance to nematodes. A reference collection of 19 genotypes of tuberose were evaluated as per UPOV guidelines for various morphological traits.
- Eight carnation accessions were added and 82 accessions belonging to three species were multiplied and maintained.
- In rose, 320 genotypes of twelve rose species and 257 commercially important rose varieties are being maintained in the form of a live repository as well as a digital repository.
- IC numbers were obtained for 39 breeding lines of rose.

Classification of varieties being maintained in the National Rose Repository

Flower: color group	Flower type		
	Single	Semi-double	Double
White or Near white	2	2	18
White blend		1	6
Green		1	
Yellow		1	29
Yellow blend (includes varieties that are primarily yellow, but yet show some tones of pink-red)			6
Orange		3	15
Orange blend (include varieties primarily orange or orange mixed with other hues)			2
Pink	1	11	65
Pink blend		5	3
Red	1	8	66
Red blend		1	1
Red purple	1	1	1
Purple			5
Pink blend (varieties primarily pink, but show tones of other hues, yellow, orange etc.)			1

- The mean stomatal index in 48 female clones of betelvine was 6.42% and in 13 male clones, 7.25%. Maximum stomatal index was observed in IIHR BV76 (9.91%) and minimum in Meetha Pan (5.21%) among female clones. Among male clones, maximum stomatal index was observed in IIHRBV96-1 (9.21%) and minimum in Mundolliyele (5.56%).
- Five types of stomata were recorded in betelvine leaves *i.e.*, tetracytic, anisocytic, cyclocytic, diacytic and pericytic. In female clone Halisahar Sanchi, all five types of stomata were observed. In Desi Bangla, four types tetracytic, anisocytic, cyclocytic and diacytic were observed and three types were observed in Godi Bangla (tetracytic, anisocytic and cyclocytic). Similarly in male clone Tellaku Ponnuru, four types of stomata (tetracytic, anisocytic and cyclocytic) and CARI-6 recorded two types tetracytic, anisocytic stomata.
- A wild edible mushroom of *Melanoleuca* genus was collected from Nagenhalli, Bengaluru North and Siddapura, Bengaluru , was conserved.



Melanoleuca spp. IIHR-15-01-bgl (1) pure culture (2), mycelial clamp connections (3) and basidiospores (4)

- Germplasm of 83 species/strains/mutants of mushrooms were maintained in the mushroom lab through tissue culture, sub-culture and as spore print.

Molecular characterization

- Scored allele data EST (Expressed sequence tags) primers CgEMS-1and CgEMS-70 were useful in differentiating pummelo germplasm accessions. Out of the 120 pomegranate accessions received from USDA, genomic DNA of 60 accessions was isolated for screening with microsatellite markers.
- Primers MiIIHR 18, MiIIHR 23, MiIIHR 26, MiIIHR 11 and MISHRS 29 differentiated zygotic and nucellar seedlings in Vellaikolumban mango. In open pollinated progenies of Nekkare, MiIIHR-23 and MISHRS 29 differentiated as zygotic and nucellar seedlings.
- In Amaranthus, four out of 25 SRAP markers (8F+8R,9F+9R, 1F+13R and 1F+14R) detected

length of polymorphism between the two varieties 'Arka Varna' and 'Arka Samraksha'

- DNA fingerprints were generated for three released varieties of marigold namely 'Arka Bangara', 'Arka Agni' and 'Arka Alankara' using SSR markers.
- For molecular characterization of 39 jasmine genotypes, the annealing temperature for primers was optimized as follows; primers 480 @50°C, 605 at 50°C, 894 at 54°C, 9a at 50°C, 357 at 48°C, 32 at 52°C, 535 at 47°C, 291 at 50°C, 360 at 50°C, 881 at 49°C, 430 at 52°C . The 39 accessions were grouped into 4 clusters based on molecular genetic distance using Jaccard's coefficient.
- In marigold, the first set of SCAR primer (SCS48F and SCS48R) derived from SRAP primers gave a monomorphic banding pattern irrespective of sterility and fertile types in marigold. The second set of SCAR primers (SC4F and SC4R) derived from AFLP showed polymorphism. SC4 primer set produced two bands of 500 bp and 300bp differentiating petaloid sterile types from fertile and apetaloid sterile types. Even though the SC4 primer was unable to differentiate homozygous and heterozygous samples, it showed polymorphism for petaloid varieties (Arka Bangara, Arka Alankara and Arka Agni), by the absence of 500bp band.
- In *Centella asiatica*, the neighbour joining cluster and similarity coefficients using 20 SSR primers revealed that IHRCA16 and IHRCA17 were highly distinct from 12 other germplasm. Induced polyploids (IIHRCA14 and 15) formed a separate cluster and were more similar to accessions from Shivmoga (IIHRCA13) and Coorg (IIHRCA12). Whether small or large leaved, a general tendency of being similar was observed for accessions from the same geographical location indicating their common origin.
- Diversity analysis of 58 germplasm of *Mucuna* using 11 ISSR primers identified UBC 834, UBC 836 and UBC 827 as the most efficient primers. The dendrogram showed two major clusters at 63 per cent revealing moderate to high genetic diversity. Both *Mucuna pruriens* var. *pruriens* and *M. prureins* var. *utilis* genotypes were dispersed together in major clusters. Sub clusters grouping based on trichome trait (itchy/non itchy) was observed.
- Dendrogram based on different Kalmegh genotypes revealed distinct level of genetic diversity with two major clusters at 50% similarity. The genetic similarity matrix generated by Jaccard's coefficient showed the extent of relatedness in Kalmegh genotypes as 0.34 to 0.83, suggesting a very high genetic base among the genotypes.

Biochemical Characterization

- Mahalanobis D^2 analysis grouped 58 genotypes of *Mucuna* into eight clusters and cluster II comprised highest number of 25 genotypes and clusters IV, VII and VIII were single entity clusters. Total phenols were the main contributors to the total divergence whereas carbohydrate was the least. IIHR MP 74, IIHR MP 17, IC 2534, Arka Dhanavantari and IIHR MP 99 recorded higher protein contents ranging from 35.5 to 38.18%. Low tannin content (0.23 to 0.24 mg/g) was observed in lines IIHR MP 91, IIHR MP 101 and IIHR MP 84.
- Leaves of the different cultivars i.e., Bangla, Deshavari, Kapoori, Meetha and Sanchi of betelvine were subjected to preliminary phytochemical characterization for alkaloids, flavanoids, terpenoids, tannins, steroids, phenols, saponins, proteins, phytosterol, carbohydrates, glycosides, cardiac glycoside and amino acids. The results were positive in all the tests conducted except for alkaloids which gave a positive result in Kapoori and Meetha pan only. Total phenol content varied from 1,062 to 1.79(mg/g) and total flavonoid content recorded a variation from 6.44 to 9.68 (mg/g). Total steroid content varied from 0.955 to 5.65 (mg/g). Total tannin content varied from 0.53 to 1.52% where as terpenoid content showed a variation from 0.963 to 1,619 (mg /g).
- Twenty eight compounds belonging to monoterpenes, oxygenated monoterpenes, phenylpropanoids, sesquiterpenes and oxygenated monoterpenes were identified as major constituents of the essential oil in betel leaves. Eugenol acetate (37.62 and 34.38 %), Iso eugenol (25.23 and 19.55%) and Eugenol (17.48 and 17.20 %) were the major constituents of the

essential oils of cultivar Godi Bangla and Swarna Kapoori respectively. 53.15% eugenol acetate, 20.69% of safrole and 10.72% of eugenol were major components in Desawari cultivar essential oil. Chavicol (32.91%) and eugenol (17.21%) were prominent in Meetha Pan essential oil whereas safrole (32.91%) and eugenol (19.53%) were major constituents of cultivar Sanchi.

- Studies on antimicrobial properties of betelvine leaf extracts have shown maximum inhibition of *Candida albicans* growth, whereas the inhibition of bacterial strains *E. coli* and *Pseudomaonas aeurginosa* varied with different extracts and concentrations as well. The leaf extracts did not shown any inhibition zone against *Staphylococcus aureus* and *Aspergillus niger* at the concentrations tested and may require higher concentration for their inhibition.
- In antioxidant assays of betelvine leaf extracts, lowest inhibition was recorded in aqueous extracts (14.12 to 46.29 %) followed by petroleum ether (6.65 to 68.61 %) and ethyl acetate (33.04–82.86 %). Methanol extract recorded highest inhibition ranging from 38.96 to 90.52 %. Ferric Reducing Antioxidant Potential (FRAP) activity in methanol extracts among the five lines tested varied from 57.01 to 81.7 mg/ 100 g equivalent to standard ascorbic acid.
- In kokam (*Garcinia indica*), extraction of Hydroxycitric acid was found to be dependent on the solvent used and its polarity. Water extractives had higher Hydroxycitric acid content (12.68%) as compared to other solvents like methanol (12.13%), ethanol (11.17%) and acetone (10.37%). The HCA content increased with the polarity of the solvent used for extraction and water was the best and safest solvent for HCA extraction from *Garcinia.*

3.1.4. Evaluation of Germplasm for Yield and Quality

Fruits

- **Mango**: Variety 'Tofanchan' recorded maximum fruit weight (264 g) while minimum fruit weight was in 'KM' (90.0 g). TSS was observed to be maximum (23.5°B) in the variety 'Athimadhuram'. Variety 'Karigal Appe' recorded maximum bisexual flower percentage (45) followed by the polyembryonic variety 'Puttu' (32).
- **Jamun:** Total leaf area and number of stomata among different collections showed a range of 10.40cm^2 to 40.80 cm^2 and 196.00/ mm^2 to 346.50/mm^2 respectively. Ten genotypes produced flowers and fruits during the second year of planting, of which the collection MP-2 was a seedling progeny. Highest number of fruits was produced in collection from 'Hurulichikkanahalli' and 'Kaveripattanam-2'. Highest fruit weight was observed in 'Konkan Bahadoli'. Good pulp recovery was observed in the 'Kaveripattanam-4'. The highest TSS (18.46°B) was recorded in Collection-6 and highest anthocyanin content in Collection-10 (178.83 mg/100 g).
- **Strawberry:** A strawberry hybrid that produced large fruits (over 20g) with good quality (TSS > 10.6 °B) was identified and evaluated.
- **Karonda:** Among 24 sweet karonda genotypes, number of fruits per plant ranged from 350 (Acc No 8/11) to 2450 (Acc No 4/6). Maximum fruit size of 3.98g was recorded in Acc No 4/11 while maximum yield (6.58kg/plant) was observed in Acc No 8/12.
- **Jackfruit:** Among 28 jackfruit accessions, highest fruit weight was observed in Palur-1 (G15) *i.e.*, 22.9 kg and lowest in A-5 (G29) *i.e.*, 5.2 kg. Maximum TSS of 31.7°B was recorded in GKVK-1 (G26) while lowest in Singapore-2 (G13) *i.e.*, 16.5°B. Highest flake to fruit ratio of 0.57 was observed in NAH-14 (G40) while the lowest in Patre Mattighatta (0.11). Rind weight ranged from 2.5 kg (NAH-14) to 10.8 kg in Tanavarike (G9).

Vegetables

- **Tomato:** Two tomato lines (VRT-2-2-3 and VRT-8-6-1) were found resistant to ToLCBV.
- ***Capsicum*:** Seven hundred *Capsicum* sp. germplasm lines of NBPGR were characterized and regenerated; and 50 new lines have been collected. Among the *Capsicum* sp. germplasm lines evaluated, IHR 4561, IHR 3448, IHR 3024 and IHR 3575 were immune to RKN; IHR 3580, IHR 3661 & IHR 3936 were highly resistant to bacterial wilt; IHR 4582, IHR 4585 & IHR 4586 showed combined resistance GBNV and ChLCV; and IHR 4503, IHR 3471 & IHR 500 showed combined resistance to CMV & ChiVMV.

Capsicum germplasm maintained at ICAR-IIHR

- **Brinjal**: A total of 30 brinjal germplasm lines were evaluated and maintained during 2015-16. Among the germplasm lines evaluated the yield per plant ranged from 1.75 kg to 2.00 kg per plant. Five local germplasm lines of brinjal, Hiriyur Local, Mallapur Local (green variegated fruits), Rampur Local (purple long fruits), Hebbale Local (small medium long purple fruits) and WCGR (green round fruits) showed variability for fruit shape, size and colour, and their yield per plant ranged from 0.75 kg to 2.5 kg/plant.

- **French bean**: Out of ten new lines evaluated, seven lines were pole types and three were bush types. The pod length ranged from 15 to 20 cm and pod width was 0.9 to 1.1 cm. Of the ten lines, 8 lines were flat poded while two were round poded. Variability was observed in pod color (purple, yellow, dark green, light green with purple shade *etc*). Pod yield ranged from 150 g to 270 g/plant. Disease and pests infestation were insignificant.

French bean germplasm

- **Cowpea**: Among 16 new pole type germplasm, the pod yield ranged from 250 to 780 g per plant with maximum in IIHR385. Pod maturity ranged from 65 to 80 days. Pod length ranged from 14 to 73.8 cm (IIHR 385). Variability was observed for pod color viz., light green (10), green (4), dark green (2), purple (1), etc. Cowpea aphid mosaic virus and rust were not observed.

- **Garden pea:** Among 16 germplasm, IIHR703 recorded highest pod yield of 91.5 g/plant followed by IIHR 684 with 77.5 g/plant and none of the accessions out yielded commercial varieties (97.50 - 116.0 g/plant).

- **Dolichos:** Out of 15 selected dolichos pole type germplasm, six selections namely, IIHR 04-140, IIHR 146-1, IIHR 146-IPS-1, IIHR 162-1, IIHR 33- IPS-1 and IIHR 04-44-1 recorded pod yield of 26.0 to 28 t/ha and were rust resistant. Among these, IIHR 146-IPS-1 is an oval poded line, while IIHR 04-44-1 is pink poded.

- **Cucumber***:* Among the wild species evaluated, two *C. hardiwickii* accessions IIHR196 and IIHR197 showed tolerance to downy mildew with promising fruit size and shape. *C. metliferous* accession, IIHR195 showed resistance to root knot nematodes. Fifty *Cucumis sativus* accessions were evaluated along with check variety, Swarna Agethi during 2015-16. Among them, IC-412889 recorded the highest fruit yield of 13.2 kg/3m^2 with 38 fruits/ plant, IC-613460 with light green fruits was field tolerant to downy mildew, and IC-613485 was medium yielding (10kg/plot) with combined resistance to Powery mildew and downy mildew. Forty seven lines were characterized as per NBPGR descriptor, seeds multiplied and supplied to NBPGR for LTS.

C. hardiwickii accession IIHR 196 (1) and C. metliferus accession IIHR 195 (2)

- **Bottle gourd :** Out of 12 new germplasm, eight were uniform with respect to fruit shape. Maximum fruit yield was recorded in IC398543 (24.65 t/ha) followed by IC 371671 (17.1 t/ha). IIHR-124 had combined resistance to powdery mildew (PDI-5.56) and CGMM virus (VI-0.67). BG-114 was moderately resistant to powdery mildew (PDI-18.89), gummy stem blight (PDI-

High yielding bitter gourd germplasm, BTG-149 (11.76 t/ha) and BTG-150(12.93t/ha)

16.67) and resistant to CGMMV (VI-0.67).

- **Bitter gourd:** Among 18 germplasm evaluated, BTG 150 (12.93 t/ha) followed by BTG 149 (11.76 t/ha) and BTG 152 (9.87 t/ha) were high yielding. Two germplasm lines viz., BTG 166 (PDI-10.26) and 167 (PDI-9.02) were resistant to powdery mildew. BTG 156 (PDI-20.68) and BTG 166 (PDI-21.46) were moderately resistant to *Alternaria* leaf spot. BTG-22 recorded highest momordicin (16.2mg/g dry weight) and charantin contents (1.71mg/g dry weight).

Ornamentals

- Nineteen tuberose genotypes were evaluated for growth, flower yield and resistance to nematodes.
- Sixty nine *Gladiolus* genotypes having different colour and floral traits maintained were evaluated for vegetative and floral traits.
- Three hundred and twenty rose genotypes including twelve species are being maintained.
- Eighty two genotypes of carnation were characterized for 58 traits.
- Eighty chrysanthemum genotypes were evaluated for desirable traits for breeding and characterized as per DUS guidelines.
- Twenty China aster genotypes were evaluated for quality floral traits.
- Thirty nine accessions across four commercially cultivated species viz., *Jasminum sambac, Jasminum auriculatum, Jasminum grandiflorum, Jasminum multiflorum* and six other species viz., *Jasminum rigidum, Jasminum nitidum, Jasminum flexile, Jasminum malabaricum, Jasminum humile* and *Jasminum primulinum* were characterized.

At CHES, Bhubaneswar

- **Status of germplasm:** The station has a total 1031 germplasm of fruit and vegetable crops. Four hundred and twenty five germplasm were collected during 2015-16. IC numbers for ten numbers of custard apple and fifteen numbers of bael germplasm were obtained from NBPGR. A new block of twenty nine underutilized fruit crops comprising rose apple, avocado, longan, rambutan, bilimbi, mangosteen, langset, milk fruit, star apple, karonda, ber, passion fruit, *A. muricata, A. cheromola, A. reticulate, A. atemoya, A. squamosa*, tamarind, etc. has been established.
- **Mango:** Forty one germplasm of mango were evaluated for horticultural traits. The germplasm, CHM-59 (IC-0598408) exhibited a short fruit maturity period, while CHM-21 (IC-0598393) was moderately regular and had a yield potential of 55-65 kg/plant. CHM- (IC-0598383) and CHM-64 (IC-0598409) had significantly high pulp to stone ratio, and CHM-64 and CHM-68 (IC-0598411) had high TSS contents. However there was a wide variation in TSS (12.68-22.7°B) and TSS acid ratio (14.72-48.84). CHM-21 was found to be relatively promising in terms of regularity, yield potential and fruit quality.

CHM-21

- **Star gooseberry:** The star gooseberry germplasm CHSG-1 was found promising in terms of fruit weight (5.2), fruits/plant (1344.5), fruit yield (12.4 kg/plant), TSS (7.6°B), edible portion (92.5%) and vitamin C content (93-186 mg/100g).

CHSG-1

- **Rose apple:** The rose apple germplam CHRA-1 was found promising in terms of fruit weight (23.5g), fruit yield (10.3 kg/plant) and fruit quality (TSS-18.6; pulp-76.5%).

CHRA-1

- **Carambola:** The carambola germplasm CHCM-4 was found promising in terms of fruit weight (87.7g), fruits/ plant (158.4), fruit yield (11.3 kg/plant), TSS (10.6°B), edible portion (77.3%) and seeds/fruit (2).

CHCM-4

- **Tamarind:** The tamarind germplasm, CHTM-3 has been found promising in terms of yield (26.8 kg/plant), pod length (10.8 cm), pod weight (20.6g), TSS (35.3°B), pulp content (50.2%), TSS acid ratio (7.35), number of seeds/pod (3.6) and vitamin C content was 92.3 mg/100g.

- **Underutilized cucurbits:** Out of the sixty nine accessions of teasel gourd, JB/11-83C, JB/11-178A and JB/11-248 produced more than 10 kg /plant. Out of nine accessions of *Solena amplexicaulis*, CHBK 4 recorded highest yield/plant (5.11 kg/ plant). In back cross progenies, the natural fruit set was medium (55%) in BC2F1 and BC2F2 while the natural fruit set was low in BC3F1 (22%). The average yield varied from 3.40 (BC2F1) to 1.42 kg/plant (BC3F1). Among the virus infected plants of *M. suboica*, yield was maximum in 3+ (7.54 kg/plant), while it was minimum in healthy plant (5.21 kg/plant). However, the average yield of healthy plant was maximum (4.26 kg/plant). Out of 25 F_2 plants of *M. suboica*, the highest yield was produced by F_2-MS-TG-1 (35.28 kg/ plant,) followed by F_2-MS-TG-2 (24.76 kg/plant). Five varieties of underutilized cucurbits were established in a protected structure available with Govt. of Odisha and are being evaluated. A total of sixty nine accessions of underutilized cucurbits were maintained in the field gene bank.

- **Leafy vegetables/*Moringa*:** A total of 146 germplasm of leafy vegetables including amaranthus (135) and one each of *Portulaca oleracea* (*Puruni saga*), *Marsilea polycarpa* (Sunsunia saga), *Ipomoea aquatica* (Kalam saga), *Glinus oppositifolius* (Pita saga), *Commelina benghalensis* (Kansiri saga), *Chenopodium album* (Bathua), *Alternanthera sessilis* (Madaranga), *Centella asiatica* (Thalkudi), *Eryngium foetidum* (Ban dhania), *Hibiscus sabdariffa* (Khata palang), *Achyranthes aspera* (Apamaranga). were maintained for evaluation. Preliminary evaluation and seed multiplication was carried out in all the germplasm. Four different species of amaranthus viz., *Amaranthus viridis, Amaranthus spinsous, Amaranthus tricolor, Amaranthus dubius* and *Amaranthus hypochondriacus* were collected.

Variability in Amaranthus germplasm

- **Beans:** Forty seven local accessions of *Dolichos* bean seeds were evaluated for their phenological and fruit traits. The pod length ranged from 4.2 to 17.6 cm, the pod width (cm) ranged from 1.12 to 3.56 cm, fruit shape index (length/ width) varied from 2.04 to 14.61, pole type accessions produced more than 100 pods per plant however, bush type produced upto 40 pods per plant. In bush type accessions, the first flowering was observed at 35 days, while in pole type first flowering occurred between 84 to 119 days. The first fruit set occurred from 90 to 130 days in pole type accessions and until 56 days for bush type. The 100 dried seed weight ranged from 30 to 75 gm. Thirty five local accessions of field bean were evaluated for various traits. Pod length (cm) ranged from 3.4 to 5.8, pod width (cm) ranged from 1.02 to 2.07, fruit shape index (length/ width) varied from 2.40 to 3.57, the number of fruits per plant ranged from 25 to 50. The first flowering occurred between 30 to 38 days, and the first harvest occurred between 52 to 60 days.

Variability in Dolichos bean germplam

- **Chilli:** Twenty hot pepper germplasm were collected from Nagaland and Manipur, six collections were made from salt affected areas (Erasamma and Kendrapara of Odisha state), thirty four accessions (thirteen of *Capsicum annuum*, *C.frutescens and* six of *C.baccatum*) were collected from ICAR-NBPGR Regional Station, Hyderabad. A total of 140 chilli germplasm were selfed for two generations and purified. Seventy six *Capsicum* germplasm (north east collections) were evaluated for bacterial wilt under field conditions. The mortality ranged from 60-100% in susceptible genotypes. Six genotypes viz., CHHP-25, CHHP 26, CHHP 30, CHHP 29 (*C. chinense*), CHHP 6, CHHP 72 (*C. frutescens)*, CHHP 55, CHHP 69 showed no symptoms of wilting (100% survival).

CHHP-29

CHHP-6

At CHES, Chettalli

- **Status of germplasm:** During 2015-16, surveys were conducted in Karnataka, Kerala and Tamil Nadu and 35 new accessions of 8 fruit crops viz., avocado, durian, mangosteen, passion fruit, jamun, rambutan, dragon fruit and jack were collected. Thirty collections of indigenous vegetables of Kodagu District viz., beans (16), cucurbits (4), brinjal (2), chilli (1), tubers (2) and leafy vegetables (6) were collected for maintenance at CHES Chettalli.
- Pummelo collections (65 nos.) were evaluated for growth yield and fruit quality parameters. The mean plant height recorded was 65.66cm. The plant spread (E-W) ranged from 1.2m to 9.50m, and plant spread (N-W) ranged from 1.0 m to 9.25m. The mean number of fruits was 117 fruits/ tree. The highest number of fruits was recorded in CHES P-17 (375 fruits). The fruit weight ranged from 454.9g to 1606g. Highest weight (1937g) was recorded in CHESP-27 while lowest fruit weight (454g) was recorded in CHESP-2. The mean TSS recorded was 10.2°B.
- Two hundred accessions of Rambutan were evaluated for growth and yield parameters. Among accessions planted in 2001, maximum plant height was observed in CHES R-28 (6.85 m), was recorded in CHESR-IV-10 (5.65 m) was highest amongst the accessions planted in 2006. Higher yields were recorded in CHES R-8 (1281 fruits) and CHESR-28 (1177 fruits) in 2001 planted accessions. Among accessions planted in 2006, higher yields were recorded in CHES I-2 (615 fruits), CHESRXIX-4 (619 fruits) and CHSR-XIII-(610 fruits). The fruit weight ranged from 16.92 g to 56.34 g, TSS ranges from 11.01 to 21.8°B and acidity ranged between 0.07 to 0.3%. The rind thickness ranged from 0.2 to 0.7cm with an average of 0.38 cm.
- Fifty six collections of avocado were evaluated. The plant height ranged from 2.90m in CHESPA-II-4 to 9.5 m in CHESPA-XIV-2. Plant girth ranged from 34.5 cm to 81.5 cm and it was the highest in CHESPA-1. The highest number of fruits per tree were recorded in CHESPA-III-1 (750) followed by CHESPA-I-2(675). The fruit shape index ranged from 0.726 (CHESPA-V-1) to 1.44 in CHESPA-I-1. Total Soluble solids ranged from 3.6°B in CHES PA-VIII-2 to 11.1°B in CHESPA-III-2. Among the accessions evaluated CHESPA-III-1, PA-XIII-1, CHESPA-X-3, CHESPA-VII-1, CHESPA-VII-4 were found to be superior.
- The growth and yield parameters of 106 collections of karonda were recorded. The number of fruits per plants ranged from 13 to 875 fruit per plant. The fruit weight was highest in CHESK-I-2 (40 g). The lowest fruit weight (2.75g) was recorded in K-VI-II. The TSS ranged from 11.6º B to 18.9º B. The accessions, K-II-7, K-V-6, K-V-10, K- VII-11 and K-VIII-1 have big size fruit (12- 16g), less number of seeds (<1.0) and higher TSS (12^0B).
- Forty one collections of jamun are under evaluation at the station. The growth observations of these accessions were recorded. The highest plant girth (123.10 cm) and height (6.80 m) were recorded in CHESJ-XIII-6.
- The growth and yield characteristics of twenty nine Malayan apple accessions were recorded. The yield ranges from 480 fruit/plant to 4150 fruits/plant in CHESM-I-1. The number of seed

per fruit ranged from 3.2 in M-1-1 to 5.8 in M-I-3. The TSS ranged from 7.2ºB in M-I-1 to 10.6ºB in M-I-3. CHES M-I-1 was found superior with respect to yield and other characteristics.

- Seven collections of star fruit (Carambola) were evaluated for growth and yield characters. Plant height ranged from 2.95 m to 7.85 m. The number of fruits ranged from 121in CHESC-I-I to 1500 CHESC-III-1 fruits per plant. The fruit weight from 46 to 90g. The TSS ranged from 7.0 to 9.0^{O}B while acidity ranged from 1.5 to 3.0 %.
- Sixteen mangosteen collections were evaluated for growth and yield characteristics. The plant height ranged from 1.00m to3.45m. The highest number of fruits per tree (56) was recorded in in CHESGM-II-3. Fruits were dull red and the fruit weight ranged from 40 to 114 g, with a TSS of 16.1ºB and very low acidity (0.8%).
- Forty five accessions of *Garcinia indica* were evaluated. The plant height ranged from 205 cm to 685 cm. The numbers of fruits ranged from 152 to 3276 per tree. The highest number of fruits per tree was recorded in CHESGI-VIII-5. The fruit yield (kg/plant) ranged from 3.2 to 58.9 and it was highest in the accession CHESGI-V-4. The fruit weight ranged from 35g to 75 g. The TSS ranged from 11.9 to 16.4ºB while acidity ranged from 2.4 % to 7.4 %.The accessions, GI V-8, GI -V-4,GI-VII-4, GI-VIII-5 were promising with respect to the yield and quality parameters.
- The growth, yield and fruit characteristics of 103 accessions of *Garcinia xanthochymus* were recorded. Plant height ranged from 1.75 m to 3.95m while the plant spread (E-W) ranged from 0.95 m to 3.50 m. The fruit yield ranged from 0 to 115 fruits/tree (CHESGX-II-5). The fruit weight ranged from 43 g in CHESGX-II-5 to 199 g in CHESGX- V-1. The TSS ranged from 13.6^{O} B to 14.8^{O}B. The accessions in CHESGX-II-6, CHESGX-II-10, CHESGX-VI-I were promising with respect to the yield and quality parameters.
- Thirty five collections of Anthurium were made from the farmer's field and planted. Among the accessions that flowered, petal colors observed were greenish pink, pink, red and white.
- Survey and collection of 41 species of wild orchids of the Kodagu district was made with the collaboration of NRC on Orchids, Sikkim. The major species collected include *Dendrobium crepidatum, Vanda tessellate, Liparis viridiflora, Rhynchostylis retusa, Phoidata pallid, Dendrobium aqueaum, Cymbidium bicolor and Aerides ringens.*

3.2. Crop improvement

3.2.1. Fruit Crops

Mango

- **Hybrid evaluation:** Fruit quality analysis carried out on 134 hybrids revealed two progenies with fruit weights of 265g and 225g each and pulp recovery higher than 65%.
- **Hybridization:** Hybridization was carried out using the varieties Alphonso, Vanraj, Amrapali, *M. odorata* and. *M. camptosperma*. A total of 18484 flowers were crossed during the period.
- **Small RNA sequencing:** Small RNA Sequencing was employed to mine the master regulators of fruit ripening i.e. miRNA in mature, half-ripe and full-ripe fruits of cultivar 'Alphonso'. Small RNA sequencing from ripening fruits using NGS technology and bioinformatic analysis resulted in identification of 569 conserved miRNAs and 139 novel miRNAs.

Papaya

- **Hybrid evaluation:** Arka Surya hybridized with *V. cauliflora* followed by selection and sib-mating gave advanced inter-generic hybrid progenies of F_6 generation that showed field tolerance to PRSV with desirable fruit qualities. The progenies have attained stability for morphological trait (broad leaf) and fruit shape similar to Arka Surya. The height to first flowering ranged from 72 to 95 cm, number of nodes at flowering from 18 to 24 trunk circumference at flowering from 24 to 38 cm, fruit weight from 600 to 980 g, TSS from 9.2 to 10.6^{o} B, pulp thickness from 2.50 to 3.95 cm and cavity index from 18.62 to 25.60 % with orange to orange red pulp in progenies.
- **Inter-specific hybridization:** To develop a PRSV resistant variety, hybridization was done with the wild species, *Vasconcellea cauliflora* and *V. cundinamarcensis* as male parents and Arka Surya, Arka Prabhath, Red Lady and H-709 as female parents. A few fertile seeds were recovered. Seedlings from earlier crosses with *V. cundinamarcensis* were challenge inoculated and the tolerant progenies were field planted.
- **Chemical and radiation mutagenesis:** Arka Prabhath was subjected to chemical and radiation mutagenesis for Targeted Induced Local Lesions IN Genomes (TILLING). Ethyl methane sulphonate (EMS) treatment was given for 4 hours at 2 doses (1% and 2%) to overnight water-soaked seeds (640 seeds). Irradiation of dry seeds was undertaken using ^{60}Co isotope with two dosages (50 and 100 Gy) served @ 2Gy.min^{-1}.
- Papaya seeds of Arka surya and Arka Prabhat irradiated with different dosage for gamma radiation. Germination of both varieties was not affected upto 400Gy but at 700Gy germination was drastically reduced. The treatment control recorded the highest germination percentage (90%). The treatments 400 and 500 Gy showed little difference in germination. The LD_{50} was standardized for dry seeds mass radiation of both varieties at 500Gy, 550Gy and 600Gy. In case of wet seeds, at 60Gy germination was drastically reduced. The half kill dose was determined as 40 Gy. LD_{50} was standardized for mass radiation of both varieties at the dosage of 35Gy, 40Gy and 45Gy.
- **Genetic transformation:** A novel construct based on dsRNA involving three distinct isolates of PRSV, namely PTSV-P, PRSV-w and PRSV-R, first reported from Rajasthan with very little homology to either the P strain or the W strain but having distinct and close relationship with the Taiwan isolate was generated. The silencing suppressor genes as well as the coat protein and other segments were used. At least 7 algorithms to predict potential siRNA sites were used to pick regions from each virus. Papaya cultivar Solo and Arka Surya were transformed with this construct.
- A micropropagation protocol for the rapid multiplication of papaya 'Arka Surya' has been developed using immature seed-embryos as

Micropropagated plants of papaya cv. Surya

the starting material. With the integration of marker-assisted selection, this protocol allows the identification of hermaphrodite sex forms at *in vitro* stage and their selective multiplication. The *in vitro* rooted plants could be acclimatized giving a good plant stand. The micropropagated plants came to flowering and fruiting and behaved consistent to the designated sex form.

- **Purification of papaya (Coorg Honey Dew):** Four high yielding stable hermaphrodite types were selected from the sibmated progenies (F_8 generation) of various crosses. The maximum plant height was recorded in CHESP-I-6 (173 cm). The girth ranged from 18-25cm. The highest TSS of 13.2^{O}B was recorded in CHESP-I-14. The number of seed produced ranged from 94-481in (CHESP-II-22).

Guava

- **Hybrid evaluation:** Evaluation of hybrid progenies of Purple Local x Allahabad Safeda for fruit traits resulted in the identification of the progeny H-1314 suitable for table purpose with big sized fruits (300-325g), firm and thick white pulp (1.6 to 1.8 cm) and medium seed hardiness (10.0-10.5 kg/ cm^2) with a TSS of 10.0-11.0^o B. The hybrid H-724 (Apple colour x Purple local) with pink pulp recorded medium sized fruits (180-200 g) with soft seeds (7.5 to 8.0 kg/ cm^2).
- **Pollen germination and storage:** The nutrient media for pollen germination in *Psidium guineense* and two *Psidium guajava* varieties, Arka Kiran and Arka Mridula were standardized. The medium containing 10% sucrose with other nutrients gave higher pollen germination of 87.3%, 87.4% and 86.3% respectively. Germination using fresh pollen from *Psidium guineense* and Arka Mridula were the same (97.7%). Arka Mridula pollen stored for 15 days gave a reduced germination percent of 86.3% while *Psidium guineense* gave 87.4%. The fruit set percentage (>75 %) using fresh pollen was on par with the stored pollen.
- **Inter-specific cross compatibility:** Cross compatibility studies using *Psidium guineense* indicated that guava varieties Arka Kiran and Arka Mridula as female parents are cross compatible with the wild species and resulted in more than 75. 5% fruit set.

Pomegranate

- **Hybridization:** Hybridization between cv. Bhagwa as female parent and bacterial blight tolerant lines (Nana, Daru, IIHR-30 and Nayana) as male parent was taken up and 47 fruits were harvested for raising seedlings.

Promising pomegranate hybrid 4/2

- **Hybrid evaluation:** Twenty eight pomegranate lines were identified for their superiority of various characters like large fruit size, bright coloured fruits with bold arils and high TSS from the population exposed to mutagenic treatments. Progenies derived from Bhagwa x Daru were planted in replicated trial for further evaluation along with check varieties. One promising hybrid H-4/2 that produces large (over 400 g) reddish fruits with thinner rind and soft dark red arils (22 mm) that are sweet (TSS 17.6 °B) was identified from a population of 400 hybrid plants.
- **Evaluation of transgenic BC1T1 population for bacterial resistance:** Challenge inoculation of 65 events of transgenic BC1T1 plants of pomegranate was done by spraying 10^8 CFU/ml *X. axonopodis* pv punicae, and scoring was done after 7, 15 and 30 days. Hypersensitive reaction was shown by resistant lines wherein disease spot did not have a halo and it was not possible to culture bacteria from these spots one week after inoculation. Whereas, in the control plants, the lesion was large and active bacteria could be recovered. Nine plants were shortlisted based on a factored value for lesion size and defoliation.

Hypersensitive reaction on resistant BC1T1 transgenic (a, b) and active lesions on susceptible non-transgenic (c) Bhagwa cultivar

- **Generation of BC2T2 seeds from transgenic plants:** Pollen from BC1T1 collected from bagged flowers was used for crossing female flowers of cv. Bhagwa maintained in a glass house. Fruits

Two year old transgenic BC1T1 pomegranate derived from cv. Bhagwa in the net house

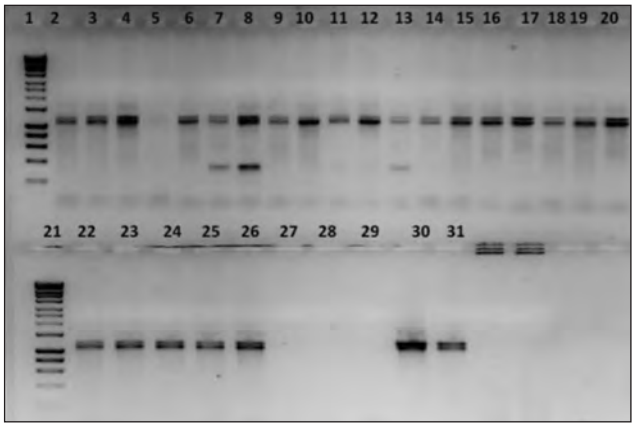
were collected and more than 3000 BC2T2 seeds were extracted.

Banana

- A cross was made between *Musa acuminata* ssp. *burmanica* (Calcutta-4), a wild species, and *Musa rubra*, a dwarf plant highly sensitive to water stress. This hybrid can serve as a pre-breeding line for incorporating dwarfness.

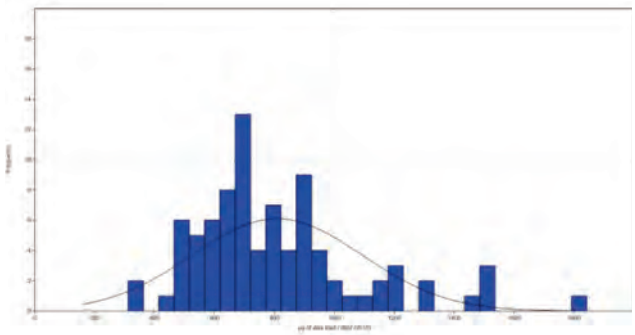
Hybrid of Musa acuminata ssp. burmanica (Calcutta-4) x M.rubra

- **Development of transgenic cv Rasthali for *Fusarium* wilt resistance:** Embryogenic cells of banana cv. Rasthali were co-cultivated with *Agrobacterium* strain AGL1 harbouring pCAMBIA1305.2-Ace-AMP1 and pflp for resistance to *Fusarium oxysporum* f. sp. *cubense*. Forty out of the fifty transformed plants were PCR positive for presence of dual genes.
- **Identification of fungal-stress responsive miRNAs and expression profiling of genes:** *Fusarium oxysporum* f. sp. *cubense* inoculated resistant (Calcutta-4) and susceptible (Kadali) genotypes were used for this study. Thirty four miRNAs identified by homology search were highly expressed in resistant genotype than in the susceptible genotype at 3 days after infection (3DAI), while only 7 miRNA showed a difference at 10DAI in Kadali. Forty defence related genes were screened for their expression in tolerant and susceptible genotypes using qRT-PCR analyses. The majority of genes have a higher expression at 3 DAI which gradually decreased at 10 DAI in Calcutta-4 and a reverse pattern of was observed in Kadali genotype.



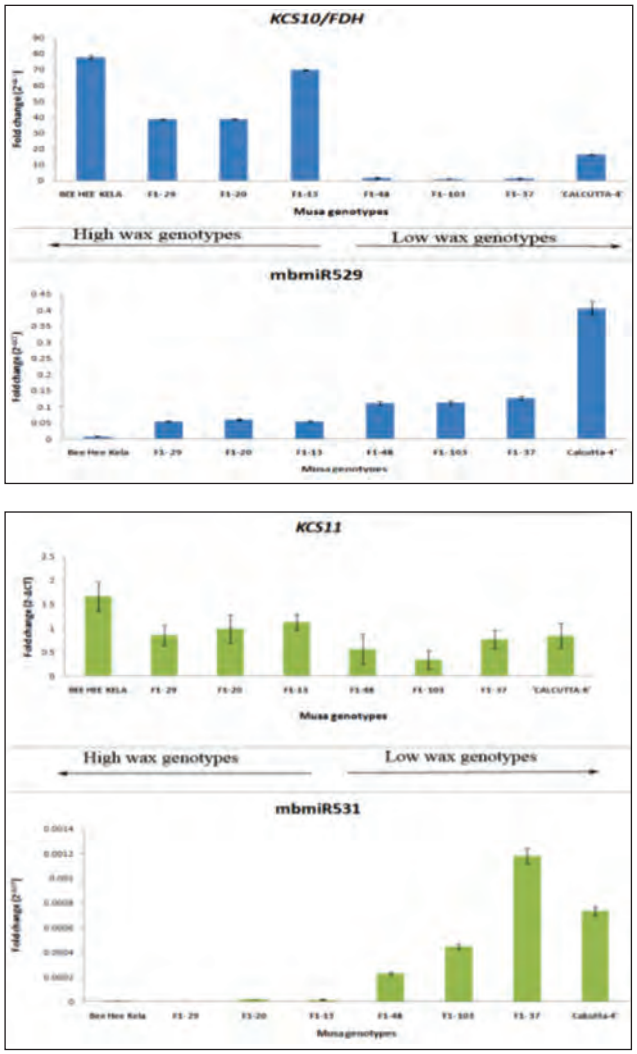
Representative gel showing Multiplex PCR confirmation of dual genes Ace-AMP1 and pflp in transformed banana plants for resistance to Fusarium oxysporum f sp cubense. Lane 1 and 21- DNA Hyperladder markers, lane 2-20 and 22-26 –Amplification of cassette (CaMV35S –Ace-AMP1-nos) and pflp cassette (CaMV35S –pflp-nos) in putative transgenic banana plants, lane 27- plant negative control, lane 28- non template control, lane 30 and 31-plasmid pCambia 1305 Ace-AMP1–pflp.

- **Segregation of drought tolerance attribute:** The content of cuticular wax in parents Calcutta-4 (*Musa accuminata; AA*) and Bee hee kela (*Musa balbisiana BB*) was 424 and 1843 µg/dm² respectively and ranged from 312 to 1534 µg/dm² in their 87 F1's (AA x BB). This was correlated with leaf water retention capacity (LWRC) indicating the contribution of cuticular wax to maintenance of leaf hydration.



Total epicuticular wax load in the F1 segregation population (AA x BB)

- **miRNA prediction and validation:** By contig based approach for computational miRNA and its target prediction, 4 contigs were obtained with miRNAs whose targets are involved in cuticular wax biosynthetic pathway like *KCS 3, KCS 11, FDH/KCS10*. Further validation of the computational prediction was done by qRT-PCR using leaf sample of four high wax genotypes



Gene expression analysis of KCS10/FDH; mbmiR529 and KCS11;mbmiR531 in leaf samples of high and low cuticular wax Musa genotypes

'Bee hee kela', F1- 20, F1-29 and F1-13 and four low wax genotypes 'Calcutta-4', F1-48, F1-103 and F1-37. Negative relation between the miRNA and its target indicated their probable role in regulation of cuticular wax biosynthesis, thus supporting the phenotypic variation observed.

- **lncRNAs identification and validation:** Computational analysis identified 1319 and 4288 putative long non-coding RNAs (lncRNAs) from the pooled transcriptome of *Musa balbisiana* and *Musa acuminata*. Examination of 40 lncRNAs from pseudostem, leaf and root of the two species for amplification by PCR on cDNA revealed species-specific amplification in case of KVR_ Lnc 16 which was mined from *Musa acuminata* transcriptome showed amplification only in *Musa acuminata* tissues.

- **Heat stress related miRNAs:** miRNAs involved in heat stress were screened on two contrasting cultivars, Grand Naine (tolerant) and Red Banana (susceptible). There was a significant change in pattern of miRNA expression indicating key role of miRNAs in the heat stress-response. Genes (HSP70, HSP90 and other stress associated proteins) expressed due to heat stress showed strong negative correlation with miRNAs in tolerant cultivar and *vice versa* in susceptible cultivars.

Sapota

- Hybrid progenies of cricket ball x PKM-1, PKM-1 x Kalipatti and PKM-1 x Cricket Ball were evaluated for plant growth and flowering. 64 hybrids flowered, out of which 5 progenies had less than 2 m height.
- Observations recorded on morphological parameters of 110 seedling progenies involving OP seedlings and those obtained after treating the seeds with EMS showed that the tree height ranged from 0.9 m to 7.6 m.
- The yield of fruits recorded from 37 seedling progenies and 15 hybrid progenies of PKM-1 x Cricket Ball, Cricket Ball x PKM-1 and PKM-1 x Kalipatti showed that seedling-16 and hybrid 9-1 produced the highest yield of 7.0 Kg (64 fruits) and 3.5 Kg (52 fruits) respectively. TSS ranged from 11.1 to 24.8^{0}B and total sugar from 9.9 to 24.4% among seedling and hybrid progenies.

Passion fruit

- A low acid (0.8%) sweet (22.0°B) hybrid with fruit weight of 124-140g suitable for direct consumption from the cross of passion fruit hybrids (Kaveri x Yellow Collection I) was backcrossed with yellow type for introgression of wilt tolerance.

Pummelo

- Non-bitter and sweet pummelo accessions such as 8-4, 10-5, 18-1, 18-3, 18-5, 19-1, 19-2, 19-3, 21-4, 24-4 and 25-4 were multiplied by soft wood grafting.
- Two hundred half sib progenies each from accessions 6, 11 and 18 were raised.
- Hybridization was carried out to develop bitter-free and sweet type pummelo with thin peel. The F_1 from crosses such as 2-4 x 19-1, 12-1 x 19-1, 3-2 x 19-1, 16-1 x 19-1, 19-1 x 16-1 and 1-1 x 19-1 are under evaluation.

Custard apple

- Inter-specific hybridization involving three cultivars of *Annona atemoya* viz. Island Gem, Bullock's Heart and Pink's Mammoth with nine *Annona squamosa* varieties viz., Balanagar, Raidurg, APK-1, Red Sitaphal, Mammoth, Barbados Seedlings, Washington 07005, Washington 98797 and Arka Sahan was carried out and the hybrid progenies were planted in the field for evaluation.
- A pre-breeding line (19/26) identified for its self fruitfulness (19/26) was crossed with different varieties of *Annona squamosa* viz., Balanagar, Mammoth, Red Sitaphal, Washington 07005, Washington 98797 and Raidurg and observations on fruit set, fruit weight, TSS and number of seeds per fruits have been recorded on all the different cross combinations. The fruit set of different crosses obtained from 19/26 ranged from 73.3% in 19/26 x Washington 07005 to 93.3% in 19/26 x Mammoth. The maximum fruit weight (787.3g) was recorded in 19/26 x Washington 98797. The highest TSS (28.3°B) was in 19/26 x Balanagar, whereas lowest (22.1°B) was in 19/26 x Mammoth. Number of seeds per fruit ranged from 53.8 in 19/26 x Raidurg to 78.2 in 19/26 x Washington 98797. Seeds from different cross combinations were sown in the nursery.

Acid lime

- Transgenic acid lime transformed with Xa21gene from rice, for resistance to bacterial canker, gave fruit set and seeds. 90 seedlings were raised and segregated into zygotic and nucellar embryos based on vigour, one week after germination.

T1 Transgenic acid lime with Xa21 *genes from rice for resistance to bacterial canker*

3.2.2. Vegetable Crops

Tomato (*Solanum lycopersicum* L.)

- **Varietal Identification:** Arka Samrat, a high yielding F_1 hybrid with triple disease resistance to ToLCV, BW and early blight with yield of 80-85 t/ha in 140 days was recommended for zone VIII (Karnataka, Tamil Nadu, Andhra Pradesh and Kerala) during 33rd AICRP (VC) meeting held at ICAR-IIVR, Varanasi from 21-24, May 2015. Fruits are oblate to high round, large (90-110g), deep red, firm and suitable for fresh market.

Arka Samrat

- **Development of hybrids for ToLCV + BW + EB:** A total of fourteen F_1 hybrids including three indeterminate hybrids were evaluated for yield and fruit quality attributes. H- 331 (48 t/ha) and H -329 (42 t/ha) were superior yielders with triple disease resistance to ToLCV+BW+EB. Arka Rakshak fruits were firm (9.0 kg/cm^2) followed by H-331 (8.7 kg/cm^2). Highest fruit weight was recorded by H - 331 (102g) followed by H-335 (102 g). H-369 (Arka Vikas fruit type) had highest TSS (6.7 ^{0}Brix).
- **Identification of stable sources of resistance to ToLCBV:** Forty seven genotypes, including hybrids, varieties and advanced breeding lines were artificially screened for resistance to ToLCBV using whiteflies under screen house. Twenty seven lines were found to be resistant, five moderately resistant and fifteen susceptible.
- **Incorporation of heat and drought tolerance:** Two firm fruited tomato lines (IIHR-2834 and IIHR-2835) with good General Combining Ability (GCA) were crossed with heat tolerant (HT) lines (CLN-3125A and CLN-3125P). Four back cross (BC1F2) populations viz., (IIHR 2835 x CLN 3125A) x IIHR 2835, (IIHR 2835 x CLN 3125P) x IIHR 2835, (IIHR 2834 x CLN 3125A) x IIHR 2834 and (IIHR 2834 x CLN 3125P) x IIHR 2834 were raised and seeds were collected from a total 42 BC1F4 plants for further advancement. A total of 180 F_6 plants derived from the cross involving large fruited HT line (CLN 3125A) and drought tolerant line (RF_4A) were raised and screened

Performance of determinate F_1 hybrids for yield and fruit quality

Name of Entry	Yield (t/ ha)	Firmness (kg/cm^2)	TSS (°Brix)	No. of locules	Pericarp thickness (cm)	Average fruit wt (g)
H-331	48	8.7	5.5	3	0.9	102
H-329	42	7.3	5.0	4	0.8	88
NS 501	41	8.7	4.8	3	0.9	97
Arka Samrat	39	8.3	5.6	4	0.7	97
Laxmi	37	6.5	5.0	5	0.7	78
H-335	36	8.3	5.7	4	0.9	102
H-373	34	6.7	5.3	2	0.6	80
Arka Rakshak	34	9.0	5.3	2	0.9	84
PH-6321	33	6.5	4.8	5	0.7	125
PH-1021	30	7.7	4.3	6	0.7	138
H-369	28	6.3	6.7	5	0.7	87
PH-1025	25	8.2	4.8	6	0.7	172
H-371	25	5.8	4.7	5	0.7	98
Abhinava	16	7.3	4.7	2	0.7	95
CD	15	1.3	1.2	1.0	0.1	27.2
CV%	16	6.2	8.2	8.6	5.1	9.2

for heat tolerance. Seeds were collected from 180 F6 plants for further advancement. Based on horticultural traits, 9 lines were selected to evaluate for heat and drought tolerance. Two IPS *viz*, CLN 3125A x RF_4A F2 - 177- 2-1-1-1 and F2- 22-1-1-1-1 and CLN 3125A x RF_4A F2 - 22-1-1-1-1 were confirmed as drought tolerant through physiological studies.

- **Development of breeding lines with high lycopene and β-carotene contents:** Two introgressed lines *viz*, BC_1F_1 25-206-82-2 (15.6 mg/100g FW) and BC1F1 17-143-7-2 (13.5 mg/100g FW) with high *β*-Carotene and lycopene contents respectively, were derived from inter-specific hybridization between *S. lycopersicum* (15SB SB) and S. *habrochaites* LA-1777.

- **Ty2 marker for MAS:** Ty2 marker was employed to check the purity of parents of Arka Rakshak, Arka Samrat and new breeding lines (5-3-7-5-2 and 4-3-3) derived from inter-specific hybrid between 15 SB SB x *S. habrochaites* LA-1777.

- **Marker aided selection:** The Ty2, T3 and Ty5 markers linked to ToLCV resistance were employed for selection in a segregating population and gene pyramiding. SSR markers were used to screen parental polymorphism.

- **Multi-transgene stacking with PR-3, PGIP and NPR1 gene in tomato for induction of broad spectrum fungal resistance:** Fourteen transgenic tomato plants with triple genes stacked were generated, which were confirmed for the presence of all three transgenes through PCR and RT-PCR. Out of the 14 triple genes stacked transgenic tomato plants generated, 6 were shortlisted based on single copy integration through Southern analysis. 40 T1 plants each from the 6 T0 lines were raised in the net house along with control lines. PCR analysis indicated segregation of the transgene and revealed single copy integration. 40 plants of each were evaluated for segregation through PCR which showed a segregation ratio of 3:1 in each event when a total of 240 plants were screened. Screening against *Alternaria solani* through whole plant challenge inoculation revealed moderate resistance (< 20% PDI) in 55 plants while the PDI in control plants ranged from 29-47%.

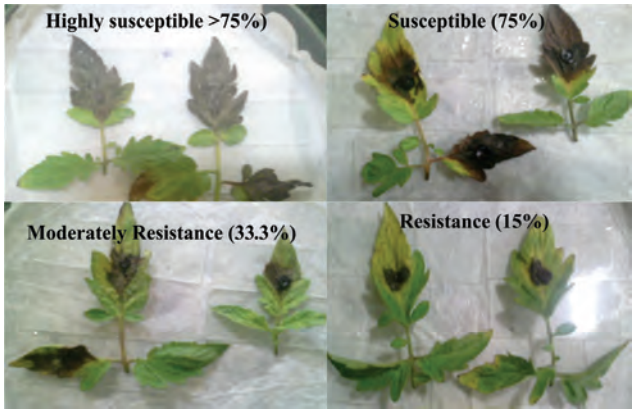
- **MAS for Ty genes in segregating (BC1F4) populations:** A total of 30 BC1F4 families derived from an inter-specific cross (15 SB SB x *S. habrochaites* LA-1777) were raised for introgression of Ty genes through MAS. Of these, 3 plants were homozygous for Ty2, 10 plants

IPS with Ty2/Ty2

BC1F1-118-120-77-1 (Ty3/Ty3)

for Ty3 while being heterozygous for Ty3 (Ty2/Ty2+Ty3/-), 5 were heterozygous for Ty3/-, 6 were heterozygous for Ty2/- and one was heterozygous for both Ty2 and Ty3 (Ty2/-+Ty3/-) . All the plants were further advanced.

- **Genotyping of ToLCV resistant lines using Ty markers:** Thirty one ToLCV resistant lines were validated with Ty markers. Three lines had Ty1, 21 lines had Ty2, 3 lines had Ty3, 3 lines had Ty1+Ty2 and one line had Ty2+Ty3.



Phenotyping for early blight tolerance: 185 F_2 RIL's of the cross 15 SB SB (SP) xLA-1777 (RP) were phenotyped for early blight tolerance by detached leaf method. 90 plants were found to be resistant, 44 plants moderately resistant, 9 plants moderately susceptible and 29 plants susceptible.

- **Embryo rescue:** Embryos (15,20,25,30,35 days after pollination) of inter-specific crosses between *Lycopersicon esculentum* (15SBSB) and two accessions of *Solanum peruvianum* viz., IIHR2805 and 2809, 2-5% seeds from fruits at 20-25 days after pollination showed regeneration response in full strength MS media. In the cross 15SBSB x 2809, two plants were regenerated and one of them could be hardened and transferred to field.

- **Genetic transformation:** Arka Vikas cultivar was transformed with three constructs, one with a dsRNA for resistance to Tospo virus, the second with dsRNA construct for resistance to Gemini virus occurring on tomato in India and a third with dsRNA construct for combined resistance to PBNV and Gemini virus of tomato.

Dolichos

- **Evaluation of photo-insensitive advance breeding lines of pole type for pod yield and quality:** Six advance breeding lines of the cross involving (IC 556824)-IPS-2, Arka Swagath, IIHR178 (pole type photo-insensitive varieties) and Arka Amogh (bush, photo-insensitive) were evaluated during *kharif*, 2015, all of which consistently performed better with yield potential of 30- 41t/ha and were photo-insensitive. These lines were identified for release during Sept, 2015 by VTIC, ICAR-IIHR as Arka Pradhan, Arka Krishna, Arka Adarsh, Arka Prasidhi, Arka Bhavani and Arka Vistar respectively.

Arka Prasidhi: Flowers are purple; Pods are dark green, long (16 -18 cm), medium width (2.3 cm), flat, smooth, slightly curved with rust resistance, matures in 65 days. Suitable for cultivation in Karnataka and South India. Yield potential 37 t/ha in 120 days.

Arka Bhavani: Pods are long (18.5 cm), slender (1.3 cm), wavy and dark green coloured, maturing in 65 days. Suitable for cultivation in Andhra Pradesh. Yield potential 32 t/ha in 120 days.

Arka Visthar : Pods are long (16.5 cm), very broad (3.3 cm), thick and dark green coloured. Pods mature in 65 days. Suitable for cultivation in Tamil Nadu and North-eastern states. Yield potential 37 t/ha in 120 days.

Arka Pradhan: Pods are green and similar to Arka Amogh; tender, smooth and shiny with undulating surface, matures in 68 days. Suitable for cultivation in Maharashtra. Yield potential 35 t/ha in 120 days.

Arka Krishna: Pod setting in clusters, starts from basal node. Pods are dark green and similar to Arka Swagath, matures in 60 days. Suitable for cultivation in Karnataka. Yield potential of 30 t/ha in 120 days.

Arka Adarsh: Pods are of medium length (12 cm), width (2.2 cm) and dark green coloured, maturing in 67 day and suitable for cultivation in Karnataka and Tamil Nadu. Yield potential of 41 t/ha in 120 days.

Cucumber

- **Evaluation of *Cucumis conomon* advance lines for yield and keeping quality:** Among eight *Cucumis melo var conomen* evaluated, IIHR-381 recorded the highest fruit yield of 19 t/ha with 12 fruit per plant, followed by IIHR-Cu 2013-68 with 17 t/ha and 16 fruit per plant. The fruits are round, yellowish with smooth surface and white flesh. Both the lines have a very good keeping quality up three months under room temperature

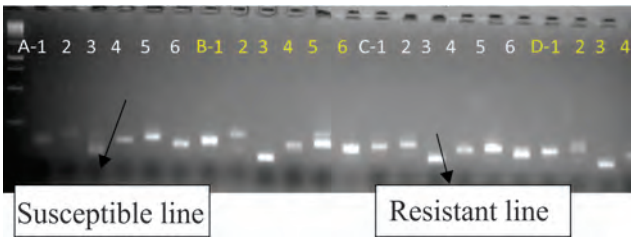
IIHR-Scu-381

IIHR-Cu-2013+68

- **Evaluation of inter-specific hybrid derivative for yield and quality and resistant to downy mildew:** Three F_3 segregating population of inter-specific cross between wild species *C. hardiwickki* X IIHR-20-10 F2, SM-12735 X IIHRCu-81, PCU-1 X SM -12375 were evaluated for yield, quality and resistance to downy mildew during *Rabi* 2015. PCU-1 X SM -12375 BC1F2 pt 4 was predominantly gynoecious with sequential fruiting and resistant to downy mildew. $BC1F_2$ plant is selfed to F_3 for next generation. BC1F3 50 plants were raised and identified superior plant # -9 having predominantly gynoecious and resistant to DM.

BC_1F_3 pt # 9

- **Development of mapping population using resistant and susceptible parents for molecular linked to downy mildew resistance in cucumber:** Interspecific cross derivative of *C. sativus* X *C. hardiwickii* F_1 plants were selfed to make F_2. In F_2 segregating population, 300 plants were raised and leaf samples were collected to identify parental polymorphism.



SSR markers linked to downy mildew showing amplification in parents on 3% Agarose gel. A: P-Cu-1 (susceptible), B: SM-12735 (resistant), C: P-Cu-5039 (susceptible), D: HW-38/18 (resistant). L-1kb ladder

- **Evaluation of elite lines for yield and quality:** Among 20 elite lines and one commercial check (Malini) evaluated, IIHR-CU-107/11 was a high yielder (5 kg/plant) with long, cylindrical, green, fruits free from bitter taste, while Malini recorded 4.5 kg/plant yield, with medium long fruits free from bitter taste.

IIHR-Cu-1107-1/11

Malini

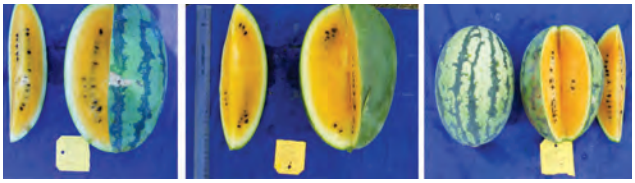
- **New initiative:** *C. hystrix* x *C. sativus* crosses were made to get F_1 fruit, which had 2 immature seeds.

❖ **DUS test monitoring:** Cucumber DUS monitoring was conducted on 02.05.2015, three candidate varieties, 16 reference varieties and 31 DUS characters were evaluated for one participating company to verify their claims.

Watermelon

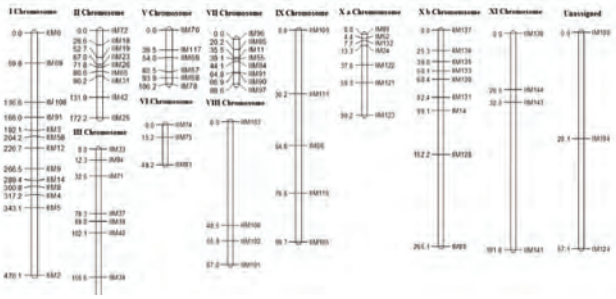
❖ Among 323 advanced lines of icebox background in F_5 generation evaluated during *kharif*, Line-283 (12.8% TSS), 298 (11.8% TSS) and 306 (13.2% TSS) in red flesh and Line-282 (11.0% TSS), 287 (11.0% TSS) and 29 (11.6% TSS) in yellow flesh background were promising. All the selected lines were forwarded to the F_6 generation.

Line-283 *Line-298* *Line-306*



Line-282 *Line-287* *Line-29*

❖ **Screening for WBNV resistance:** 29 genotypes along with commercial check NS-295 were evaluated for WBNV resistance during summer 2015. Line 15-121 (BIL-53) recorded 100% survival at 60 days after sowing compared to 9% survival in NS 295. These lines were crossed with icebox inbreds to study genetics of resistance and transfer into elite back grounds. A draft linkage map has been developed employing 155 SSR markers based on the RIL and BIL families of the cross *C.lanatus var citroides* x Arka Manik.



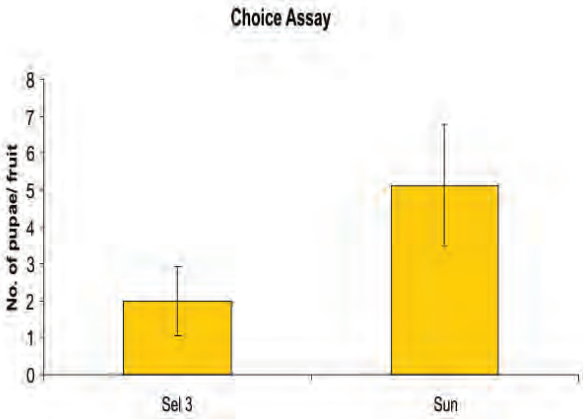
Frame work linkage map based on BIL population of C. lanatus var citroides x Arka Manik

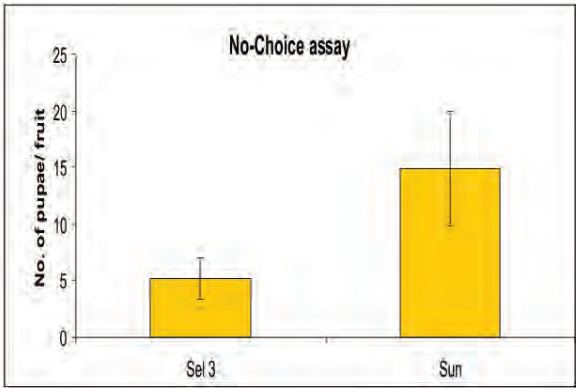
Muskmelon

❖ Among 50 advanced lines in canary yellow background evaluated during summer, *kharif* and *rabi*, Sel-3 derived from pedigree selection in segregating progenies up to F_9 generation from the cross between a selected F_2 plant of IIHR-801 and IIHR-756 (Honey Dew) was most promising. Sel-3 has elongated globe shaped fruits with golden yellow smooth rind, creamy white flesh with crisp and juicy texture. It recorded an average yield of 31.60 t/ha compared to other open pollinated varieties like Arka Jeet (13.82 t/ha), Pusa Madhuras, (19.86 t/ha) and Durgapura Madhu (17.18 t/ha). Sel-3 also recorded the highest TSS of 12.66% compared to all check varieties and hybrids tested.

Selection - 3

❖ Artificial screening of Sel-3 for tolerance to fruit fly with both choice and no-choice assays revealed that Sel-3 was less preferred compared to commercial check, Sun Hybrid.





Pumpkin

❖ During *rabi*, *C.maxima* x *C.moschata* families were evaluated and Sel-11 was found to be vigorous and suitable as rootstock. Among 9 families of butter nut types, Sel-39 was the most promising and among 20 summer squash genotypes, Sel-136 was promising. All the selected lines have been selfed and forwarded to next generation.

Butter nut Selection-39

C.maxima x C. moschata Selection-11

Amaranth

❖ **Varietal release:** Two antioxidant rich, high yielding varieties, Arka Samraksha and Arka Varna were recommended for release for the state of Karnataka by the State Varietal Evaluation Committee.

Arka Samraksha: Pulling type amaranth with green stem

Medium large, lanceolate shaped green leaves

Yields 10.91 t/ha in 30- 35 days duration

Antioxidant capacity of 499 mg /100 g fr. wt.

Nitrate content of 27.3 mg / 100 g fr. wt.

Oxalate content 1.34g /100 g fr. wt.

Leaf protein is 4.0 %

Arka Varna: Pulling type amaranth with pink stem, petiole and veins

Small ovate shaped pinkish green leaves

Yields 10.58 t/ha in 30-35 days duration

Antioxidant activity of 417 mg /100 g fr. wt.

Nitrate content of 37.6 mg /100 g fr. wt.

Oxalate content 1.42g /100 g fr. wt.

Leaf protein is 4.1 %

❖ **Preparation of DUS Test guidelines of ridge gourd, amaranth and palak:** DUS Test guidelines for amaranth, palak and ridge gourd were prepared and the finalized guidelines were published in the Plant Variety Journal.

❖ **Maintenance breeding of reference varieties:** Nineteen reference varieties of amaranth, nine varieties of ridge gourd and five varieties of palak were maintained.

Ridge gourd

❖ **Advancing the segregating populations**: Out of 16 F5 families of four pedigree populations, 33 IPS belonging to all four pedigree populations have been advanced to F_6 generation based on the selection criteria viz., fruit length (24-53cm), fruit girth (4.5-15.0 cm), fruit weight (50-500 g), fruit color (light green, green, dark green) and ridge shape (normal, split).

❖ **Evaluation of hybrids for yield and yield parameters:** Out of six hybrids evaluated during summer, RGH-66 (37.48 t/ha) followed by RGH-64 (35.67 t/ha), RGH-63 (33.92 t/ha) and RGH-52 (29.28 t/ha) out yielded the check hybrids, Naga (25.69 t/ha) and Mallika (21.87 t/ha). Out of six hybrids evaluated during *kharif*, three hybrids namely, RGH-66 (35.66 t/ha) followed by RGH-

RGH-66 and RGH-52 lines of ridge gourd

63 (32.88 t/ha) and RGH-64 (32.26 t/ha) out yielded the check hybrids, Mallika (26.93 t/ha), Rama (26.66 t/ha) and Naga (24.57 t/ha).

- **Evaluation of hybrids for nutritional qualities during summer:** Antioxidant activity, chlorophyll content and nutritional composition was estimated in all the hybrids as well as parents. Among the hybrids, RGH-45 recorded maximum total phenol content (33.94 mg), total flavonoids (11.99 mg), DPPH activity (15.43 mg) and RGH-66 recorded maximum FRAP content (39.81mg). Chlorophyll a and b contents were maximum in RGH-46 (8.27mg) followed by RGH-45 (6.85mg). Among the hybrids, RGH-52 recorded maximum potassium (4.8%), calcium (1.27%), magnesium (1.01%), copper (40.4ppm), iron (79.80ppm) and manganese (17.8ppm). RGH-45 recorded maximum nitrogen (3.29%), RGH-63 recorded maximum phosphorus (0.75%) and RGH-66 recorded highest zinc (50.6ppm) whole the check hybrid Mallika which had minimum quantities of all these nutrients.

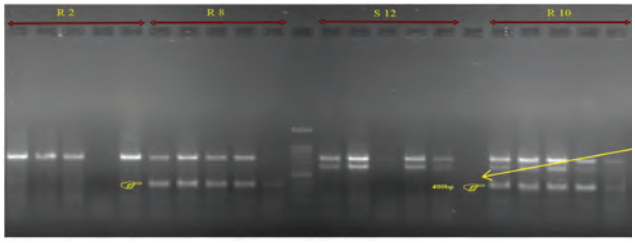
- **Development of mapping populations against downy mildew:** One hundred F_3 plants of two downy mildew S x R pedigree populations viz., IIHR-52-1-30 x IIHR-17-1-7-4 and IIHR-23-8-10 x IIHR-7-5-1 were selfed and advanced to F_4 generation during *kharif* by single seed descent method in order to develop mapping populations for the identification of molecular marker linked to downy mildew resistance. Another set of 22 IP's of five back cross populations were also advanced to BC_1 F_3 and BC2 F_3 generation.

- **Advancing the TLCVND virus resistant inbred lines:** Eleven ToLCND virus resistant inbred lines and a susceptible line, IIHR-102-3 were evaluated during summer for yield and disease resistance.

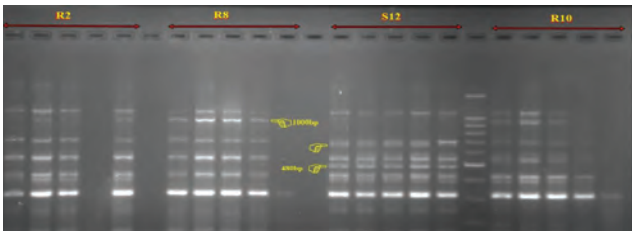
RV-2 and RV-11 high yielding ridge gourd lines

There was no incidence of ToLCND virus and hence could not be scored for the disease. However maximum yield was recorded by RV 2 (20.36 t/ha) followed by RV 11 (19.71 t/ha) and RV 8 (19.41 t/ha) compared to the other lines and susceptible check, IIHR-102-3 (15.8 t/ha).

- **Validation of molecular markers linked to ToLCNDV resistance:** Out of 10 SRAP primer combinations, 3 differentiated the resistant parent from the susceptible parent. Of these, two (Me10/Em6 and Me2/Em3) primer combinations produced a 1000bp and a 400bp marker, respectively, which were present only in the resistant parent (indicated by arrows in figure). The other (Me 10/Em6 and Me10/Em1) produced a 480bp, and 380bp marker, respectively, which were present only in the susceptible parent (indicated by arrows). Fragments with the expected size 450bp, 500bp (susceptible parent) 1000bp (resistant parent) in Me10/Em6 combination and 400bp (resistant parent) in Me2/Em3 combination were excised, cloned and sequenced.



Amplification profile and polymorphism between resistant and susceptible genotypes with primer combination Me2F/Em3R at 400bp R2, R8, R10 (Resistant lines), S12 (Susceptible line), M- 100bp Ladder

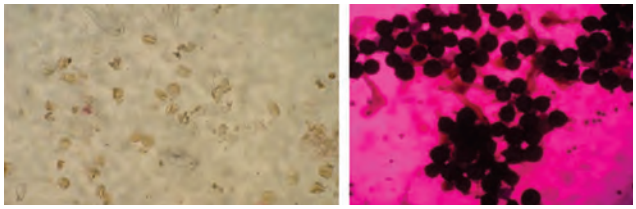


Amplication with primer combination Me10/Em 6

- **Characterization of male sterility in ridge gourd**: Two male sterile mutants were identified in RG-12 (long fruited) and RG-28 (medium long fruited) germplasm lines which were characterized by the production of rudimentary male flowers in the racemes, that remained unopened and fell down 12–16 days after emergence, in contrast to the bright yellow flowers with fertile pollen and healthy anthers in male fertile plants.

Male sterile and male fertile flowers, rudimentary male flowers, fertile male flowers

❖ **Pollen fertility status of *ms* and *mf* lines:** Among all the male parents, RG 53 (84%), RG 58 (83%) and RG 73 (82%) exhibited highest pollen fertility and 0% fertility was recorded in both the male sterile mutant sources. The plants with rudimentary male flowers in both the *ms* back grounds were selected and crossed with 27 fertile monoecious parents and a total of 40 hybrids were developed. These F_1 hybrids are planted along with their male parents during summer.



Sterile and fertile pollen

❖ **Expression of male sterility and restoration of fertility in F_1 hybrids:** Out of 40 hybrids, 12 hybrids exhibited complete sterility though their respective male parents had very good pollen fertility. This shows that the cytoplasmic inheritance of male sterility in ridge gourd and these parents can be used to develop male sterile as well as maintainer lines. Twelve other hybrids that were completely fertile could be possible restorers with homozygous fertility restorer genes. The remaining 16 hybrid populations were not uniform with respect to fertility; this could be due to heterozygous fertility restorer genes present in those male parents. These male parents can be used for developing either maintainer lines or restorer lines after progeny evaluation and back crossing.

Pollen fertility status of *ms* and *mf* lines in ridge gourd

Genotype	Range		Mean	Genotype	Range		Mean
	Min	Max			Min	Max	
RG2	43%	94%	78%	RG58	67%	96%	83%
RG4	25%	67%	40%	RG70	40%	93%	72%
RG5	36%	100%	81%	RG72	54%	100%	81%
RG6	33%	87%	61%	RG73	71%	100%	82%
RG13	36%	88%	62%	RG74	50%	83%	67%
RG16	39%	86%	63%	RG80	57%	96%	78%
RG17	03%	43%	29%	RG82	58%	100%	78%
RG21	03%	11%	3%	RG89	46%	100%	69%
RG22	31%	65%	51%	Sucheta	27%	68%	63%
RG26	03%	100%	26%	Deepthi	53%	80%	64%
RG30	13%	100%	41%	A Sujat	28%	74%	68%
RG36	56%	100%	75%	A.Sumeet	43%	91%	61%
RG37	61%	82%	70%	P.Nasdar	29%	65%	52%
RG53	62%	95%	84%	Min %	3%	Max%	84%

Bottle gourd

- **Evaluation of bottle gourd inbred lines for yield and disease resistance during *rabi*-summer:** Out of the 30 inbred lines evaluated during summer for yield and yield components, three namely, IIHR-90 (58.73 t/ha) followed by IIHR- 23 (42.20 t/ha) and IIHR-91 (41.50 t/ha) out yielded the other inbreds. Fifteen inbred lines viz., IIHR-3, 75, 77, 79, 81, 90, 94, 95, 97, 98, 105, 106, 108, 112 and 118 had combined resistance to CGMMV (Vulnerability Index ranged from 0.0-10.0) and gummy stem blight (PDI ranged from 0.0-4.66).
- **Evaluation of hybrids for yield and disease resistance during summer:** Out of the five hybrids along with two check hybrids evaluated during summer for yield and yield components, BGH- 8 (26.84 t/ha) and BGH- 36 (26.70 t/ha) out yielded the check hybrids, Ruma (23.14 t/ha) and Raveena (23.13 t/ha). BGH 30 was moderately resistant (PDI-23.05) to powdery mildew and CGMM virus (VI-17.33).

High yielding bottle gourd hybrid, IIHRBGH-8

Bitter gourd

- **Screening of inbred lines for powdery mildew resistance:** Forty five bitter gourd inbred lines were evaluated during *kharif* for powdery mildew resistance. Among them, BTG -144-2-1 (PDI-1.45), BTG - 80-5-1(PDI-2.98) were resistant and AUDPC of these lines was also very less (29.10 and 62.50 respectively) compared to the susceptible line, BTG-5 (1272.73) and Arka Harit (1153.85). Apparent rant of infection ("r" value) was 0.05 in BTG-144-2-1 and only 0.14 in BTG-80-5-1 against the susceptible lines whose 'r' values ranged from 5.58-10.62. These two germplasm lines were highly resistant for the second consecutive year. Twenty seven other lines were moderately resistant (PDI ranged from 11.22-23.93) to powdery mildew. Rest of the lines were either moderately susceptible or susceptible. Seeds of all these 45 germplasm lines were multiplied for further evaluation.

Powdery mildew resistant line, BTG-144-2-1 (centre along with susceptible lines, BTG-31 and BTG-147 (left & right)

AUDPC values and apparent rate of powdery mildew infection in bitter gourd inbred lines

Germplasm	Average PDI of powdery mildew	AUDPC	Apparent rate of infection (r)
Btg -144-2-1	1.67	33.4	0
Btg - 80-5-1	2.22	45.85	0.19
Btg - 40	16.67	325	2.3
Btg - 26	36.67	700	4.6
Btg - 148	40.56	830.5	6.26
Btg - 134	46.67	925	14.95
Btg - 12	51.17	1052.5	12.07
Punjab - 14	65.00	1337.5	9.2
Preethi	69.17	1400	5.75
Meghana-2	76.67	1625	13.41
PDM	79.52	1610.7	5.75
Pusa Vishesh	84.58	1718.75	5.46
Arka Harit	88.83	1820	6.67
Btg - 151	89.17	1800	5.75

❖ **Identification, maintenance and hybridization of gynoecious plants:** Gynoecious plants were observed in IIHR-147 and IIHR-61 germplasm which were crossed with the germplasm lines having different genetic back ground like, long/ medium long fruits, green, dark green/cream fruit color etc., F1 seeds of these crosses were collected for further evaluation.

BTG-147 Gynoecious plant

❖ **DUS testing of bottle gourd (Lagenaria sinceraria) and bitter gourd (Momordica charantia):** Eleven bottle gourd entries and 18 biter gourd entries were characterized for DUS traits and monitoring of the DUS Entries was conducted successfully with the participation of private seed company, M/s Neziveedu Seeds Company who contributed the entries.

❖ **Maintenance of reference varieties:** Twenty four reference varieties of bottle gourd were maintained. Sixteen bitter gourd reference varieties namely, Pusa Vishesh, Pusa Do-Mausami, Sel.5, MC-84, Sel.1, Arka Harit, Hirkani, Phule Green Gold, Phule Ujwala, Meghana-2, Preethi, NDBT-9, Kalyanpur Baramashi, NDBT-7, HABG-1, Co-1 were also maintained.

Chilli and Bell pepper

❖ **Varietal identification and large scale seed production:** Arka Khyati (MSH-206), a CGMS based high yielding chilli F_1 hybrid for fresh market, with fruits of 12 X 1cm, smooth and medium pungent, light green and turn red on maturity, tolerant to CMV, yielding 40-45t/ ha (fresh) & 5-5.5t/ha (dry) chilli in 180 days was recommended for notification of crop variety under Section 5 of the Seeds Act, 1966 by the State Seeds Sub-Committee on Crop Standards Notification and Release of Varieties of Horticultural Crops, Karnataka during Dec 2015 by University of Horticultural Sciences, Bagalkot. Large scale seed production of CGMS based chilli F_1 hybrids *viz*, Arka Meghana, Arka Harita and Arka Khyati and chilli variety, Arka Suphal was taken up under the Seed Village Concept during the period.

Arka Khyati (MSH 206), CGMS based high yielding chilli F_1 hybrid recommended for notification

CGMS based chilli F_1 hybrids seed production under seed village concept

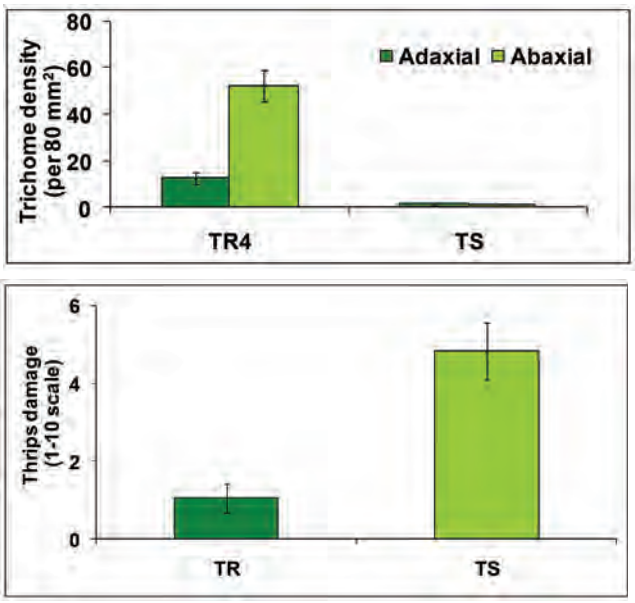
❖ **Evaluation of advanced breeding lines for biotic and abiotic stress tolerance in chilli and bell pepper:** Five promising chilli populations derived from IHR 3453 × IHR 4503 and IHR 4516 × IHR 3476 with high yield, significant WUE and root mass were selected, evaluated and further

Performance of advanced breeding lines with combined resistance to CMV, ChiVMV & thrips

advanced. Three promising chilli inbred lines with combined resistance to CMV, ChiVMV and thrips were evaluated along with the susceptible check for yield, fruit quality, resistance to thrips, CMV and ChiVMV.

One hundred chilli lines were screened for tospovirus resistance through mechanical inoculation and among them three lines showed high level of resistance to GBNV based on visual observations and ELISA testing. In order to introgress major soil borne pathogens (bacterial wilt, *Phytophthora* root rot and nematodes) R genes into moisture stress tolerant line, IHR 4517-crosses were attempted in all possible combinations and the F_1 seeds were collected.

Five advanced bell pepper lines with an average yield of 3.5 kg/ plant were evaluated for heat tolerance under controlled conditions. The Carbon exchange rate ranged from 19.6 – 21.4 µmmol/m^2/s in CHT3-1 and Arka Mohini and the pollen germination ranged from 12-16% at 40^{0}C in CHT3-1 and Arka Mohini.



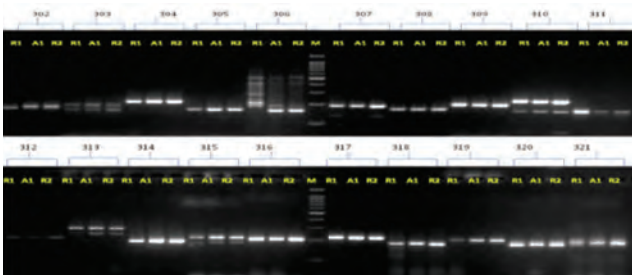
Trichome density and thrips damage in thrips-resistant vs thrips susceptible lines in chilli

❖ **Evaluation of advanced breeding lines for fruit quality traits in chilli and bell pepper:** Genetic analyses of backcross populations of IHR 3476 (non-pungent, sweet pepper, *Capsicum annuum*) and IHR 4501 (highly pungent, *C. chinense*) revealed superiority for five fruit quality traits such as placenta length, placenta width, TSS, fruit to seed ratio and total capsaicinoids over the parent IHR 3476.

❖ **Development of DUS guidelines for *Capsicum annuum* L.:** ICAR-IIHR as Nodal Centre for stipulating DUS guidelines for *Capsicum annuum* L. finalized the draft and the same was gazette notified in July 2015. Forty-nine example varieties (including chilli, bell pepper and paprika) were maintained during the period.

❖ **NAGS for *Capsicum* sp:** ICAR-IIHR is a National Active Germplasm Site (NAGS) for *Capsicum* sp. Seven hundred and eighteen capsicum germplasm lines (EC lines-212 and IC lines-508) received from NBPGR, New Delhi were characterized for 46 morphological traits along with three released varieties and multiplied during the period. Morphological variability was digitalized and seeds were deposited at NBPGR, New Delhi for LTS.

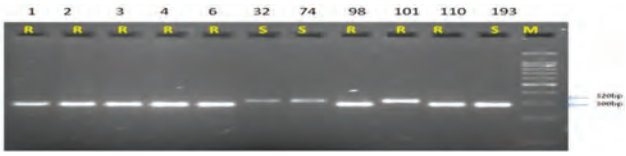
❖ **Diversification of male sterility in chilli and bell pepper:** Twelve CGMS lines and one GMS line along with their corresponding maintainer lines were maintained. Genotyping for sterile cytoplasm, sterile nuclear genes and fertility restorer genes was carried out. In order to diversify GMS line in chilli, 19 sets of crosses were attempted and the seeds collected. For incorporating sterile genes into bell pepper lines, four cross combinations were done utilizing MS3 (B), MS4 (B) and MS12 with Arka Mohini and Arka Gaurav and seeds collected. In order to search new sterile cytoplasm across the *Capsicum* sp.(*C. annuum*–9, *C. chinense*–19, *C. baccatum*-10, *C. frutescens*–11, *C. chacoense*–4, *C. pubescens*-3 and *Solanum pseudocapsicum*–1) common stable maintainer line (MS_2B) was used as male parent and 36 F_1's were raised to get F_2 seed for further phenotyping and genotyping. For MAS background selection, 325 SSRs markers



Gel picture showing the PCR amplification 324 SSR primers with recurrent parents (RP) and one CGMS line (MS3 A) of chilli with an amplicon sizes between 150-550 bp; R1= A. Suphal & CM334, A1= MS3A, R2= A. Mohini & P. Jwala; M= 100bp ladder

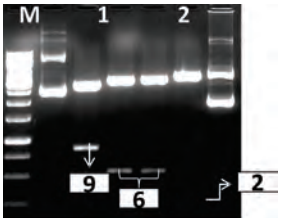
were screened across six cross combinations, in which 309 were amplified and 138 markers showed polymorphism. The primers used were evenly distributed across 12 chromosomes in chilli and the polymorphic primers that are < 6 per LG needs to be strengthened further. Hence, another 90 SSRs are procured for further genotyping. For MAS foreground selection markers linked to sterile cytoplasm, sterile nuclear and restorer genes were validated.

- **Marker assisted selection in chilli:** Eight nematode resistant lines and three nematode susceptible lines were genotyped with eight SSR markers, two SCAR markers and one CAPS marker that are linked to *Me* genes; and among them GPMS171 showed polymorphism between R and S lines.

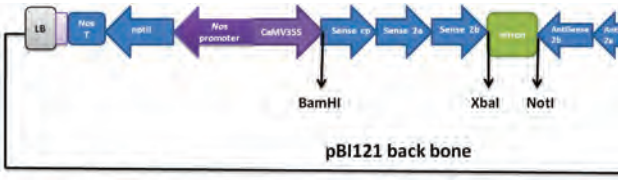


Gel picture showing PCR amplification GPMS-SSR primers with eight resistant (R) and three susceptible (S) samples. Amplification at 320bp indicates susceptibility and 300-bp fragment in resistant (R) lines (M=100bp ladder)

- Genetic fidelity test was carried out in both ultra dried (3.5 and 1.3%) and room temperature (RT) dried (5.8%) chilli seeds. No deleterious effect of ultra drying was seen at biochemical and molecular level as there were no noticeable changes either in protein, enzyme expression and DNA integrity as compared to RT dried seeds
- **Design and preparation of dsRNA construct in pBI121 for cucumber mosaic virus (CMV) resistance in chilli:** Confirmation of CMV Sense+Intron+Antisense fragments in pBluescript



M- 1kb ladder, 1- pBluescript-CMV uncut plasmid, 2- pBluescript-CMV plasmid digested with BamHI+SacI (970bp), 3- pBluescript-CMV plasmid digested with BamHI+ NotI (600bp), 4- pBluescript-CMV plasmid digested with SacI+XbaI (600bp), 5- pBluescript-CMV plasmid digested with NotI+XbiI(230bp), 6- pBluescript control uncut plasmid



Schematic representation of RNAi gene construct of coat protein (cp), RNA dependent RNA polymerase (2a), silencing suppressor (2b) for CMV resistance in chilli.

- At CHES, Bhubaneswar, work has been initiated for marker assisted root stock breeding in chilli and F_1 hybrids. The following crosses viz., CM 334 x Arka Suphal, Arka Suphal x Anugraha and Anugraha x CM334 have been made for combing the resistance to bacterial wilt, *Phytophthora* root rot and root knot nematodes and generation of BC_1F_1 of these crosses is being attempted.

Brinjal

- **Varietal development:** Three advanced breeding lines of crosses derived from IIHR-108 × IIHR-3 namely Arka Avinash (IIHR-37-36-4-20) (40-42 t/ha), Arka Harshitha (IIHR-37-36-4-4) (36-38 t/ha) and Arka Unnathi (IIHR-37-36-13-16) (34-36 t/ha) with high yield and resistance to bacterial wilt were identified for release at institute level by VTIC during September, 2015.
- **Evolving high yielding varieties / F_1 hybrids of Manjarigota fruit types:** Out of fifteen individual plant selections evaluated for fruit yield and quality, two IPS derived from cross IIHR438-2 x IIHR-571-5-3-1-2-7 (2.45 kg/plant), IIHR438-2 × IIHR-571-5-3-1-4-3 (2.00 kg /plant) were promising for fruit yield, quality and texture.
- **Performance of advanced breeding lines in Manjarigota fruit type (spiny parent):** Out of ten IPS derived from crosses between IIHR228 ×IIHR-571, one IPS IIHR 228 ×IIHR-571 -6-4-1-9-4 (1.86 kg/plant) was promising for fruit yield, quality and texture. The seeds of promising individual were multiplied and collected for further evaluation.
- **Incorporation of bacterial wilt resistance in Manjarigota fruit type:** Out of fifteen individual plants evaluated for resistance to bacterial wilt, one IPS namely, 2BMG-1×IIHR438-2-1-2-46-1-7 with 2.3 kg/plant was promising and performing better for bacterial wilt resistance and yield whereas commercial check MEBH-10 succumbed to wilt.

Trait	Arka Avinash	Arka Harshitha	Arka Unnathi
Growth habit	Plants tall and spreading	Plants tall and spreading	Plants tall and spreading
Plant Colour	Dark green stem with dark green foliage	Dark green stem with dark green foliage.	Dark green stem with dark green foliage
Flower colour	Purple	Purple	Purple
Fruit colour	Green long with fleshy green calyx	Green long with fleshy green calyx	Green long with fleshy green calyx
Fruit texture	Smooth	Smooth	Smooth
Days to first fruit maturity	50-58	48-55	48-52
Crop duration	65-115 days	65-115 days	65-115 days
Yield potential	40-42 t/ha	36-38 t/ha	34-36t/ha

Arka Avinash

Arka Hrashitha

Arka Unnathi

- **Evaluation of segregating progenies in Bottle Brinjal background:** A large F_2 population derived from crosses between IIHR-104 and Arka Neelakant, Arka Nidhi were evaluated for resistance to bacterial wilt and yield. Individual plant selections were made based on fruit size, fruit shape, fruit colour yield and resistance to bacterial wilt. Yield per plant ranged from 2.5 to 3.0 kg/plant. Seeds from the best performing IPS were collected and advanced to F_3 generation for further evaluation and selection.

2BMG-1 x IIHR438-2-1-2-46-1-7

IIHR104 x Arka Neelakant

IIHR104 x Arka Nidhi

- **Maintenance and seed production of wild species:** Eleven wild species namely *Solanum aethiopicum L., S. incanum L. / S. insanum, S. indicum L., S. macrocarpon L., S. mammosum L., S. nigrum L., S. sisymbrifoliumL, S. torvum Swartz, S. viarum L., S. gilo* (two accessions) were raised for maintenance and seeds were multiplied and shared with other institutes and SAUs.
- **Plant Variety Protection and DUS testing (PPV&FRA):** Thirty four varieties/hybrids were raised for maintenance breeding and seeds multiplied. All the candidate varieties were characterized for 47 morphological traits as per the DUS test descriptors
- **Fruit and seed set of BC1 and F1 interspecific hybrid (*S. macrocarpon* x *S. melongena*):** $BC1F_2$ and BC_2 seeds were obtained from the reciprocal cross of *Solanum macrocarpon* x *Solanum melongena* which could be utilized as novel genetic stocks for use in pre-breeding and crop improvement studies.

GAEggplant Rs	Description and GenBank accession number	Plant species	Identity (%)	E- value
> LRStRGA9	*Lycopersicon hirsutum* clone PK34_210 RGA marker sequence	*Lycopersicon*	100	6.8
> LRStRGA-5	*Solanum melongena* genes for DNA polymerase θ-like protein, hypothetical proteins, BURP domain-containing protein 17-like	*Solanum melongena*	75%	1e-30
> LRStRGA-34	*Bartonella schoenbuchensis* R1 contig4, whole genome shotgun sequence	*Bartonella schoenbuchensis*	89%	1e-12
>Eggplant E-34	*Solanum demissum* haplotype R3b genotype SH83-92-488 late blight resistance gene cluster	*Solanum demissum*	69%	1e-10

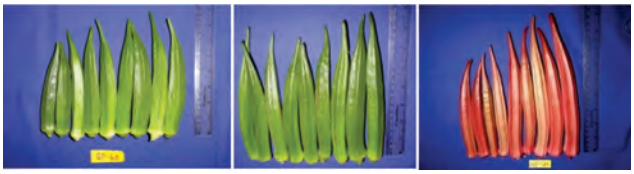
❖ **Screening and evaluation for brinjal shoot and fruit borer resistance and yield:** Among 16 inter-specific F_4 lines (*S.macrocarpon* x *S.melongena*) screened by artificial challenging of *Leucinoides* moths in net-houses, 16 plants were identified for resistance to BFSB (0-10%) and high yield (2.5 to 3.9 kg/plant). Significant negative correlation (r=-0.470) was found between polyphenol oxidase and percent fruit infestation due to BFSB. Thirty one advanced breeding F_4 lines resistant to *Leucinoides* were selected after confirmation through biochemical analysis and forwarded to F_5 generation for further screening and evaluation.

❖ **Marker assisted breeding in brinjal:** Resistance-gene markers for plant defence were isolated from bacterial wilt (BW) resistant *Solanum torvum*, CARI-1 (Andaman islands) and IIHR 107. Wilt susceptible, IIHR-108 and Ramnagar local were also used. Seven different degenerative primers were designed for conserved R-genes/RGA motifs and used to screen resistant and susceptible varieties. Analysis of four RGA sequences revealed that LRStRGA9 having high similarity to PK34_210 RGA sequence of tomato showed resistance to bacterial wilt. Similarity search between Eggplant RGAs and GenBank accessions carried out using the BLASTp algorithm. Some of the selected hits had high level of identity and E-value with R-genes from different plants.

❖ **Transgenic brinjal:** Fruit damage by fruit and shoot borer at 10-15 days, was 87% (13/15) and 20% (2/10) respectively on control and Bt transgenic brinjal plants.

Okra

❖ **Evaluation and characterization of germplasm for yield, quality resistance to YVMV and powdery mildew diseases during summer:** Fifty one accessions including two local checks, Arka Anamika and Pusa Sawani were evaluated and characterized as per NBPGR descriptors. Among them, Acc. IIHR- 394 gave the highest fruit yield of 1.21 kg/plant with 17.1 cm fruit length, 1.60 cm fruit diameter and zero incidence of YVMV and PM followed by IIHR-372 with 1.17 kg/plant while Arka Anamika and Pusa Sawani recorded 620 and 360 g yield per plant with 30-50% susceptibility to YVMV. Fruits are dark green, smooth, tender and have five ridges and maturity of <40 days after sowing. IIHR 400, recorded purple fruit with 1.036 kg/plant yields and 0% incidence of YVMV.



IIHR -394 *IIHR-372* *IIHR-400*

❖ **Evaluation of elite lines of okra for yield, quality and resistance YVMV and powdery mildew during *kharif*:** Among forty three elite lines evaluated, IIHR-11-1-50 , IIHR-11-1-53, IIHR-11-1-69 and IIHR HR-299-1 were high

yielding (27.6,26.5, 24.2 and 24.6 kg / 3 m^2) and resistant to YVMV and PM. Fruits were 11.2 cm long with a diameter of 1.4 cm, smooth, tender, dark green, free from hairs and matured early at 50 days after sowing. It can be grown both in and *kharif* seasons in both poly houses and under open field.

- **Screening of wild species for resistance to YVMV:** Among six wild species screened for YVMV under filed condition during summer, *A. tetraphyllus* (EC-329394), *A. angulosus* var.*grandiflorus*, IIHR-320, *A. cailee and A.tuberculatus* (IC-305676) showed zero incidence while the highly susceptible line Acc 1685 recorded 80% incidence of YVMV.

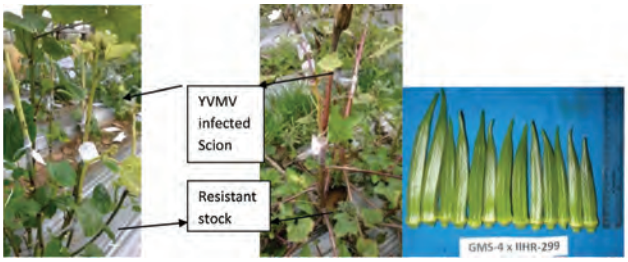
IIHR-11-1-5

A. angulosus var. grandiflorus

- **Evaluation of GMS based F_1 hybrids for yield, quality and resistance to YVMV disease during summer:** Among eight GMS based F_1 hybrids evaluated with two check commercial hybrids (Sarika and Sonakshi) and the sick line Acc.1685, the two hybrids, GMS-4 x IIHR 299 (GMSH-7) and GMS-4 x 551 gave higher yield (23.4 t/ha and 21.5 t/ha respectively) and showed resistance to YVMV under field condition. The commercial check, Sarika recorded 19.4 t/ha with no incidence of YVMV. The fruits of GMS 4 x IIHR299 are dark green, smooth, thin, free from hairs and with five ribs and showed early maturity with 50% flowering in 35.6 days.

- **Estimation of mineral, mucilage and crude fibre content in pre-release hybrids:** Among the seven pre-release hybrids, the top-yielding hybrid, GMS-4 x IIHR -299 had higher amount of phosphorous (0.75%), potassium (3.70%), magnesium (1%) and zinc (43.34 ppm) in fresh fruits with 0.795% mucilage and 6.85% crude fibre. However, GMS-4 x 285 had higher amount of iron (51.1ppm) and manganese (12.6 ppm) coupled with higher mucilage content (1.08%).

- **Artificial screening of wild species against YVMV:** Among the six wild species screened artificially using side grafting with YVMV susceptible scion, *A. angulosus var. grandiflorus* and *A. tetraphyllus*, there was no incidence of YVMV after 30, 60 and 90 days of grafting.



A. angulosus var. grandiflorus *A. tetraphyllys*

- **Development of inter-specific hybrids for transfer of YVMV resistance into cultivated lines**: YVMV resistant lines with three wild species, namely, *A. callie*, *A. teteraphyllus* var. *tetraphyllus* and *A. angulosus* var. *grandiflorus*. *A. esculentus* X A. Caille – F_1 viable seeds but sterile hybrid and F_1 treated with colchicine. Viable seed and sterile hybrids and in F_2 82 seeds were collected. *A. esculentus* (2288) x *A. tuberculatus* and *A. tetraphyllus*. In case of *A. angulosus* flowering initiation was delayed and no synchronization between cultivated and wild species due to photo-insensitive in nature. *A. esculentus* was crossed to *A. angulosus* F_1 seed sown and no fertile flower was noticed. The same F_1 plant was treated with 0.15 % colchine get doubled the chromosome and C1 plant was selfed and C2 seeds at NBPGR, RS, Thrissur.

- **Inheritance of YVMV resistance:** Out of a total of 500 F_2 plants of the cross between YVMV resistant and susceptible plants screened, 269 plants showed resistance. Chi-square analysis indicated that two genes might govern YVMV resistance.

- **Development of molecular markers linked to YVMV:** Mapping population is developed using resistant and susceptible parents. F_1 30 plants, F_2 500 plants and BC1 and BC2 each 30 plants were raised for inheritance studies. YVMV symptom appeared very late, up to 60 days P_2 got 65% YVMV and F2 only 60 plants.

- **DNA finger print database for deep lobed lines:** DNA finger printing of deep lobed lines namely, IC-0598746, IC-0598747, IC-0598748, IC-0598749 and IC-0598750 revealed three major clusters. The line, 10-11-594 (IC-0598749) falling under Cluster I was free from yellow mosaic virus, cluster II consisting of 10-11-551(IC-0598746) and 10-11-581 (IC-0598747) lines showed early flowering and dark green fruit colour while Cluster III [10-11-478 (IC-0598748)] gave the highest fruit yield of 1.05 kg/plant with purple coloured petals on two sides.

Onion

- **Breeding for resistance to purple blotch disease**: Thirty two F_1 hybrids were developed by crossing four purple blotch disease resistant male sterile lines and eight male fertile lines. Among the crosses, the three hybrids namely, PBR MS 318 x PBRC 340, PBR MS 319 x PBRC 339 and PBR MS 317 x PBRC340 were resistant to purple blotch disease and gave high bulb yield. Of the twenty advanced lines evaluated for combined resistance to purple blotch, basal rot and white rot during *kharif* season, three namely PBR-130-81, PBR-126-67 and PBR-522-610 showed combined resistance to all three diseases under field condition.
- **Breeding for tolerance to soil moisture stress**: Thirty five advance lines were evaluated of which, MST 22-726 and MST 19-723 showed tolerance to soil moisture stress in both field and laboratory conditions with a high 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 polyhouse condition in pots with the same age of the seedlings.
- **Breeding for processing:** Evaluation of crosses between Arka Swadista (18-20% TSS, and 16-18% dry matter content) with inbreds of selected commercial lines for processing qualities showed that the progenies were of intermediate size and quality. Isolation of male sterile lines showed segregation for colour, fertility and sterility. The best performing progenies of male sterile and fertile lines were selected.
- **Breeding F_1 hybrids of yellow, rose and multiplier onion for export:** Rose onion, Rose MS 807 x Rose MF131; yellow onion YLMS91 x YLMF63 and multipliers MLTMS59 x MLTMS62 male sterile lines were back crossed with identified maintainer lines (BC2F1) to develop the isogenic lines.

Male sterile lines of yellow (MSYL-29) *Rose onion (Rose MS 601-20)*

- **Identification of male sterile lines:** Six each of red and white onions, seven yellow onion and four multiplier onion lines were identified.
- **Molecular study:** Two markers tightly linked to both alleles at MS locus that will allow breeders to directly select maintainer lines in different background onions were obtained. This is expected to improve the speed of selection of hybrid F_1 cultivars in onion.

Carrot

- **Development of stable high carotene male sterile lines:** Four advanced male sterile lines (MS 138-203, 202-208, 233-203, 261-214) were identified as stable with good root yield and quality characters. Among the maintainer lines, MF 116-125 and MF 118-166 were pure and stable for fertility with good root yield and quality. Three male sterile lines, HC-116-125, HC-125-200 and HC-202-208 had high carotene content with good quality characters.
- **Breeding for resistance to powdery mildew disease:** The advanced line NL83 showed resistance to powdery mildew disease with a PDI of 8. The NL83 had long roots (17cm), good root size (3.5-4cm), root weight (80g), high carotene content (15 mg %), deep orange, self-core and cylindrical smooth roots.

Male sterile line: MS 30-50 *NL 83 with resistance to powdery mildew*

❖ **Identification of male sterile lines through genotyping and phenotyping:** Among the 20 male sterile lines identified, MS 279 and MS- 280 were pure while MS- 244, MS- 245, MS- 247, MS- 257, MS-263 and MS-280 were promising for root yield and quality characters. SSR4 marker was present in male-fertile progeny while being absent in male-sterile F1 plants showing a perfect match with the phenotypic trait.

French bean

❖ **Evolving pole type varieties with resistance to rust and MYMV:** Evaluation of crosses between MYMV resistant lines and advanced rust resistant breeding lines of the cross IIHRPB-1 x IC-525236 and crosses involving IIHRPB-2, 3, 4, 7 (pole type) and IC-525236, Arka Anoop (rust resistant) and IIHR 231 (dark green and pencil podded) gave 40 IPS (dark green, round and stringless pods) with rust resistance. Yield ranged from 17-23 t/ha.

IIHR 231 (IIHRPB-2 x IC-525236) *IIHRPB-7 x Arka Anoop*

❖ **Evolving varieties tolerant to stem fly:** Six breeding lines of the crosses Arka Anoop x IC 525239 and IC 525235 x Arka Anoop along with parents and high yielding varieties, Arka Suvidha and Arka Anoop were evaluated for stem fly tolerance. Stem fly larvae were present to the extent of 2.2 per plant in resistant breeding line compared to 14 in control. The yield ranged from 7.25 to 16.2 t/ha. Pod yield was maximum (16.2 t/ha) in (IC 525235 x Arka Anoop)-3 BS-1.

❖ **Evolving varieties tolerant to high temperature:** Ten breeding lines of the cross IC 525224 x IC 525239 along with parents and high yielding Arka Komal and Arka Anoop varieties were evaluated during summer for high temperature tolerance. Breeding line IC 525224 x IC 525239-05-1-6 could withstand day temperature up to 35^{0}C with a maximum yield of 13.2 t/ha. Number of pods per plant (30) and pod yield (13.2 t/ha) were maximum in (IC 525224 x IC 525239)-10-1-6-1.

(IC 525235 x AA)-09-3 BS-1

(IC 525224 x IC 525239)- 10-1-6-1.

Cowpea (*Vigna unguiculata subsp sesquipedalis and unguiculata* L.)

❖ **Evolving cowpea variety resistant to rust:** Five breeding lines of the cross VS-389, Pusa Komal, Arka Suman and Arka Samrudhi were evaluated. IIHR-16 (VS 389 x Pusa Komal) 09-1-5-2-4 is early (50days) and the pods are borne above the canopy and yielded 20t/ha. Pods were light green, stringless and thin. There was no incidence of rust disease.

(VS 389 x Pusa Komal) 09-1-5-2-4

Garden Pea

❖ **Evaluation of advance breeding lines for earliness, pod yield and quality:** Evaluation of five advance breeding lines of the cross involving Arka Pramodh and Oregon Sugar (Mid-season line tolerant to high temperature, resistant to powdery mildew and rust), IIHR 103 and IIHR 105 (both early lines) during *kharif* 2015 led to three lines, IIHR 2-9, 3-16 and 5-13 were identified by VTIC, IIHR and released as Arka Nirmal, Arka Harini and Arka Mayur respectively.

❖ **Evaluation on of Advance breeding lines for High temperature tolerance (up to 35°C):** Evaluation of advance breeding lines of the cross involving KTP 4, IIHR 544, Arka Sampoorna, Oregon Sugar Arka Ajit, Arka Priya and Arka Pramodh during summer, showed that IIHR 15-6,

IIHR 15-15 and IIHR 15-21 were tolerant to high temperature. These were released as Arka Tapas, Arka Uttam and Arka Chaitra respectively.

Arka Nirmal

Plant height: 45-50 cm
Pod maturity: 40-42 days
Pod length: 7.5 cm
Pod width: 1.3 cm
Pod shape: Straight round
10 pod weight: 75 g
Shelling %: 60
Seeds: Dark green bold and sweet.
Pod yield: 8.5 t/ha in 60 days.

Arka Harini

Plant height: 55 cm
Pod maturity: 43-45 days
Pod length: 8.5 cm
Pod width: 1.2 cm
Pod shape: Straight round
10 pod weight: 75 g
Shelling %: 60
Seeds: Dark green bold and sweet.
Pod yield: 8.7 t/ha in 60 days

Arka Mayur

Plant height: 55 cm
Pod maturity: 45 days
Pod length: 8 cm
Pod width: 1.3 cm
Pod shape: Straight oval
10 Pod weight: 70 g
Shelling %: 57
Seeds: Dark green bold and sweet.
Pod yield: 8.4 t/ha in 60 days.

Arka Tapas

It is a medium tall, mid-season variety.
Pods mature in 60 days.
Pods are nearly oval-round at maturity, medium long (7.8cm) and pod width is 1.57 cm.
Pods are dark green and straight.
Seeds are dark green round, medium and sweet.
Pod yield: 6.6 t/ha in 90 days

Arka Uttam

It is a tall, mid-season variety.
Pods mature in 62 days.
Pods are round at maturity, medium long (6.9 cm) and pod width is 1.43 cm.
Pods are dark green and straight.
Seeds are dark green round, medium bold and sweet.
Pod yield: 7.4 t/ha in 90 days.

Arka Chaitra

It is a tall, mid-season variety.
Pods mature in 64 days.
Pods are round at maturity, medium long (6.9 cm) and pod width is 1.40 cm.
Pods are light green and straight.
Seeds are round, light green, medium bold and sweet.
Pod yield 7.1 t/ha in 90 days.

3.2.3. Ornamental Crops

Tuberose

- **Breeding for small flowered tuberose varieties for garland purpose:** Inter-varietal hybridization was carried out involving Arka Sugandhi, IIHR-6, Mexican Single, Shringar, Vaibhav and Variegated.
- **Multiplication of promising lines:** The promising lines such as Hybrid 1 x 6 (1), Shringar OP, IIHR-4 and clonal selection of Arka Nirantara were multiplied for further evaluation.
- **Evaluation of intervarietal hybrids:** A total of 157 F_1 hybrids of the five different crosses were evaluated for growth and flowering characters.
- **Screening for nematode resistance:** The cultivars/OP/hybrids, viz., Shringar, IIHR-2, Suvasini, IIHR-5, IIHR-6, Mexican Single, Pearl Double, 1x6(1), 1x 6(2), Hybrids-6(op), Variegated, Arka Sugandhi, Hyderabad Single, Hyderabad Double, Vaibhav, Arka Nirantara,

Shringar OP, Swarna Rekha, Phule Rajani, GKTC-4, Calcutta Single, Calcutta Double, Bidhan-1, Bidhan-2 and Bidhan-3 were found tolerant while the genotypes IIHR-4, Prajwal and Shringar OP were susceptible.

Gladiolus

- **Evaluation of genotypes for *Fusarium*, thrips and viruses:** The genotypes were evaluated against two geographically diverse cultures of *Fusarium* viz., IIHR culture and Solan culture of which *Psittacinus* hybrid was found to be resistant. The highest damage was recorded in 'Arka Shobha' (57.5%) followed by 'Arka Naveen' (56.6%) and lowest recorded in 'Arka Amar' (12.5%). In four varieties, the presence of Bean yellow mosaic virus was detected with mosaic symptoms. BYMV was absent in the variety 'Arka Aarti'
- **Evaluation of advanced lines:** Five promising hybrid selections having orange-red (IIHRG-3), yellow (IIHRG-4), red-purple (IIHRG-6 and 7) and purple–violet (IIHRG-12) floret colour with cut flower traits are at pre-release stage.

Rose

- **Breeding for cut flower:** IIHR 7-1, IIHR 7-2 and IIHR 3-18-2 were superior performers among the eight advanced breeding lines tested under polyhouse for yield and quality. IIHRR 9-6 scored the highest with respect to stalk length (80 cm), flower stalk yield (150/m^2), keeping quality (6 days) and resistance to pest and diseases. IIHRR 9-6 was moderately resistant to mite. The mite damage was less (<10%) compared to commercial varieties 'First Red' and 'Tajmahal'

IIHR 9-6 in naturally ventilated polyhouse

Flowers of IIHRR 11-2 suitable for open field cultivation

- **Breeding for open field conditions:** IIHRR 11-2 was found to be promising for open field cultivation with a higher production potential (1.5 kg/plant/year) compared to Ruby Star, Charisma, Sopha Gold and Single Orange. The flowers have an attractive colour and flower opening with a shelf life of 6 days. Considering the floriferousness of breeding lines, IIHRR 13-31, IIHRR 13-28-1, IIHRR 13-24, IIHRR 3-7-11 and IIHRR 9-13, (a climber line) were selected for further evaluation.
- **Resistance breeding for black spot:** Among the 21 genotypes screened for incidence of black spot, IIHRR 3-7-12 had the least incidence (<10 PDI) while IIHRR 4-9-19, IIHRR 4-5-12, IIHRR 4-4-2, IIHRP-36 and IIHRR 11-2 showed PDI ranging from 26 to 50.
- **Resistance breeding for powdery mildew:** The resistance of IIHRR 13-4 against powdery mildew was confirmed by artificial inoculation.

Carnation

- Screening of 10 accessions against two *Fusarium* isolates (IARI and IIHR) was completed. Three genotypes viz., Charmant, Bizet and Orange Vienna were found to be tolerant.
- IIHRCH-5 recorded higher stalk length (> 55 cm) (Grade A) and 10.3 days of vase life, while traits such as flower size, bud length and stem strength were on par with the commercial checks.
- Six *Dianthus chinensis* lines were stable for flower colour and flower form. Seed setting was recorded in varieties, Pink Dover, Liberty and Bizet when used as seed parent.

Gerbera

- **Hybridization and evaluation of hybrids:** Two hundred crosses were made among different parents. Five hybrids, IIHR 15-7, IIHR 3-4, IIHR 6-18, IIHR2-1 and IIHR3 showed varying degree of tolerance to thrips. Quality traits such as, flower diameter, stalk length and stalk diameter were significantly higher in these hybrids compared to check, although they did not show tolerance to pests and diseases.

IIHR3-4

IIHR15-7

IIHR 6-18

Chrysanthemum

- **Breeding for quality traits:** Evaluation of 209 open pollinated seedlings of Pink Cloud, Lalpari, Red Stone, Flirt, Autumn Joy, Shukla, Sunil, Liliput and White Prolific for flower traits revealed that 2-13, 2-16 and 5-9 were early flowering with attractive flowers. IIHR 4-8 and one novel OP line IIHR 6-33 with golden yellow foliage were promising.

IIHR 6-33 with golden yellow foliage

OP line IIHR 4-8 for pot culture

China aster

- **Breeding for cut flower, bedding and pot culture:** A total of 62 crosses were made for cut flower, bedding and pot culture using five IIHR varieties as female parents.
- **Evaluation of pure lines for cut flower:** Evaluation of pure lines with Arka Kamini as check for cut flower traits showed that pure lines, IIHRCC 5-1, IIHR G-13, IIHR J-3 and IIHR J3-2 were promising for cut flower. New variants with reduced length of petals were found from Arka Poornima and Arka Violet Cushion and a new semi-double variant was recorded from Arka Shashank.
- **Evaluation of pure lines for vase life:** Vase life of cut flowers of three advanced lines and Local Pink were evaluated under room condition (24°C - 28°C and 50 - 67% RH) in distilled water. Maximum vase life was recorded in Line IIHR J 3 (12.8 days) followed by IIHR 69-2 (11.6 days), IIHR J 3-2 (10.2 days), whereas, Local Pink recorded least vase life (8 days).

Crossandra

- Screening of *Crossandra* genotypes against *Phytopthora* wilt by artificial inoculation showed the highest mortality of 66.7 % in 'Local' crossandra followed by 22.2 % in 'Arka Kanaka' and 11.1 % in 'Arka Shravya'. 'Arka Ambara' and 'Arka Shreeya' showed no mortality. IIHR varieties and selections were more floriferous and resistant to wilt compared to Local variety under field conditions.
- Gamma ray irradiation (18 Gy) led to mortality (55 %) in rooted cuttings and leaf abnormalities at 40 and 50 Gy in 'Arka Ambara' and 'Arka Shravya' after 45 days.
- Arka Shravya was suitable for pot culture and landscaping due to its spreading habit and floriferous nature.

Marigold

- **Registration:** A novel genetic stock IIHRMGYP-1 was registered by NBPGR with the registration number INGR15036.
- **Apetaloid male sterile lines:** Two apetaloid sterile lines bearing flowers without petals were stabilised through selfing and intercrossing. IIHR10521AB and IIHR10572AB were the two male sterile lines stabilized over six generations of intercrossing. Both the lines were similar in their sterility character except for plant height. Apetaloid sterile plants were homozygous recessive (msms) and fertile plants of sterile line were heterozygous (Msms).
- **Petaloid male sterile lines:** Petaloid male sterile lines IIHRR 2_2(S) having cytoplasmic male sterility and an isogenic maintainer line IIHRR 2_2 (F) were stabilized. Crossing of petaloid male sterile lines with pure fertile lines resulted in progenies of all petaloid sterile plants (100%) and confirmed the inheritance by cytoplasmic male sterility.

Jasmine

- Seventeen species were collected and reconfirmed through *in vitro* pollen germination.
- Mutation breeding in *J. malabaricum* using Ethyl Methane Sulphonate showed no morphological changes in young plants.
- Six hybrid seedlings (*J. malabaricum* x *J. grandiflorum*) were maintained in nursery and these seedlings will be established in field for further evaluation.

Anthurium

- Evaluation of seventeen hybrids comprising fragrant and non-fragrant types showed parity

with the commercial hybrid in stalk length. However, spathe length and diameter of hybrids were less and spadix diameter was bigger than the check variety.

- *In vitro* leaves from 16 lines were used for callus induction on MS medium supplemented with auxin 2,4-D. Twelve lines successfully produced callus (nodular callus) between 25 to 32 days. The callus formed was used to induce somatic embryogenesis. The somatic embryos were then transferred to plantlet development media.

Fragrant IIHR1-7

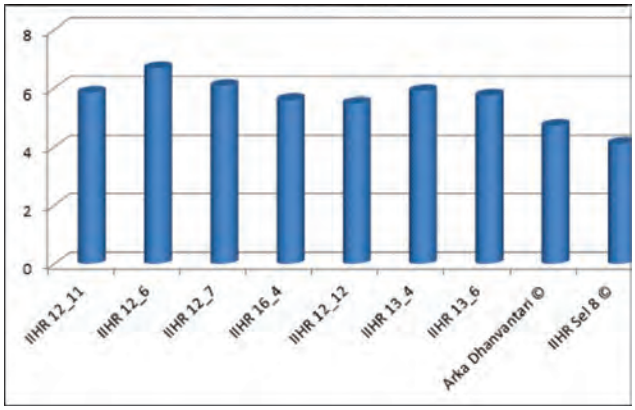
Non-fragrant IIHR 11-5

Shoots from callus

3.2.4. Medicinal Crops

Mucuna pruriens

- **Evaluation of advance breeding lines**: Eight advanced selections were evaluated in a replicated trial along with three checks. Promising selections and IIHR PS 2 (310g, 5.38%) IIHR PS 14 (322g; 5.0 %) in long duration and in medium duration IIHR PS 6 (265g; 5.01%) showed superior performance.
- **High L-dopa Selections:** High L-dopa selections isolated from different crosses with (identified L-dopa donors) wild lines with pods having itchy trichomes as male parent were evaluated. The selections IIHR 12-6 and IIHR 12-12 combined higher seed yield (173g/plant and 163g/plant) with high L-dopa content (6.73% and 6.03% respectively).



Mean L-dopa content (%) of high L-dopa selections over two years

- **Selections based on seed coat colour:** Eight selections with novel seed coat colour variants were evaluated for seed yield and L-dopa content. Seed yield ranged from 157 to 265 g/plant and L-dopa content varied between 4.50 to 5.73%. IIHR SC 6 line recorded higher seed yield of 265 g/plant with an L-dopa content of 5.32%.
- **Genetic analysis:** Studies revealed that both additive and non-additive gene actions are important in the inheritance of the characters. Based on *gca* effects of the parents, the parents Arka Dhanvantri, IIHR Selection 8 and IIHR Selection 2 were best general combiners. This attribute may be exploited in future breeding programme to generate genetic variability for improvement of traits such as, number of flowers per plant, pod length, pod weight, number of bunches per plant, number of pods per bunch, dry pod yield and seed yield per plant. Studies on specific combining ability effects indicated that the cross IIHR Selection 2 × IIHR Selection 8 was the best specific combiner for economically important traits like, pod length, pod weight, dry pod yield per plant and seed yield per plant. High yielding hybrids were produced not only by crossing two high yielding parents, but also by crossing low yielding with high or average yielding parent, Arka Dhanavantari × Arka Aswini and IIHR Selection 8 × IIHR Selection 3. This finding suggests that in velvet bean, it may be possible to select recombinants excelling in yield and quality from the segregating generations following simple pedigree method to achieve yield improvement through heterosis breeding, involving genetically distant lines with high or average *per se* performance, as parents.

IIHR SEL PS 6

IIHR SEL PS 2

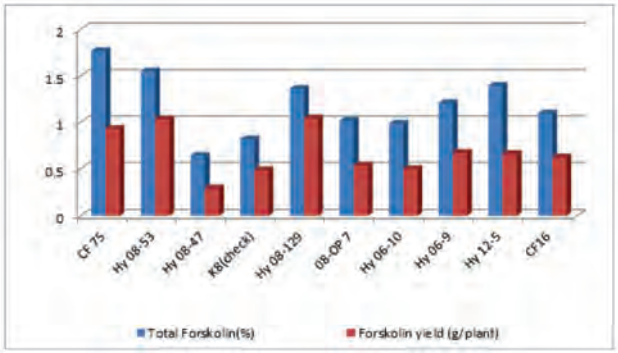
IIHR SEL 13-6

IIHR SEL 12-6

Coleus forskholii

- **Evaluation of advanced selections:** Eight good tuberous rooted hybrids and check K-8 were evaluated for morphological and yield traits.

Out of them, Hy 08-129 and Hy 08-53 recorded significantly higher root yield per plant (76.7 and 66.6g) over check K8 (59.5g). Remaining hybrids were on par with the check for root yield/ plant except Hy 12-5. 08-OP 11, DHS 10, Hy 06-5, DHS 14. Higher total forskolin was recorded in CF 75 (1.77%), Hy 08-53 (1.55%), Hy 12-5 (1.39%), Hy 08-129 (1.36%). Hy 08-129 and Hy 08-53 recorded higher forskolin yield/plant. Hy 08-OP 7, Hy 06-9 and CF 16 recorded forskolin content above 1.0 % while check recorded 0.82 %. Among sixteen selections evaluated, 08-OP 11, DHS 10, Hy 06-5, DHS 14 and Hy 06-40 recorded higher forskolin yield/plant ranging from 0.71 to 0.50g /plant.



Performance of superior hybrids of Coleus forskohlii

- **Establishment of hairy roots of *Coleus forskohlii:*** Hairy roots of *Coleus forskohlii* from leaf cultures transformed with *Agrobacterium rhizogenes* have been obtained. *In vitro* nodal, leaf and root cultures have been initiated. Callus has been generated from both roots and leaves for initiation of suspension cultures.

Withania somnifera (Ashwagandha)

- **Evaluation of Advanced breeding lines:** Eight advance breeding lines (F7 generation) were evaluated in the second year along with three national checks (JA-20, JA-134, RVA-100) and Arka Ashwagandha, an improved variety developed at IIHR. All the advance breeding lines were clearly distinguishable from currently cultivated varieties based on morphological traits, especially for fruit color (red *vs* yellow), which will be useful for variety identification and protection. In the second year performance, advance breeding line F7-1 was distinctly superior for dry root yield (10.2 Q/ ha) to currently cultivated varieties (JA-20, 4.2 Q/ha; JA-134, 3.20 Q/ha; RVA-100, 3.35 Q/ha; Arka Ashwagandha, 8.60 Q/ha). It is one of the potential hybrids derived line with high dry root yield, withanolide content and field resistance to diseases and pests.

Centella asiatica (Mandukaparni)

- **Evaluation for yield and active ingredient:** Twelve germplasm lines, two polyploids and one released variety were evaluated for biomass yield and Tri-terpenoids content for three years i.e., 2013 to 2016. Broad leaved germplasm were harvested once a month, moderate leaved once in two months and small leaved ones in three months and year wise dry biomass yield is compiled. Based on dry biomass yield two entries IIHR CA-13 (22.76 q/ha) and IIHR CA-1 (25.06 q/ha) which were high yielding than check with 14.30q /ha were selected as promising lines for biomass yield.
- The quality was higher during March-August than September to February. IIHR CA-13 recorded higher content of Asiaticoside (>3 %) and total Tri-terpenes (>6%) than released variety Vallab Medha (< 2.0 % Asiaticoside and around 5% total Tri-terpenes). This variety is good for extraction purpose as industry needs >2 % of Asiaticoside and >6% total Tri-terpenes for cost effective extraction. Whereas IIHR CA-1 with < 2% Asiaticoside and >5% total Tri-terpenes is good for human consumption. Hence, IIHR CA-1 which is erect type for easy harvesting, fast growing with good leaf size is a potential vegetable type as *Centella* is also used as green leafy vegetable in many parts of Karnataka, India and many other countries.

Promising line of Centella asiatica IIHR CA-1

- **Colchicine induced polyploids:** Two polyploids IIHR CA-14 and IIHR CA-15 were developed through colchicine treatment and polyploidy was confirmed through cytological investigations.

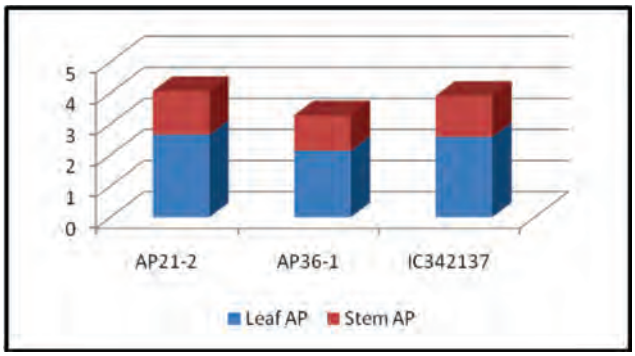
IIHR-CA-14

IIHR-CA-15 (Polyploid-2)

The lines have chromosome number, 2n=36 and possessed thick and broad leaves with improved yield and quality than parent.

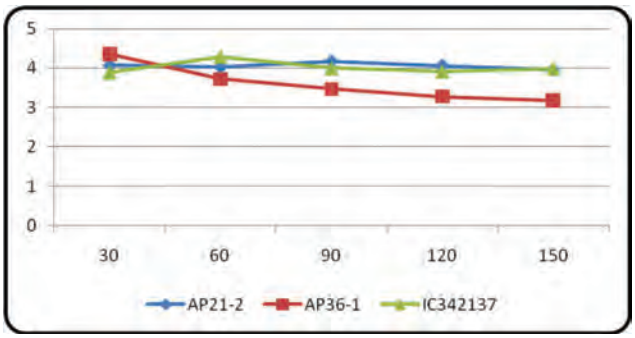
Andrographis paniculata (Kalmegh)

❖ **Studies on ontogenic variation for andrographolide content:** Variation for total andrographolide (AP) content in stems and leaves was studied in three genotypes AP 21-2, AP 36-2 and IC 342137 at 30, 60, 90, 120 and 150 days after planting (DAP). Four bioactive terpenoids, andrographolide (AP1), 14-deoxy-andrographolide (AP2), neo-andrographolide



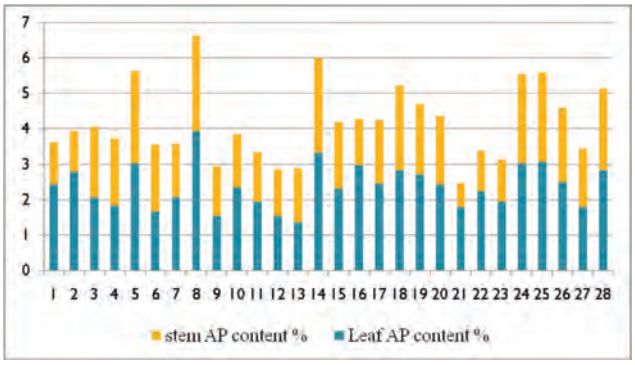
Leaf and stem andrographolide content in genotypes

(AP3), and andrograpanin (AP4) were estimated in stems and leaves during different stages of growth following HPLC protocol. Total andrographolide content and AP1, AP2, AP3 and AP4 showed varying pattern both in stems and leaves of genotypes studied. In leaves, AP1, AP2 and AP3 were higher at 120 DAP where as AP4 decreased with time. In stems, AP1, AP3 and AP 4 decreased over time where as AP2 increased. Total andrographolide content in leaves was stable in AP 21-2 and IC342137 while it decreased in AP36-1. The study revealed that andrographolide content differed in stem and leaves based on genotype and stage of harvest. Out of three genotypes, AP21-2, IC 342137 showed a stable content both in leaves and stem.



Variation in andrographolide content over different harvests

❖ **Evaluation for biomass and andrographolide content:** 28 lines were evaluated for biomass and andrographolide content with CIM Megha, Anand Kalmegh as checks. Leaf and stem yield recorded at 75 DAP and andrographolide (AP) content in both leaves and stems was estimated by HPLC. Dry biomass ranged from 13 to 83g/plant at 75 DAP and AP content varied from 2.85 to 6%. AP yield/plant varied from 73 to 438g/plant. 12 lines recorded significant higher yield than the check and Selections 18-3, 18-7, 18-8 and AP 35 recorded very high AP content (5 to 6%). Selections AP 18-3, AP 35, AP 40 and AP45 yielded > 400g/plant AP yield per plant. Lines *viz.* AP35, AP18-7, IC111291, AP18-8 and AP18-3 recorded higher content in stems also.



Performance of Kalmegh selections for andrographolide content at 75 DAP

3.3. Crop production

3.3.1 Fruit Crops

Mango

- **Rootstock studies:** The maximum tree height and spread were recorded with nine years old Totapuri trees grafted on Olour rootstock followed by Turpentine rootstock, while the least tree height and spread was with Nekkare and Vellaikulamban. The fruit yield was highest on trees grafted on Turpentine (99.0 kg / tree), followed by Olour (83.3 Kg / tree) and least on Vellaikulamban (44.3 Kg / tree).

- **Organic nutrition:** Vegetative growth, fruit yield and fruit quality established that Alphonso mango trees were unaffected by the various organic nutrition treatments tried. The highest yield of 18.6 kg / tree was recorded with 50% of the RDF as FYM along with *Azotobacter* + PSB + AM fungal inoculation.

- **Jelly seed disorder in Amrapali:** Comparison of healthy (H) and jelly seed (JS) affected fruits of Amrapali mango for the composition of fatty acids showed a significant reduction in the contents of two very long chain fatty acids (VLCFAs), tetracosanoic and hexacosanoic acids in JS seed, along with an abrupt rise in cytokinins - zeatin, zeatin riboside, dihydrozeatin riboside, isopentenyl adenine (iP) and isopentenyl adenosine (iPA), compared to H seed. A concurrent increase in the GA_3 and IAA was also observed in the jelly seed while ABA was significantly lower compared to H seed. These changes suggested that the biochemical events preceding seed germination were in progress in JS seed, and the decrease of VLCFAs in seed of JS affected Amrapali mango triggered the induction of early germination through the production of cytokinins.

- Pre-harvest treatment of developing fruits with GA_3 (2 g/l) led to higher levels of amylase and lipase activities while paclobutrazol (10 g/l) treated fruits exhibited lesser activity compared to control. Consequently, the incidence of JS was higher in GA_3 applied fruits (76%) and lower in paclobutrazol treated fruits (6%) compared to 48% in control. These results indicated that the rate of JS incidence is regulated by the initiation of seed germination events

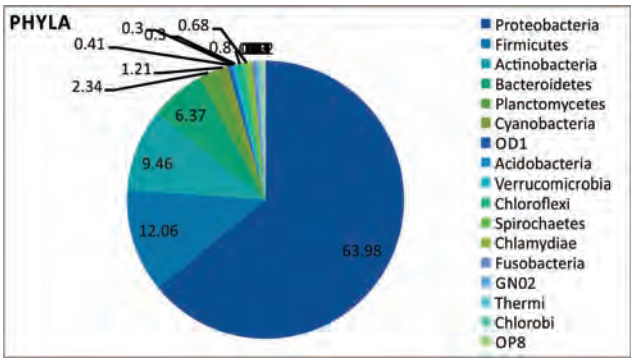
- Application of paclobutrazol (PBZ) @ 0.50g a. i. /m canopy spread by the collar drench method was found to be significantly effective in reducing vegetative growth, advancing flowering by reducing duration of bud break and increasing flowering intensity in 17-year-old mango var. Arka Neelachal Kesari, percentage of bisexual flowers, fruit yield and yield efficiency. It was observed that the effect of PBZ was more pronounced in enhancing flowering intensity during off-year. Higher application rate of PBZ aggravated flower compaction. PBZ application increased TSS and acidity but reduced fruit weight, TSS: acid and sugar: acid ratio, whereas pulp content and pulp stone ratio were unaffected. Among three methods; collar drench, dibbling and ring application, collar drench and ring method were more effective in influencing flowering apart from low soil residual concentrations of PBZ. Among ring and collar drench method, the later was more cost effective. It was observed that, the soil residue of PBZ reached to non-detectable level after seven months of application.

- Usually mango is not trained like other vines, but at CHES, Bhubaneswar, mango has been trained on Y shaped trellis and hedge system to harness more solar energy and to obtain quality fruit. An extra early variety Arka Neelachal Kesari has been trained on different systems planted at a spacing of 3 x 4 m. The number of fruiting terminals (4th level) has been kept constant (240) by regulating the number of primary, secondary and tertiary branches. Among different systems, the hedge system was better in obtaining quality fruit in terms of fruit weight and TSS.

Banana

- Cultivation versus metagenomic profiling of endophytic bacterial diversity in the shoot tip tissue of banana cv. Grand Naine (*Musa* sp.), revealed the prevalence of a diverse uncultivable microbial ecosystem *in planta*. Members of the phylum Proteobacteria were predominant followed by members of the phyla Firmicutes, Actinobacteria, Bacteroidetes, Planctomycetes, Cyanobacteria and minor proportions of 14

other phyla. Earlier cultivation based studies had revealed the association of members of the phyla Proteobacteria, Firmicutes and Actinobacteria in the shoot-tissues in banana and other plant species. The enormous endophytic bacterial diversity documented in the shoot-tip tissue of banana (covering 46 classes, 269 genera and 656 species), changes our present understanding of the plant - endophyte association and interactions amongst them.



Diversity of endophytic bacterial phyla present in the shoot-tip tissue of banana cv. Grand Naine deciphered through 16S rRNA metagenomic profiling

Guava

- **High Density Planting (HDP) in Guava cv. Allahabad Safeda**: The first round of pruning was carried out in the high density guava orchards. The yield varied from 6.2 t/ha to 13.0 t/ha in the initial year of cropping with an average fruit weight of 110.0g. A new HDP trial with cv. Arka Kiran was initiated.
- **Enhancement of Water Use Efficiency (WUE) in rainfed guava cv. Arka Kiran:** Application of coir pith as soil mulch recorded 171 % more soil moisture than the un-mulched control (3.79 % moisture), indicating its superiority in conserving soil moisture for a period of 65 days after the cessation of rains.
- Coirpith mulch resulted in better canopy spread (5.97 m^2 as against 3.48 m^2 in control) and enhanced the number of fruits in guava significantly (324/ plant as against 172/plant in the control). The treatment also recorded a yield advantage of 54 to 55%. However, the mean fruit weight was reduced by 12-17 % with coir pith application as compared to control. The trend was similar during both fruiting seasons suggesting the suitability of coir pith mulching for rainfed guava production.
- Polythene mulching in the basins of guava plants maintained higher soil moisture (181 % more than un-mulched control), till 95 days after cessation of rains. The fruit number (208.7/plant) and the yield (14.73 kg/plant) were at par with the control (172.3 and 14.1kg/plant, respectively).

Guava cv.Arka Kiran trees with coir pith mulch

- The post flowering irrigation of guava trees, resulted in significantly higher number of fruits (148/plant), while among the irrigation levels, 100% CPE was found to yield higher fruits (164/plant). A similar trend was observed in fruit yield /plant.

Guava cv.Arka Mridula plants under drip irrigation trial during the year

- Highest WUE (408 to 429 kg/ ha.mm) was recorded when irrigation was scheduled only during one phenophase and lowest WUE was recorded with irrigation at both phenophases. Irrigation at 50% CPE recorded highest WUE (416.3 kg/ ha.mm) as compared to either 75 % CPE or 100% CPE.

- Under Eastern coastal region conditions, branch bending during May was found effective to induction of profuse *mrig bahar*/ rainy season flowering and thereby production of a heavy crop load during winter. The branch bending maintained high C:N ratio which improved the fruit set and reduced the fruit drop.

Grapes

- Eight canopy management treatment combinations were imposed during November-December 2015 in Red Globe and Crimson Seedless grape varieties. In both the varieties, the treatment combination of berry thinning at 8-10 mm stage + ethrel application + basal leaf removal at veraison, produced quality bunches in terms of berry diameter, berry length, TSS, anthocyanin content and bunch compactness. The bunches harvested from the treatments without the berry thinning component recorded increased physiological loss of weight (PLW) on the 7th day after harvest. However, the treatments with bunch thinning component recorded the least PLW on 7th day.
- The effect of pinching level on fruitfulness in Crimson Seedless grapes was studied by imposing three treatments viz., pinching at 3rd, 4th and 5th leaves and were compared with un-pinched shoots as control. Maximum fruitfulness was recorded in the vines which were shoot pinched at 5th leaf compared to other treatments and the same shoots recorded leaf area of approximately 3300 cm^2. However, shoot pinching at 3rd leaf or un-pinched shoots (control) recorded least percentage of fruitfulness. The lower level of pinching (3rd leaf) also resulted in reduced leaf area while control vines recorded maximum leaf area, inter-nodal length and total shoot length.
- In studies on biochemical factors influencing fruitfulness in straight and sub canes of coloured grape varieties viz., Flame Seedless, Sharad Seedless, Red Globe, Crimson Seedless and Saritha Seedless, sub-canes were developed and were compared against straight canes with respect to their biochemical composition and fruitfulness. In all the varieties, development of subcanes after back pruning has a significant effect on fruitfulness. The highest fruitfulness was recorded in Crimson Seedless and Flame Seedless varieties while least was in Sharad Seedless and Saritha Seedless. The percent fruitfulness was directly correlated with the C:N ratio, phosphorus content and total protein content of shoots measured during fruit bud differentiation stage and inversely correlated with total shoot length, cane diameter and inter-nodal distance.

Pomegranate

- Pomegranate cv. Bhagwa exhibited dwarfness when grafted on Daru rootstock. Maximum plant height (2.36 m) and canopy spread (1.62m NS and 2.06m EW) were recorded in tissue cultured plants, while grafted plants were reduced in size (1.82 m) and canopy spread (1.51m NS and 1.44m EW). The maximum fruit girth (24.88 cm) was recorded from air layered plants while it was lowest on grafted (23.3 cm) plants. Aril weight (135.98 g) and aril to rind ratio (1.43) were highest in air layered plants, while grafted plants exhibited the lowest aril weight and (121.13g) and aril to rind ratio (1.28). Tissue cultured plants recorded the highest yield per plant (12.43 kg) while the average fruit weight was highest (230.73g) in air layered plants, as against 206.85g in grafted plants. A new HDP trial with spacing of 3.0 x 1.5m was initiated with cv Bhagwa and Ruby.

Fig

- High Density Planting (HDP) trial on Poona and Deanna cultivars revealed that tree height, spread, trunk girth, fruit yield and quality parameters were unaffected by spacing treatments. The estimated yield was found to increase with closer spacing, the maximum yield (15.34 t/ha) was obtained at 5.0 x 2.0m spacing while the lowest yield (6.60 t/ha) was obtained with wider spacing of 5.0 x 4.0m in cv. Poona. In cv. Deanna the maximum yield of 9.00 t/ha was obtained at 5.0 x 2.0m spacing and least yield (5.35 t/ha) was obtained in the wider spacing of 5.0 x 4.0m. A fresh HDP trial of fig cv. Excel at 2 x2m spacing was initiated.

Jamun

- Jamun trees cv. Dhoopdal, planted in the spacing trial did not enter the flowering phase even after six years of planting.

Jack

- Rootstock trial of jack revealed that jack seedlings grew taller compared to rootstocks. Fruiting was not observed on grafted plants, with the exception of jack on *A. hypargyraeus* which initiated fruiting.

Annona

- The *in situ* grafting technique for custard apple has been standardized in order to ensure better establishment, growth and precocity in bearing. Five to six month old rootstock can be *in situ* wedge grafted during December–January. Custard apple (*Annona squamosa*) and Ram phal (*A. reticulata*) may be used as root stocks. However the graft success was relatively more in *A. squamosa*. Pre-cured (7-8 days), 15-20 cm long scions containing 8-10 active buds should be grafted at a height of 15-20 cm. The graft success (85- 94.5%) and growth rate was significantly high. The *in situ* grafted plants started bearing flowers after two years.

- **Pruning studies:** The influence of intensity (25%, 50% and 75% pruning of previous season shoots) and time (60, 75 and 90 days after harvest) of pruning were studied in cv. Arka Sahan. The highest shoot emergence was observed with 75% pruning done 90 days after the last harvest. Fruit yields were higher with earlier pruning. The pulp content of fruits were lowest in 75% pruning. Tree height, E-W spread, fruit weight, TSS and pulp seediness were unaffected by the treatments or their interactions.

- **Integrated nutrient management:** A new field experiment involving INM cum fertigation was initiated on five year old Arka Sahan trees.

Papaya

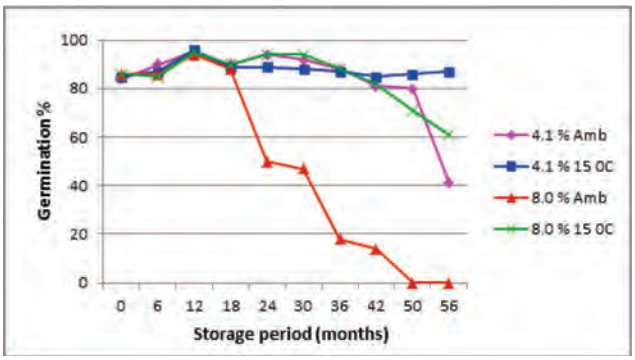
- **Optimizing productivity under salinity and drought stress:** Salinity (200 mM NaCl) treatment increased the total soluble sugars, reducing sugars, individual sugars- glucose and sucrose contents and reduced the starch content. Increases in the total soluble sugars (42.6%) and glucose (59.5%) were high in Arka Prabhat, while increases in reducing sugars (45.2%) and sucrose (55.2%) were high in CO-4. The reduction in starch content was lowest in CO-4 (19.1%) and highest in Arka Surya (41.9%). Under salinity conditions, both CO-4 and Arka Prabhat showed low lipid peroxidation values and greater induction of SOD and catalase activities. Arka Surya recorded an increase in the glutamine content by 52.5% and alanine content by 39.5%, while CO-4 recorded an increase in leucine content by 183.7% and arginine content by 74.7%, indicating the role of amino acids in salinity tolerance.

- In cultvar CO-4, salinity stressed plants showed 16 new proteins, besides the up-regulation of 21 proteins and down-regulation of 12 proteins. In cultivar Arka Surya, salinity stressed plants showed the up-regulation of 15 proteins and down-regulation of 11 proteins with the concomitant appearance of 8 new proteins.

- Seedlings of papaya cultivars Arka Surya and CO-4 inoculated with the endophytic plant growth promoting fungus *Piriformospora indica* (10^8cfu/g), when subjected to salinity treatment recorded higher fruit number/plant, and fruit quality attributes viz., carotonoids, flavonoids and ascorbic acid contents.

Seed storage studies

- Seeds of cultivars Arka Surya and Arka Prabhath with 4.2 and 4.1% moisture contents respectively, when packed in moisture vapour impervious containers, recorded higher than 80% germination, even after 50 months of storage under ambient temperature. Whereas seeds with around 8.0% moisture contents, when stored at the same conditions recorded a significant reduction in the germination percentage (lower than 50 %).



Seed germination as affected by seed moisture and storage temperature over 56 months of storage in papaya cv. Arka Prabhath

- Papaya seeds with moisture contents of 8.0% when stored at 15^0C, maintained a high degree of germination (above 80% germination) upto

42 months of storage. Whereas seeds with 4% moisture content maintained greater than 80% germination even after 56 months of storage.

- The results showed that papaya seeds dried to 4% moisture content can be stored under ambient conditions for periods upto 4 years and upto 5 years when stored at 15° C.

Cropping system studies in Goorg Madarin

- A cropping system experiment was established in CHES, Chettalli during 2004, in which various combinations of Coorg mandarin budded plants were grown with Coffee (C X R) and black pepper (Panniyur 1) under the shade tree *Erythrina lithosperma*. The treatments did not influence the plant height, stock girth, bud joint and scion girths, whereas the plant spread was significantly influenced by the treatments. The plant spread ranged from 2.79 to 3.55 m and 3.67 to 4.13 m in the North-South and East-West directions respectively. The fruit yield of budded Coorg mandarin plants varied from 7.76 to 12.8 kg/plant which was relatively higher when compared to seedling plants (7.76 kg/plant). The coffee (green) yield varied from 2.23 to 3.10 kg/plant and pepper (dry) yield ranged from 1.85 to 2.84 kg/plant. A definite effect of the treatments was not observed on coffee and pepper.

3.3.2 Vegetable Crops

Chilli and Bell pepper

- **Organic farming:** Inorganic treatments recorded significantly higher number of fruits per plant (115-123.3) compared to organic treatments (50.3-74.0) in chilli (Arka Meghana F_1 hybrid). Similarly the fruit length and fresh weight of red ripe chilli fruit were also maximum with inorganic treatment i.e. integrated nutrient management. With respect to dry chilli yield, integrated nutrient management treatment recorded the highest yield of 3.55 t/ha which was markedly superior to yields recorded in organic treatments (1.65 to 2.81 t/ha).

- **Fertigation under protected cultivation:** Seven bell pepper hybrids were evaluated in a naturally ventilated polyhouse during January 2015 to November 2015. Fertigation with water soluble fertilizer @ 200-150-250kg NPK/ha (K through SOP), was found to give highest yield (99.6t/ha). With the exception of 25 % reduced fertilizer application, the normal fertilizer application (92.2t/ha) and other fertigation treatments were at par with the best performing treatment. Among the colour capsicum hybrids tested, Triple Star and Inspiration (red), Sunny and Bachata (yellow), recorded significantly higher yields (94.6 to 98.1 t/ha) compared to regular hybrids Bomby and Orobelle (86.7 to 90.6 t/ha).

- **Root stock studies:** Green bell pepper hybrid Indra was grafted on to seven chilli selections/varieties, and grown inside a nylon net house between September 2014 to August 2015. The graft success was above 90 percent. Green capsicum hybrid Indra grafted on different chilli roots recorded yields of (119.9 t/ha to 147.8 t/ha) compared to non-grafted Indra hybrid (120.0 t/ha).

Brinjal

- **Organic farming:** An experiment was conducted with four levels of nitrogen substitution through Farm Yard Manure (25, 50, 75 and 100 %), recommended dose of FYM application, and three inorganic treatments viz., conventional practice (Recommended FYM @ 25 t/ha + Recommended N P K fertilizers), recommended N P K fertilizers alone and safe production, using the variety Arka Anand. During the first year of experimentation, the highest yield was observed with integrated system (33.2 t/ha), which was at par with the organic treatment wherein the 100 % of the recommended N was made available through FYM (33.0 t/ha). The yields under different organic treatments ranged between 33.0 to 23.0 t/ha.

Okra

- **Organic farming:** Plant growth parameters viz., plant height and girth of Arka Anamika, were higher in inorganic treatments. Pod yield in the inorganic and safe production treatments were >18 t/ha while in organic treatments, the yield recorded was in the range of 14.8 to 17.9 t/ha. The minimum pod yield of 12.5 t/ha was observed, with the application of chemical fertilizers alone.

Cucumber

- **Optimizing Water Productivity and Nutrient management:** In a fertigation trial on cucumber (variety Vani), the bi-weekly application of 100% RDF of NPK (75:56:75 k/ha) through water

soluble fertilizers resulted in highest yield (79.5 t/ha) followed by weekly application of the same amount of nutrients (76.3 t/ha).

French bean

- **Organic farming:** In French bean (Arka Suvidha), integrated nutrient management recorded significantly higher yield (13.0 t/ha), followed by organic treatment wherein 100% of the recommended N dose was supplied through FYM (12 t/ha). The lowest yield was recorded with the application of chemical fertilizers alone (9.18 t/ha).
- Proteins regulating seed viability and vigour in frenchbean cv Arka komal were isolated and characterized by comparing proteome of viable and non viable seeds. A total of twelve proteins involved in germination metabolism controlling cell regulation, protein movement, transcription and translation were identified.

Iceberg lettuce

- **Protected cultivation:** Iceberg lettuce variety Bruma was evaluated in a naturally ventilated poly house during early summer (March to April 2016) under different spacing and fertilizer levels. The spacing of 37.5 x 30 cm, recorded significantly higher yield of 21.2 t/ha, the fertilizer dose of 120:80:120kg NPK/ha was found optimum.

High Temperature Tolerance Studies

Capsicum

- Five genotypes of capsicum viz., Arka Gaurav, Arka Mohini, PBC 848 and CHT 3-1 CHT3-2 were studied under temperature gradient chambers and controlled environmental conditions. The genotype CHT 3-1 had the higher photosynthetic rate compared to other genotypes under both the conditions. Considerable reduction was observed in pollen germination at higher temperature in all the genotypes. Among the genotypes, higher pollen germination (20%) was observed in PBC 848 at higher temperature (40°C). The total carbohydrate content in flowers was higher in Arka Mohini (14.3 mg/g) and CHT3-1 (10.55 mg/g).

French bean

- The Temperature Induction Response (TIR) technique for evaluation of French bean genotypes using the gradual induction temperatures from 30 to 40°C for 3 h and the challenging temperature of 45°C for 3 h was standardized using cv. Arka Sharat using the per cent seedling survival as an index. Using this standardized TIR technique, ten French bean genotypes were evaluated. Based on the per cent seedling survival and recovery of stressed seedlings, the genotype, IC 525224 x IC 525239 IPS-1 was found to be most tolerant followed by IC 525224 x IC 525239-12 and Arka Anoop.

Garden Pea

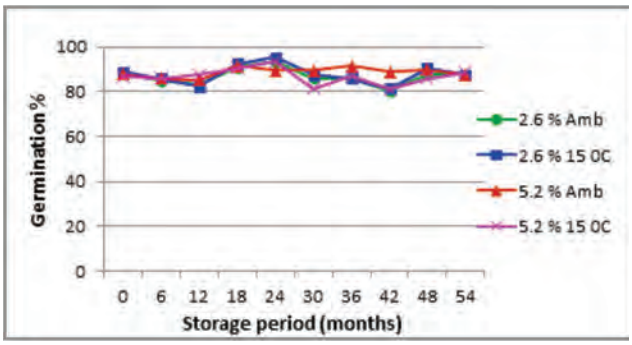
- Fourteen pea genotypes were evaluated under field conditions during summer when the temperature was 35-37 °C during day and 21-23°C during night. Based on the number of filled pods, pod weight and gas exchange characteristics, the genotype 18 x Oregon S-2 was identified as the most tolerant.

Tomato

- Based on physiological parameters viz., relative water content, chlorophyll content, membrane stability index, photosynthesis rate and activities of antioxidative enzymes under poly tunnel conditions , two lines viz., IIHR 2202 and IIHR 4-3-3, and two hybrids viz., IIHR 329 and IIHR 335 of tomato were identified as tolerant to high temperature (40°C).

Onion

- **Seed storage studies:** Onion seeds of cultivars Arka Nikethan and Arka Kalyan with low (2.6 and 2.8%) and high (5.2 and 5.1%) moisture contents, when packed in moisture vapour proof containers and stored at ambient and 15°C, for 54 months retained closer to 90% germination. This shows that onion seeds dried to around 5% moisture levels can be stored under ambient conditions for almost 4 years.



Seed germination as affected by seed moisture and storage temperature over 48 months of storage in onion cv. Arka Nikethan

- **Evaluation of ICAR- IIHR vegetable varieties in the high altitude and rainfall regions of Kodagu region of Karnataka** Among the ten Amaranthus varieties evaluated during the *rabi* season, Arka Suguna recorded the highest leaf yield of 18.9 t/ha. Among the eight brinjal varieties Arka Anand recorded the highest marketable fruit yield of 50.9 t/ha. Among the seven chilli varieties evaluated, Arka Meghana recorded the highest green pod yield of 33.7 t/ha. This variety is highly preferred in the Kodagu region of Karnataka. Among the seven French bean varieties evaluated Arka Sharath (18.3 t/ha) and Arka Anoop (19.5 t/ha) performed well during the *rabi* seasonAmong the eight *Dolichos* varieties evaluated Arka Amogh recorded the highest pod yield of 17.5 t/ha during *rabi* season.

- Exotic high value vegetable crops viz., lettuce, red cabbage, celery, sprouting broccoli, Brussels sprouts, *Asparagus*, cherry tomato, leek, Chinese cabbage, baby corn, sweet corn and zucchini were evaluated during winter season under open conditions. Among the evaluated crops lettuce, sprouting broccoli, red cabbage, chinese cabbage and zucchini were found to perform well in the humid tropics of Kodagu.

3.3.3. Ornamental Crops

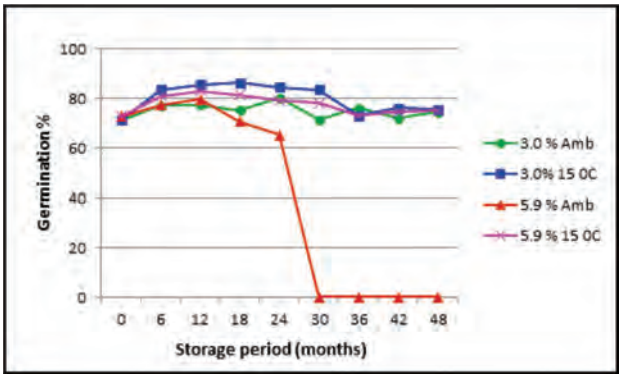
- **Enhancing cut foliage production through cultural interventions**: In leather leaf fern *(Rumohra adiantiformis*), substrate combination of cocopeat +soil+ vermicompost (1:1:1 v/v)+ 2% Arka Microbial Consortium (AMC) along with application of 50% N and K to substrate in 2 equal splits during June and January + 50% as foliar spray at fortnightly intervals @ 100:30:60 kg NPK/ha/year produced maximum number of cut foliage/plant/month (8.45), length of lamina (29.37 cm), length of stipe (25.82 cm), length of frond (54.88 cm), width of frond (20.81 cm) and stipe diameter (3.55 mm).

- Photomorphogenic effect of colour shade nets on leather leaf fern indicated that plants grown under red shade net (light intensity range of 240.50 to 370 µ mol m^{-2} s^{-1}) recorded maximum production of cut foliage /plant/month (6.60), length of lamina (24.90 cm), frond width (17.77 cm) and number of pinnae (10.26). Maximum photosynthesis rate was recorded in plants grown under white shade net (5.25 m moles (CO_2) $m^{-2}s^{-1}$) which was on par with red shade net (4.38m moles (CO_2) $m^{-2}s^{-1}$).

- Plants of *Philodendron* 'xanadu' grown under white shade net (light intensity range of 240.50 to 370 µ mol m^{-2} s^{-1}) recorded maximum production of cut foliage /plant/month (14.53) which was on par with green shade net (13.71). Plants under green shade net recorded maximum length of stalk (25.86 cm) and average width of lamina (5.26 cm). Photosynthesis rate was highest in red (9.96 m moles (CO_2) $m^{-2}s^{-1}$) and was on par with white (9.76m moles (CO_2) $m^{-2}s^{-1}$) and green (9.17 m moles (CO_2) $m^{-2}s^{-1}$) shade nets.

China aster

- **Seed storage studies:** Seeds of China aster cv. Arka Kamini with 3.0% moisture content when packed in moisture vapour impervious container, maintained 75% germination even after 48 months of storage under ambient temperature, whereas seeds with 5.9% moisture content when stored under the same conditions failed to germinate after 30 months of storage. It can be concluded that seeds dried to around 3% moisture can be stored even under ambient conditions for 4 years.



Seed germination as affected by seed moisture and storage temperature over 48 months of storage in china aster cv. Arka Kamini

Gladiolus

- **Effect of BAP on corm multiplication:** Studies on six varieties of IIHR showed that the BAP treatment increased the number of corms while the number of cormels decreased.

3.3.4. Medicinal Crops

- **Standardization of organic farming technology for *Coleus forskohlii*:** Planting at monthly intervals from July to November and harvesting

at 150 and 180 DAP were evaluated in *Coleus forskohlii* variety K 8. September planting combined with harvesting at 180 DAP, produced the maximum dry tuberous root yield (1633.75 kg/ha).The highest total forskolin content (1.673%) was obtained with November planting and harvesting at180 DAP.

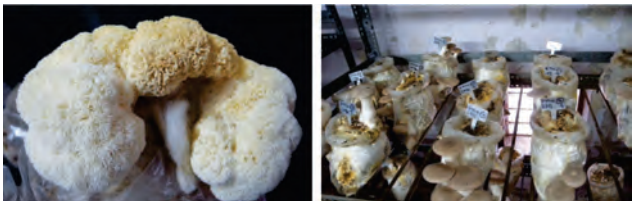
Organically grown Coleus forskohlii

Betelvine

- **Evaluation of standards:** Eight standards viz., gall wasp tolerant *Erythrina subumbrans, Melia dubia, Gliricidia sepium, Sesbania grandifolra, Oroxylum indicum, Moringa oleofera, Ceiba pentandra* and *Grevellia robusta* planted at 3 spacings viz., 1.5 x 1.5 m, 1.5 x 1.0 m and 1.5 x 0.5 m were evaluated in variety Hirehalli Local. *Erythrina subambrans* attained the maximum height of 247.7 cm while *Oroxylum indicum* attained the least height (94.5 cm). The maximum spread was recorded in *Sesbania grandiflora* (151.2 x 137.5 cm) followed by *Oroxylum* (137 x 139.5 cm).
- **Cultivation of betelvine in polyhouse:** Of the eight betelvine varieties evaluated in poly house Maghai pan produced maximum number of leaves/plant (32.8) followed by Godi Bangla and Mysore Chiguru.
- **Soil fertility status in betelvine gardens:** Soil samples collected at two different depths (0-30 and 31-60 cm) from twenty betelvine plantations of Hirehalli, Tumakuru district, were analyzed for their physico-chemical and chemical properties. The soil pH of the betelvine plantations ranged from 7.34 to 7.72. The electrical conductivity (EC) of the surface soil varied from 0.17 to 0.32 dSm^{-1} with a mean value of 0.24 dSm^{-1}. The organic carbon content ranged from 0.78-1.02 per cent with a mean of 0.84 per cent in surface soils (0-30 cm), indicating that the soils were high in organic carbon. Soil analysis up to 60 cm soil depth revealed that betelvine plantations was high in organic carbon, medium in available N, P, K and S, high in exchangeable Ca and Mg, and nearly sufficient in DTPA extractable Fe, Mn, Zn and Cu. All the nutrients were higher in surface than subsurface soils.

3.3.5. Mushroom

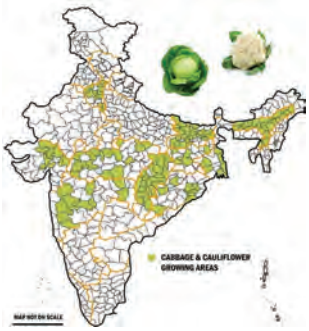
- Three substrate combinations and two strains of *Pleurotus eryngii* (King oyster mushroom) were evaluated. Strain Pe-ERVN performed better on all three substrates. The substrate combination of Arka Fermented Cocopeat (AFC), sawdust, wood chips, rice and wheat bran and the combination of (AFC) with rice and wheat bran recorded higher yield as compared to substrate with only sawdust and wood chips.



New culinary medicinal mushroom Hericium erinaceus and Pleurotus eryngi on different substrates

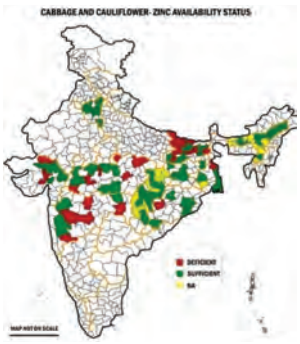
3.3.6. Soil Health Management

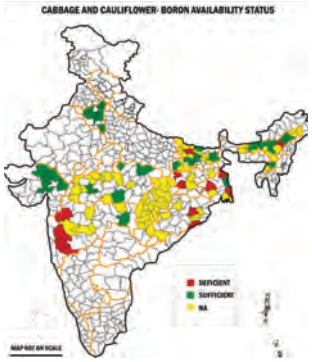
Preparation of boundary maps for cabbage and cauliflower and development of micro nutrient delineation maps

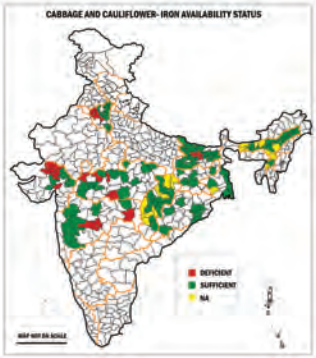


Boundary map of prime cabbage and cauliflower producing states of India

- The national crop boundary map for cabbage and cauliflower was prepared, and superimposed with the information on micronutrients status of soils (district-wise) collected from published reports of AICRP on Micronutrients, ICAR-IISS, Bhopal and different centres of state agricultural universities to obtain the micronutrient delineation maps. One hundred and forty one districts spread



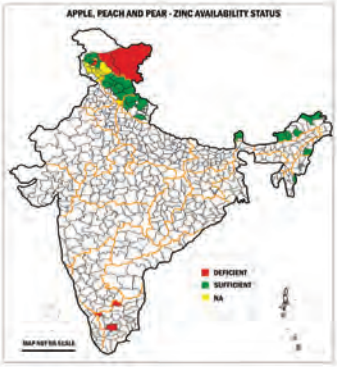




Micronutrient delineation maps for cabbage and cauliflower in India

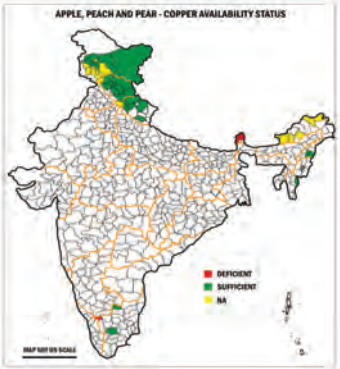
across eleven states were identified as prime cole crop producing districts from 11 states. Fifty eight districts (41%) were found to be deficient in Zinc. The predictable response to Zn application by cabbage and cauliflower was especially high in Gujarat and West Bengal. The soils in twenty three districts spread across Maharashtra and West Bengal, showed zinc deficiency to a tune of 45 to 50%. The extent of boron deficiency in prime cabbage and cauliflower growing areas varied from 22 to 28% in the states of Maharashtra and West Bengal.

❖ **Preparation of boundary maps for apple and development of micronutrient delineation maps:** The national crop boundary map for apple, peach and plum were prepared, along with the micronutrient delineation maps of Zn, Cu, Fe, Mn and Boron. Out of forty nine districts growing these crops, only seven districts viz., Leh, Kargil, Srinagar, Pulwama, Shopian, Krishnagiri, Nilgiris and Dindigul were found to be deficient in available soil zinc. Soils in thirty one districts were observed to be sufficient in zinc. However, information of the available zinc status of 23% of the apple growing districts comprising (11 districts) is not available.



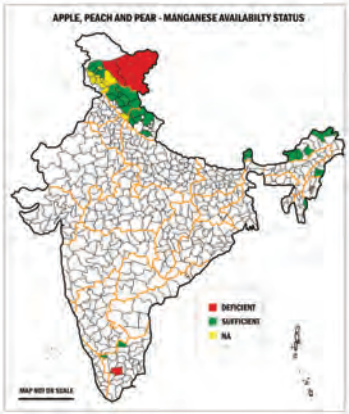
Zinc fertility status of apple, peach and plum growing regions of India

❖ The copper delineation map of three districts viz., North Sikkim, West Sikkim and Nilgiris showed deficiency in the available copper content. Soils in nine districts were observed to be sufficient in copper. However, information on the available copper status of 35% of the apple growing districts comprising 17 districts was not available.



Copper fertility status of apple growing regions of India

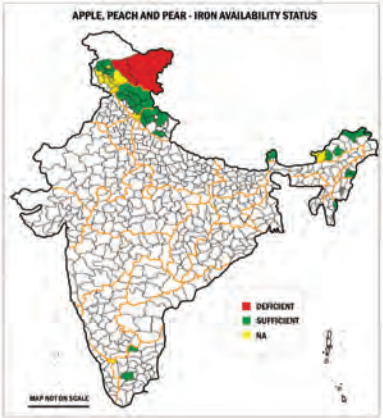
❖ The manganese fertility status of Indian soils showed that three districts viz., Leh, Kargil and



Manganese fertility status of apple growing regions of India

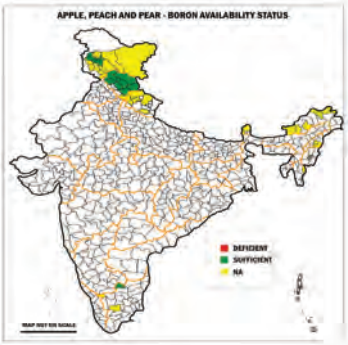
Dindigal in Tamil Nadu are deficient in their available manganese concentrations, while 36 districts are sufficient in manganese. Information on the available manganese status of eleven districts is not available.

- The iron fertility map reveled that three districts viz., Leh, Kargil and Nilgiris were deficient in their available iron status, while 33 districts are sufficient in available iron concentrations. Information on the iron content of thirteen districts us not available.



Iron fertility status of apple growing regions of India

- The boron fertility map revealed that none of the fifteen districts for which data is available showed deficiency in soil available boron. But boron deficiency is very common in orchards indicating that the expression of the deficiency may be more due to imbalance among potassium, calcium and boron rather than the boron content in the soil. The excessive use of nitrogen, potassium, and magnesium, and prevailing deficiency levels of calcium, and zinc predisposes the trees to boron deficiency.

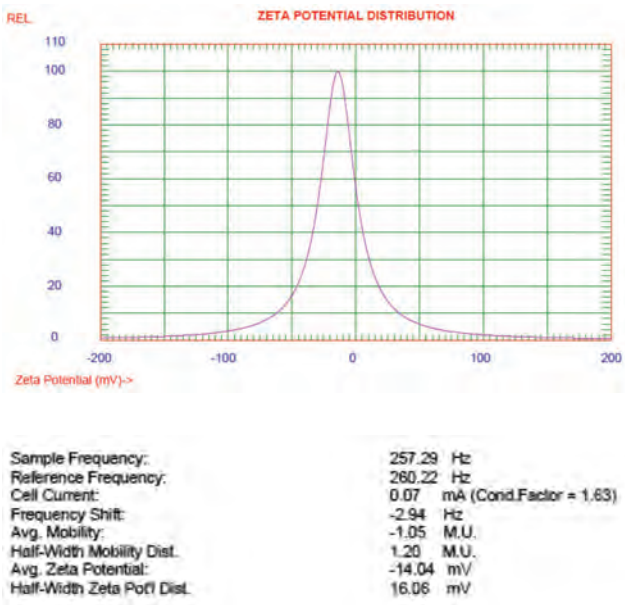


Boron fertility status of apple growing regions of India

- **Evaluation of IIHR Grapes Micronutrient Formulation:** The evaluation of IIHR grapes micronutrient formulation was undertaken through KVK Doddaballapur, Bengaluru on grapes variety Bengaluru Blue. The crop was pruned in July and harvested in November. The results indicated that grapes cultivated in this region responds only to zinc and boron application, while it failed to respond to the foliar application of iron and manganese. Application of the grapes micronutrient formulation improved the yield and TSS.

- **Magnesium requirement of tomato:** Magnesium is emerging as a serious nutritional constraint, which hampers the realization of the potential of the new hybrids of vegetables. Severe deficiency symptoms of Mg appear in the farmers' fields. At many sites the available Mg *per se* is not the yield limiting factor but the rate of Mg flow into the plant at critical growth stages appears to be the yield limiting factor. During first four harvests of tomato the yield levels are so high with the new hybrids like Arka Rakshak, leading to the insufficient rate of absorption of Mg for further fruit development. Hence an experiment was conducted on a soil having high Mg levels (253 ppm) to study the response of tomato to applied Mg in such situations. The results indicated that tomato responds upto 25 kg Mg as $MgSO_4$ per hectare in high Mg soils.

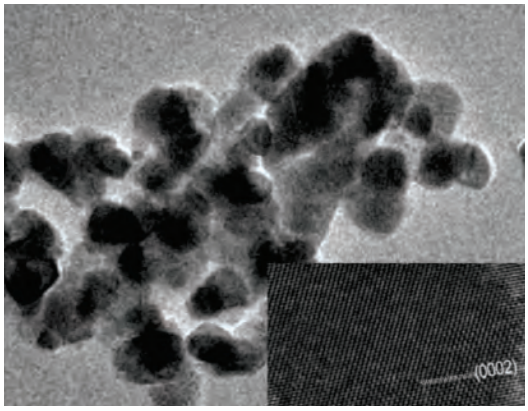
- **Synthesis and characterization of Nano ZnO:** Nanocrystalline zinc oxide was prepared by using the oxalate decomposition technique. Zeta potential measurements made by photo collision



Zeta potential of ZnO Nanoparticles

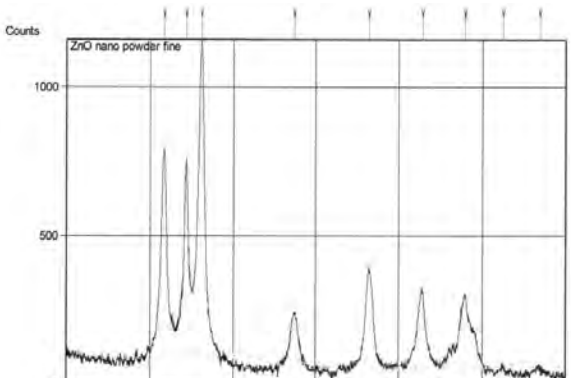
spectroscopy (DLS technique) using laser diffraction analyzer revealed that ZnO nano-particles have zeta potential of -14.04 mV which indicated a high tendency to agglomerate.

- TEM measurements conducted to determine the size, shape, and morphlogy of the ZnO nanoparticles showed a mean particle diameter of 25 nm and were aggregated as there were no protecting ligands on the surface. The particles are crystalline as revealed by the high magnification image and the lattice of ZnO was clearly visible.



TEM image of ZnO nanoparticles. Inset shows the high resolution image of a single particle

- The X-Ray diffraction spectra of the synthesized particles, showed well-defined peaks at 2θ values, which corresponded to the hexagonal phase of ZnO nanoparticles.



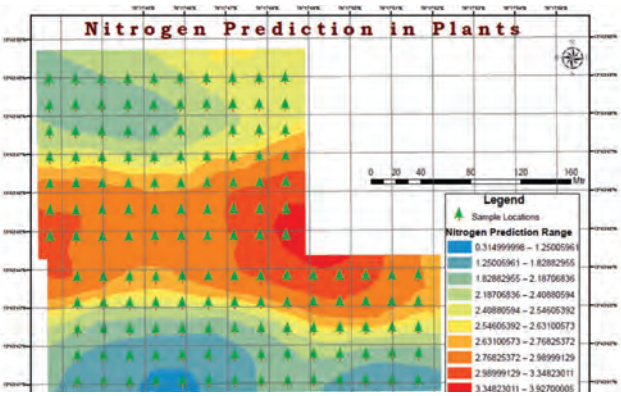
Peak List:

Pos. [°2Th.]	Height [cts]	FWHM [°2Th.]	d-spacing [Å]	Rel. Int. [%]
31.6944	**1023.19**	**0.0100**	**2.82320**	**68.63**
34.3356	**965.60**	**0.3568**	**2.61183**	**64.77**
36.1673	**1490.80**	**0.1007**	**2.48365**	**100.00**
47.4107	298.70	0.1557	1.91759	20.04
56.4213	496.30	0.3990	1.63087	33.29
62.8429	387.10	0.4065	1.47879	25.97
67.8963	373.62	0.5843	1.38051	25.06
72.4264	51.00	0.0900	1.30492	3.42
76.8804	40.00	0.0900	1.24005	2.68

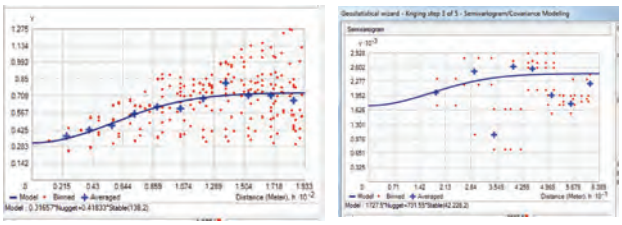
X-Ray Diffraction of ZnO nano particles

- **Effect of ZnO nanoparticles on cabbage and cauliflower:** Foliar application of nano ZnO (150 ppm) recorded significantly higher above ground biomass and root growth in both cabbage and cauliflower at 45 DAP and at harvest. In cauliflower, the chlorophyll and carotenoid contents were significantly increased by application of ZnO nanoparticles at 150 ppm, whereas in cabbage, the application of nano ZnO at 250 ppm concentration recorded the highest chlorophyll content compared to the corresponding $ZnSO_4$ concentration. The yield of cauliflower was highly influenced by nano ZnO application irrespective of concentration used compared to $ZnSO_4$ application, while the yield of cauliflower did not vary with increasing concentraitons of nano ZnO. The uptake of zinc was higher in both cabbage and cauliflower due to the foliar application of nano ZnO.

- **Multivariate foliar chemical composition and nutrient contour maps for developing diagnostic norms for pomegranate:** Intensive grid sampling was carried out in 23 acres of a pomegranate orchard of uniform age. The geo-statistical parameters and semi-variogram models were developed for both essential and nonessential elements in soil and plant. In general the Nitrogen and Potassium concentrations in the plant showed



Nutrient contour map for N in plant



Semi-variogram model for soil and plant N in pomegranate

a poor relationship with their available soil concentrations. Among the non-essential Pb was absent in soil but detectable in plant tissues. A high degree of concurrence was noticed with the As contents in both soil and plant.

- **Effect of additional K (KNO_3) on reducing salinity effect in onion varieties:** Under pot culture conditions additional K application @ 10 ppm improved all the growth parameters of onion varieties Arka Kalyan, Arka Niketan, Arka Bindu and Arka Pragathi grown water salinity levels of *0.6*, 2.5, 5.0 and 7.5 dSm^{-1}. Additional K application reduced leaf and bulb Na contents by 22.4 and 36.7 percent respectively and leaf and bulb Cl contents were reduced by 17.85 to 23.0 percent respectively in the onion varieties studied.

- **Effect of conventional and specialty fertilizers through fertigation in banana, tomato and papaya :** The effect of conventional and specialty fertilizers applied through fertigation on growth/yield parameters, soil/leaf NPK status and nutrient uptake of ratoon crop of banana var. Grand Naine were studied during 2015-2016. The highest number of fingers (143) and finger weight (137.1 g) were recorded with the application of 100% NPK through specialty fertilizers. The soil N, P and K contents increased in 20-40 cm depth, in the treatments where speciality fertilizers were applied. Similar observations were recorded in papaya with the application of 100% recommended dosage of N and K through specialty fertilizers. The depth wise distribution of N, P and K in papaya showed that the contents were higher in 20-40 cm depth. In tomato cv. Arka Rakshak, specialty fertilizer application did not have a significant effect on tomato growth and yield.

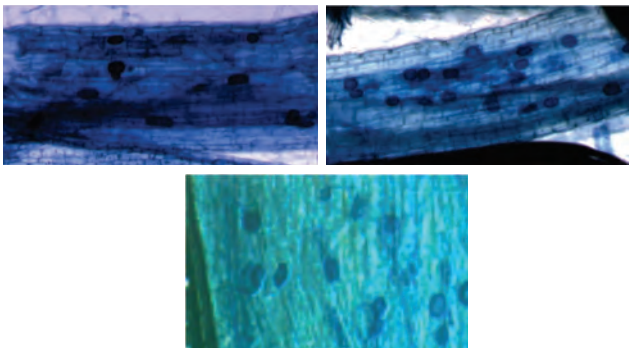
- **Standardization of Production Technology for Soilless Cultivation of Tomato Hybrid Arka Rakshak on Arka Fermented Cocopeat:** The production technology for soilless cultivation of tomato hybrid Arka Rakshak on Arka Fermented Cocopeat under protected conditions has been standardized. The split application of 15:35:15 percent of the recommended NPK (180:120:180 kg NPK/ha), during establishment to early flowering, followed by 12.5:12.5:12.5 percent application during fruit development and 72.5:52.5:72.5 percent application during harvest recorded the highest number of flowers (118.62), number of fruits (80.14) and yield (4.23kg/plant and 93.9t/ha). Nutrient scheduling significantly improved the TSS while other quality parameters were not significantly improved.

- Among the substrates studied, tomato plants raised on Arka Fermented Cocopeat registered maximum plant height (174.25cm), stem diameter (12.44mm), number of branches (27.58), number of flowers (111.04), number of fruits (72.93) and yield (3.94 kg/plant and 87.6t/ha) compared to commercial cocopeat (3.45 kg/plant and 76.7t/ha) and soil (2.62 kg/plant and 58.2 t/ha). The fruit quality was better when tomato plants were grown on Arka Fermented Cocopeat compared to commercial cocopeat and soil.

Vigorous growth of tomato hybrid Arka Rakshak on Arka Fermented Cocopeat under protected conditions

Microbial Interventions for Horticultural Crop Production

- **Standardization of Soilless Arbuscular Mycorrhizal Inoculum Dose for Protray Raised Vegetable Nurseries:** The soilless Arbuscular Mycorrhizal (AM) fungal inoculant technology was developed with the objective of facilitating the production of mycorrhizal colonized seedlings and planting materials. The dose standardization of this inoculant was taken up for protray raised vegetable seedlings and raised bed onion nurseries. A 5% (w/w) dose of the soilless Arbuscular Mycorrhizal (AM) fungal inoculant,



Soiless AM fungal inoculum colonized roots of tomato, brinjal and onion

which comprises mainly of colonized roots of the host plant (maize/ ragi) and the fermented cocopeat used to raise the host plant was found to be sufficient to achieve AM fungal colonization in protray raised seedlings of tomato (62.5%) and brinjal (54%). For onion seedling on raised beds an inoculum dose of 50 g / m^2 recorded AM fungal colonization of 76.5 % compared to the conventional soil based inoculum applied at 100 g / m^2 (67 %) , which indicates a 50 % reduction in the inoculum dose over the conventional mode of inoculation.

- **Standardization of methodology for production of mechanically aerated compost teas:** The methodology for the production of mechanically aerated compost teas was developed. The requirements are powdered, stable ($Q_{4/6}$ ratio below 5.0) and mature compost (free of phytotoxicity as determined by the radish grow out test)-300 g; tap water-20 litre; an aquarium internal filter (costing around Rs.650) and a bucket. The compost is suspended in water and the suspension is aerated daily for five days for one hour in the morning and evening. At the end of the five day period the mechanically aerated compost tea recorded a pH of 7.0 to 7.2 and EC ranging from 1.0 to 1.2. The mechanically aerated compost tea improved the radish seed germination by 87.6 % over water control and by 50.9 % over manually aerated compost tea. Phytotoxic effects were not observed in radish seeds germinated in the presence of undiluted mechanically aerated compost teas. After filtration the mechanically aerated compost tea can be diluted (1:10 v/v), with tap water and applied to protray raised vegetable nurseries for enhancing seed germination and seedling growth.

3.3.7 Pesticide residue studies in fruits and related environment

- **Residue studies of Azoxystrobin, Carbendazim, Difenoconazole and Pyraclostrobin on banana:** Azoxystrobin (250 SC) residues on banana whole fruit were 0.372 and 0.573 mg/kg from treatment 0.5 & 1.0 mL/L. The residues dissipated slowly and remained on the fruits upto 35 days from standard dose treatment and 45 days from double dose treatment. At the standard dose azoxystrobin residues were detected in pulp on the 1st day whereas at double dose residues were detected in pulp on 1st and 5th day only. The residues in the banana whole fruit degraded with the half-life of 8.5 and 12.2 days, respectively. The pre-harvest interval calculated based on the persistence study and maximum residue limit (MRL) of 2 mg/kg was 1 day for both treatments. Residues of azoxystrobin were not detected in field soil. Carbendazim (50 WP) residues on banana whole fruit were 1.164 and 1.843 mg/kg from treatment at 1 and 2 g/L. The residues dissipated slowly and remained on the banana fruits upto 45 days from both treatments. A small amount of residues remained in banana pulp upto 20 and 25 days, but it was always below MRL. The residues in the banana whole fruit degraded with the half-life of 14 days from both treatments. The pre-harvest interval calculated based on the persistence study and maximum residue limit (MRL) of 0.1 mg/kg was 49 and 61 days for standard and double dose treatments. Difenoconazole (25 EC) Difenoconazole residues on the banana whole fruit were 0.454 and 0.776 mg/kg from treatment at 0.5 & 1.0 mL/L. The residues dissipated slowly and remained on the fruits upto 35 days from standard dose treatment and 45 days from double dose treatment. In fruit pulp the residues remained upto 25 and 35 days, but it was below MRL. The residues in the banana whole fruit degraded with the half-life of 11.6 and 13.5 days, respectively. The pre-harvest interval calculated based on the persistence study and maximum residue limit (MRL) of 0.1 mg/kg (EU) was 24 and 38 days for treatments at standard and double doses, respectively. Pyraclostrobin (20 WG) residues on the banana whole fruit were 0.345 and 0.552 mg/kg from treatment at of 1 and 2 g/L. The residues dissipated slowly and remained on the fruits upto 30 days from standard dose treatment and 35 days from double dose treatment. In fruit pulp pyraclostrobin residues were not detected. The residues in the banana whole fruit degraded with the half-life of 9.9 and 10.8 days, respectively. The pre-harvest interval calculated based on the persistence study and maximum residue limit (MRL) of 0.02 mg/kg was 40.5 and 52 days.

- **Residue study of difenoconazole and thiamethoxam on mango:** Difenoconazole (25 EC) residues on the mango whole fruit were 0.206 and 0.456 mg/kg from treatment at 0.5 and 1 g/L. The residues remained on mango fruits upto 25 days from standard dose treatment and 30 days from double dose treatment. In fruit pulp the residues were not detected. The residues in the mango whole fruit degraded with a half-life of 11.1 days. The pre-harvest interval calculated

based on the persistence study and maximum residue limit (MRL) of 0.1 mg/kg was 12 and 24 days. Thiamethoxam (25 WG) residues on the mango whole fruit were 0.141 and 0.370 mg/kg from treatment at 0.25 and 0.5 g/L. The residues remained on the fruits upto 25 days from standard dose treatment and 30 days from double dose treatment. In fruit pulp, thiamethoxam residues were not detected. The residues in the mango whole fruit degraded with the half-life of 7.8 and 9.9 days. The pre-harvest interval calculated based on the persistence study and maximum residue limit (MRL) of 0.5 mg/kg was 1 day for both treatments.

- **Residue study of captan and chlorothalonil on pomegranate:** Captan (50 WP) residues of captan were 3.084 and 5.928 mg/kg from treatment at 1 and 2 g/L. The residues dissipated slowly and remained for 40 days from recommended and 60 days from double dose treatments. The residues dissipated at the half-life of 7.3 and 9.0 days. The pre-harvest intervals based on the MRL of 0.02 mg/kg were 53.0 and 74.5 days, respectively. The edible aril was free from captan residues. Chlorothalonil (75 WP) residues were 2.53 and 4.32 mg/kg from treatment at 2 and 4 g/L. The residues dissipated slowly and remained for 40 days from recommended and 60 days from double dose treatments. The residues dissipated at the half-life of 7.4 and 9.8 days. The pre-harvest intervals based on the MRL of 0.01 mg/kg were 60.5 and 87.0 days, respectively. The edible aril was free from chlorothalonil residues.

- **Residue studies on high value vegetables under protected conditions:** Zucchini (green and yellow varieties) were grown in polyhouse. Imidacloprid, acetamiprid, profenofos and fenazaquin were applied on the crop during fruit setting stage as foliar spray. The first three are used to control aphids in zuchhini while fenazaquin is a relatively new acaricide for control of mites. Profenofos is also used for control of pumpkin fruit fly. All pesticides were sprayed twice at 15 day's interval during fruit formation stage. Residues of the pesticides were analysed on the fruit at various intervals by LC-MS/MS. Residues of imidacloprid in zucchini dissipated with a half life of 1.5 to 2.0 days in green and yellow varieties respectively. Recommended pre-harvest interval was 2.9 and 3.5 days. Similarly the half-lives for acetamiprid ranged from 1.1 to 1.6 days. The insecticide persisted for 10 days in both the varieties and the pre-harvest intervals were 3.4 and 4.3 days, in the two varieties respectively. Profenofos residues dissipated with a half-life of 1.9 to 2.0 days. The pre-harvest intervals were 15.7 and 16.7 days. Foliar application of fenazaquin resulted in residues dissipating with half lives of 1.3 days in both varieties and pre-harvest intervals recommended based on MRL of 0.2 mg/kg (EU) were 4.0 days before harvest of the fruits. Persistence of pesticides in yellow variety of zuchhini was found to be only marginally higher than that in green variety. Broccoli grown in polyhouse was treated with imidacloprid (for control of aphids), carbendazim against black leg disease, fipronil and chlorantranilipreole for control of DBM on the crop during head formation stage as foliar spray. Residues of the pesticides were analysed on the florets at various intervals. Residues of imidacloprid in broccoli dissipated with a half life of 3.9 days and based on the MRL (EU) of 0.5 mg/kg the pre-harvest interval recommended was 7.6 days. Similarly, carbendazim, fipronil and chlorantranilipreole residues were found to dissipate with half lives of 3.9, 4.3 and 4.7 days respectively and the recommended waiting periods were 18.6, 35.0 and 17.7 days respectively based on EU MRLs 0.1, 0.01 and 0.3 mg/kg. Fipronil sulfone, a toxic metabolite of fipronil was also detected in trace levels for 20 days after last application of fipronil. All residues were detected till 25 to 30 days after last application

- **Plant extracts for dislodging of surface residues of pesticides from vegetables:** Extracts from four plants (identity not revealed) were used for washing vegetables (tomato, cucumber, chilli and brinjal) spiked with different pesticides. The per cent dissipation of pesticide residues was compared with washing with running water and washing with a commercially available wash solution. Dislodging of different surface pesticide residues of vegetables was at par or higher when plant extracts were used as compared to running water or washing with the commercial wash solution. One plant extract was able to dislodge 38 to 96% of residues of pesticides from vegetables. Further experiments are in progress.

3.4. Crop protection

3.4.1. Fruit Crops

Mango

- **Pest management:** Evaluation of 24 varieties and hybrids of mango revealed that the damage due to leaf webber, *Orthaga euadrusalis* was 1.5 to 15.3% of canopy area in PKM-1. The damage by panicle webber was 21.2% in Pusa Surya. Damage by inflorescence midge (*Procantarinia* sp.) ranged from 21.2 to 72.3%. Amrapali and Mallika sustained flower bud damage upto about 50 per cent. Fruit set was also found affected by the pest. The mango inflorescence midge was recorded in West Bengal, Orissa and Jharkhand consecutively for the fourth year indicating that the pest has established in the region.

- Summer ploughing with soil application of chlorpyriphos dust @ 10 kg/ha followed by spray of carbosulfan @ 2 ml/L at bud burst stage resulted in the lowest infestation and highest fruit set compared to control and all the treatments.

- **Mango blackening:** Smudgy blemishes or surface blackening on late maturing mango varieties was recorded in Odisha. This melanised fungal growth on fruits which appears at maturity after rains reduces the visual appeal. Field studies showed that the fungus colonises the wax layer of fruits and is not removed by simple washing with water. In addition, symptoms due to the mycelial growth of this fungus on the waxy layer was different from sooty mould. Dipping of blackened mango fruits for 15 minutes in a combination product solution being developed at CHES, Bhubaneswar removed the blemishes without injury to peel.

Before treatment

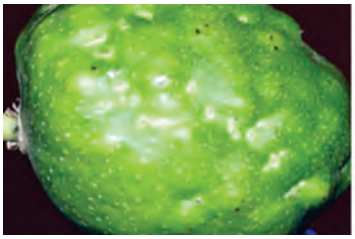
After treatment

Growth of sooty mould fungi due to mealy bug infestation

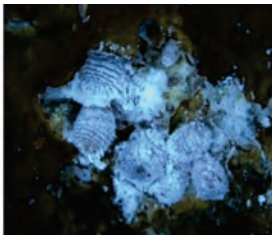
Surface blackening due to colonization of fungi on waxy layer of fruit

- **Mango-disease surveillance:** The incidence of anthracnose due to *Colletotrichum gloeosporioides* was high in all districts of Karnataka with a maximum (47%) in Bengaluru and minimum in Mysore (22%). Other diseases viz., leaf blight (24%), die back (48%), sooty mold (48%), anthracnose fruit rot (46%), stem end rot (44%) and malformation (18%) were also higher in Bengaluru district. Black band (52%) was most serious in Tumkur district followed by Bengaluru (48%) while Kolar and Chitradurga recorded lower severity (40%).The severity of blight was lower in Mysore and Tumakuru districts (18%) while die back (24%) and anthracnose fruit rot (32%) were lower in Mysore. Malfomation was least (12%) in Kolar district.

- **Mango-pest surveillance:** Surveillance studies indicated that thrips (*Scirtothrips dorsalis*), gall midge (*Procantarinia* sp), mite, (*Olygonychus mangifera*) and root mealybug (*Formicococcus mangiferacola*) are the emerging pests in mango. Among leafhoppers, *Idioscopus nitidulus* was the most dominant species (91%) while the incidence of *I. nagpuriensis* (7%) and *Amritodus atkinsoni* (2%) were low. The incidence of leafhoppers on Alphonso ranged from 5-18% in Karnataka, 8-12% in Tamil Nadu and 5-10% in Chittoor District of Andhra Pradesh. Mango stem borer, *Batocera rufomaculata* was severe in closely spaced orchards that were more than 15 years old.



Gall midge (unidentified sp.)



Mealybug infestation on roots infested fruit

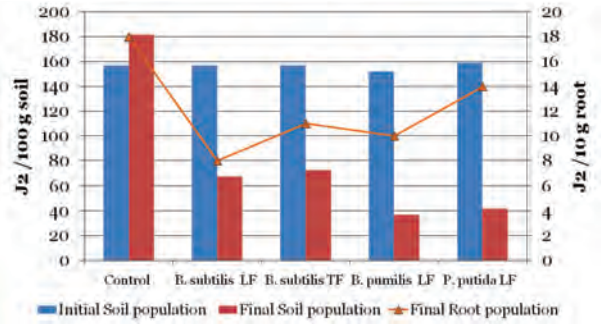
- **Management of mango hoppers and thrips**: Entomopathogens, azadirachtin and insecticides were evaluated for the management of leafhoppers, *Idioscopus* sp. and thrips (*Scirtothrips dorsalis*) on mango. Four sprays of *Metarhizium anisopliae* oil formulation @ 0.5ml/L at weekly interval reduced the hopper incidence by 82.1% which was on par with two applications of imidacloprid @ 0.25ml/L. This formulation resulted in 71.20% reduction in thrips population. Azadirachtin (1%) effected a moderate reduction.

Banana

❖ **Report on occurrence of blast/pitting disease of banana in Eastern India:** Isolated occurrence of blast/pitting of fruits in banana in cv. Grand Naine was observed in Bhubaneswar, Orissa. Spindle shape spots were observed on leaves, mid-rib and petiole. Pathogenicity of the isolated culture was confirmed by inoculation and reisolation. Amplification of the DNA region between ITS1 and ITS4 with the universal primer pair ITS 1 and ITS 4 showed similarity with *P. angulata* Hashioka (GU066873, AY265322, JF719830) reported to occur on banana from other countries.

Pitting of banana

❖ **Management of *Radopholus similis* on banana:** Biopesticide formulations, *Bacillus subtilis* (1% A.S), *Bacillus subtilis* (1% W.P), *Bacillus pumilus* (1% A.S) and *Pseudomonas putida* (1% A.S) were effective in controlling *Radopholus* in banana. In six years, population density of burrowing nematode was reduced significantly in all the treatments. The root population density of *R. similis* was recorded as 18, 8, 11, 10 , 14 J_2 /10 g root, in control, *B. subtilis* – 1% A.S., *B. subtilis* – 1% W.P., *B. pumilus* – 1% A.S. and *P. putida*– 1% A.S treated plots respectively.



Effect of bio-pesticides on the management of Radopholus on banana

❖ **Bioagents for nematode management in tissue cultured banana plants, pomegranate and guava rootstocks**: Bioagent strains of *Trichoderma harzianum*, *Paecilomyces lilacinus*, *Pseudomonas fluorescens*, *Pseudomonas putida*, *Bacillus subtilis*, *Bacillus pumilus*, *Bacillus amyloliquefaciens*, *Bacillus megaterium* were effective in enhancing plant growth promotion with reduced *Meloidogyne incognita* infestation in tissue cultured banana plants, pomegranate and guava root stocks.

Bacillus subtilis treated

Control

Effect of bioagent treatment on pomegranate rootstocks

Control

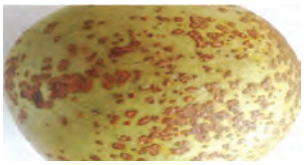
Bacillus subtilis treated

❖ **Banana scarring beetle incidence:** Periodical survey revealed that banana scarring beetle *Nodostoma subcostatum* (Jacoby) is a key pest in Bhubaneswar. The highest population and damage were recorded in rainy season, though populations were recorded in other months too.

Damage by scaring beetle

Bael

❖ **Occurrence of bael fruit canker in Odisha:** Incidence of bacterial canker caused by *Xanthomonas campestris* pv. *bilvae* was recorded on fruits upto 15%.



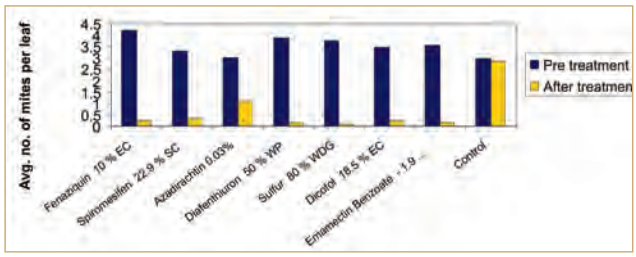
Canker on bael fruit

Incidence of sooty blotch (moldy growth) on bael fruit was recorded and the fruit-bearing bael accessions were affected by the disease. Among these CHBL-9 had the least incidence (50%).

- *Cryptophelbia* infestation was recorded on bael and tamarind consecutively for third year.

Citrus

- **Management of mites on citrus:** Treatment with acaricides viz., fenaziquin 10% EC, spiromecifin 22.9%SC, azadirachtin 0.03%, diafenthiuron 50%WP, sulfur 80%WDG, dicofol 18.5% EC, and emamectin benzoate 1.9EC were effective for the management of red spider mite. Among the treatments, sulfur @ 2g/l was significantly better over other acaricides.



Efficacy of newer acaricides against red spider mite

Papaya

- **Integrated management of PRSV :** IDM comprising border cropping with castor and Sesbania, silver mulching and spraying of neem oil and micronutrients significantly reduced the spread (0.5 to 1.0 %) of papaya ring spot virus and increased the yield of papaya (20%).

Pomegranate

- **New Pest Records:** Severe incidence of tea mosquito bug, *Helopeltis antonii* was recorded on pomegranate, in Bengaluru. The new flush presented a burnt appearance following congregation and sucking of sap by the nymphs and adults of the pest. About 59% of the foliage was affected. Another pest recorded was a nectar robbing purple sunbird, *Nectarinia asiatica* in the commercial orchards around Hosadurga area of Karnataka, which damaged flowers, leading to flower drop and poor fruit set.

Tea mosquito bug infestation on pomegranate

Pomegranate flowers damaged by purple sunbird

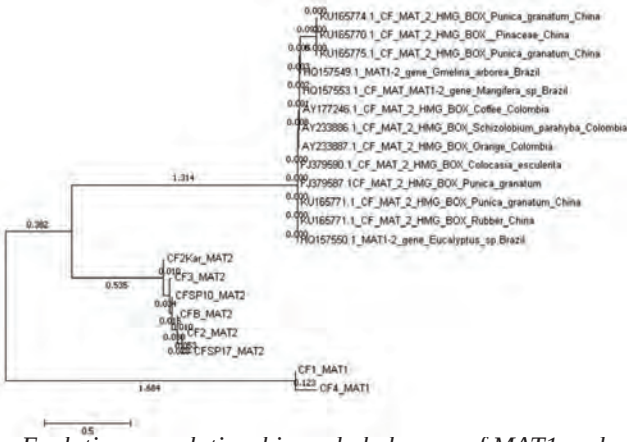
- **Management of bacterial nodal blight:** Of the 29 botanicals investigated *in vitro* for the antibacterial activity against *Xanthomonas axonopodis* pv. *punicae*, the causal agent of bacterial blight of pomegranate, six botanicals were promising. Clove and x-plant (identity withheld) gave the maximum inhibition zone (60 mm) followed by garlic (30 mm), henna and betel (20mm). Water extract recorded the highest inhibitory zone of 34.7 mm dia followed by ethanol extract (18 mm), methanol (10.3 mm) and acetone extract (9.0 mm).

- **Effect of soil type on the survival of pomegranate wilt pathogen *Ceratocystis fimbriata*:** Three types of soils with varying silt, clay and loam contents were tested with two isolates of the pathogen (CfSP10 and CfB). Both isolates could survive beyond one year in the soils where the clay content was higher (31 and 57%) and loam was less (11 and 17%) while in soil with more loam (51%) and less clay content (11%), the pathogen survived upto 11 months only. This indicated that red soil with sandy loam texture may be recommended for filling of pits in case of new plantings and in places where replanting is to be carried out after removal of the dead plants.

- **Occurrence of both mating types of *Ceratocystis fimbriata* (MAT1 and MAT2), causal agent of pomegranate wilt in India:** Out of 8 isolates collected from Karnataka and Maharashtra, two belonged to MAT1 and six belonged to MAT 2 type. Phylogentic analysis based on sequence homology revealed that the isolates belonging to two mating types were different from those reported on different crops including pomegranate from other countries.

Recovery of *C. fimbriata* colonies of two isolates (CFB and CFSP10) from different soil types after 12 months (No. of colonies at 10^{-2} dilution)

Soil type (clay:silt:sand)	CF- B		CFSP10	
	Conidia	Perithecia	Conidia	Perithecia
Soil 1 CFSP5(57:32:11)	27	105	7	100
Soil 2 CFSP8(31:52:17)	4	21	14	1
Soil 3 CFSP7(11:38:51)	1	0	0	0



Evolutionary relationship and phylogeny of MAT1 and MAT2 isolates from India compared to other isolates, sequences of which were retrieved from NCBI

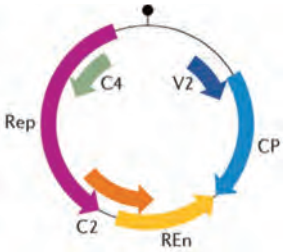
3.4.2. Vegetable Crops

❖ **Survey for incidence of virus diseases in vegetable crops**: Survey conducted in Anantapur and Guntur (AP), Indore (Madhya Pradesh) and Davanagere, Haveri and Raichur (Karnataka), showed an incidence of 53.7 to 100% chilli leaf curl virus, 11.5 to 23.5 % cucumber mosaic virus, 7.5 to 21.5 % chilli veinal mottle virus, and 2.5 to 15.7% groundnut bud necrosis virus.

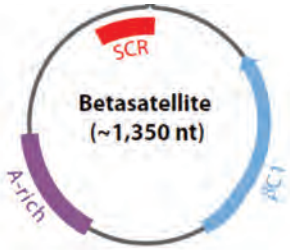
Chilli

❖ **Molecular characterization of begomo viruses and associated satellites infecting chilli:** Studies showed that at least three begomo viruses are associated with chilli leaf curl disease, which included chilli leaf curl virus (ChiLCV), Tomato leaf curl New Delhi virus (ToLCNDV) and Tomato leaf curl Joydevpur virus (ToLCJV), 42 β-satellite and 34 α-satellite isolates associated with chilli leaf curl disease were molecularly characterized and complete genome sequence was determined. Based on PASC analysis, at least five β-satellites and eight α-satellite species were found associated with ChLCD i.e., Ageratum conyzoides symtomless α-satellite, Chilli leaf curl,

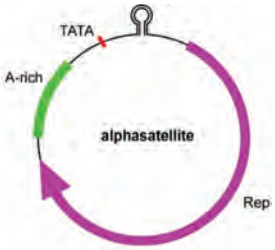
Chilli leaf curl disease



genome organization of ChLCV



Genome organization of β-satellite DNA.



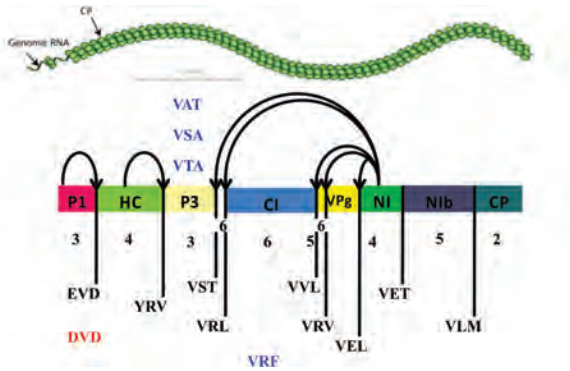
α- satellite DNA

Mesta yellow vein mosaic α-satellite, nanovirus-like α-satellite, Tomato leaf curl α-satellite and a new α-satellite species.

Beans and Cowpea

❖ **Molecular characterization of potyviruses**: Bean common mosaic virus (BCMV) which belongs to the potyvirus group infecting beans and cowpea was molecularly characterized and complete genome sequence of Bengaluru and Coimbatore isolates were determined. The 5′UTR of the genome was comparable to other BCMV isolates and potyviruses (75 to 213 nucleotides). The polyprotein showed 91.5% nucleotide identities and 95.0% amino acid similarity with BCMV.DXHo16 infecting soybean in China (KJ807806). The isolate from USA infecting bean BCMV.RU1M (KJ645793) had least nucleotide identity of 79.4% and amino acid identity of 82.0%. Phylogenetic analysis based

on genome sequences showed that the 57 BCMV strains/isolates mainly clustered into five highly supported clades. BCMV isolates collected from soybean plants from China formed an independent clade, which is phylogenetically distant from other strains or isolates. The ICAR-IIHR cowpea isolate of BCMV clustered along with this group as an independent sub group. It was clear that variations in amino acids may be attributed to this diversity. It is intriguing to postulate that these BCMV strains have evolved with an ability to efficiently infect soybean.



Genome organization of Bean common mosaic virus infecting beans and Cowpea

❖ **Diagnosis and molecular characterization of Phytoplasma infecting vegetable crops**: The causal agent of phyllody and witches broom in *Amaranthus* plants was identified as a new phytoplasma species, based on 16S rRNA genome sequence, with close relationship to 16SrII group of phytoplasmas.

Okra

❖ **Nematode management:** Seed treatment of okra with *Bacillus pumilus* 1% A.S @ 10ml/kg and application of 5 tons of FYM enriched with *B. pumilus* @ 5 l/ha recorded the maximum reduction (63.1%) of *M. incognita* population and higher yield (25.5%) on par with seed treatment with *P. putida* 1% A.S @ 10ml/kg seed and application of 5 tons of FYM enriched with *P. putida* @ 5 l/ha in reducing the nematode population (61.0%) and increasing the yield (24.8%).

Capsicum

❖ **Screening of capsicum germplasm for root knot nematode resistance:** Out of 200 lines screened, 21 lines were highly resistant, 13 resistant and 42 moderately resistant to root knot nematode, *Meloidogyne incognita*.

Capsicum germplasm screening for root knot nematode resistance

Tomato

❖ **Nematode management:** Substrate treatment with *B. subtilis* or *B. amyloliquefaciens* @ 5 ml/kg cocopeat in protrays and soil application of 5 tons of FYM/2 ton of vermicompost enriched with either of the above @ 5 l /ha recorded significantly higher yield over control (29.4%) and lower nematode population (64.4% decrease over control) in soil and roots of tomato comparable with the chemical nematicide, carbofuran.

Screening of tomato and brinjal germplasm/ varieties for resistance to root knot nematodes.

Germplasm/ Varieties	Gall index	Reaction
Black beauty	3.5	S
S. incannum	3.5	S
S. indicum	2.5	MR
S. gilo	4.0	S
S. ethiopicum	3.0	MR
S. macrocarpum	2.0	R
S. nigrum	4.0	S
S. mammossum	4.5	HS
S. vierum	4.0	S
S. gilo	4.0	S
Arka Samrat	4.5	HS
Arka Ananya	4.0	S
Arka Sheel	4.0	S
Arka Nidhi	4.0	S
Arka Keshav	4.0	S
Arka Kusumkar	4.0	S
Arka Neelkant	4.0	S
Arka Anand	4.0	S
Arka Sirish	4.0	S

Gall index was rated 0 (Immune reaction); 1 (Highly resistant = HR); 2 (Resistant = R); 3 (Moderately resistant = MR); 4 (Susceptible= S) and 5 (Highly susceptible = HS)

Brinjal

- **Screening for bacterial wilt tolerance:** Among 49 brinjal lines tested, CHBR-3, CHBR-35 and CHBR-6 were tolerant to bacterial wilt caused by *Ralstonia solanacearum*. Preliminary screening of 120 lines for resistance to leaf curl and anthracnose diseases showed zero anthracnose incidence in CHHP 102, CHHP 103 and CHHP 8 while lines CHHP 118, CHHP 110 and CHHP6 were free from viral disease.
- **Resistance to root knot nematodes:** Among the 19 brinjal germplasms/varieties screened, *S. macrocarpum* showed resistant reaction, while *S. ethiopicum* and *S. indicum* showed a moderately resistant reaction to root knot nematodes.

Screening of tomato and brinjal germplasm/ varieties for resistance to root knot nematode.

Gherkins

- Under field conditions, consortia formulation of *B. subtilis* and *T. viride* recorded maximum reduction of nematode population (70.9%) and increase of yield (32.1%).

Teasel gourd/spine gourd

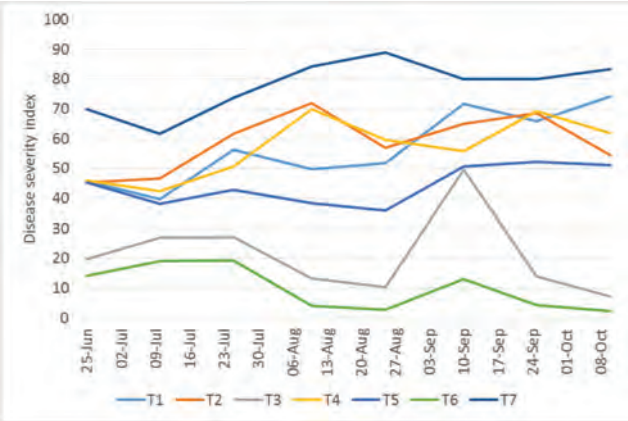
- Out of 80 teasel gourd germplasms accessions screened for downy mildew incidence, 10 showed 10-20% incidence, 16 had about 20% incidence and the rest 54 had more than 30% incidence. Out of 7 germplasm of *Solena amplexicaulis*, one showed tolerance to downy mildew disease. The inter-specific hybrids of dioecious *Momordica* species were screened against downy mildew. Arka Neelachal Shanti recorded 14%, BC3F1 11%, BC2F1 21% and BC1F1 18% downy mildew incidence. *Momordica* hybrid screened for the presence of viral disease showed that 59 were disease-free while the remaining were affected by the virus. None of the plants achieved highest scale of infection resulting in distortion of plants.
- **Evaluation of bioagents in vegetables:** Among the three formulations evaluated in field conditions on chilli, brinjal and tomato, isolate 1 (*B. borstelensis*) induced higher speed of germination in all three crops. Isolate AN15 *(B. subtilis*) gave higher plant biomass, seedling growth and yield per plant , while all three isolates reduced the incidence of bacterial wilt compared to control plots for all three crops.

3.4.3. Ornamental Crops

Rose

- **Evaluation of selected fungicides against black spot of rose caused by *Diplocarpon rosae:*** Spraying of trifloxystrobin and tebuconazole (combination product) at 0.1% at 15 days interval was effective for the field management of rose black spot caused by *Diplocarpon rosae* with a PDI ranging from 2-19 while in control it reached 88 PDI. Disease severity was 4.2% as against 88.0% in control in which defoliation was complete and flower production was reduced by 90%. Propiconazole was the next best fungicide with the PDI ranging from 10 - 48.

Evaluation of selected fungicides against black spot of rose caused by Diplocarpon rosae



T1-Mancozeb (0.1%), T2-Carbendazim (0.1%), T3-Propiconazole (0.1%), T4-Azoxystrobin (0.1%), T5-Kresoxin Methyl (0.1%), T6-Trifloxystrobin+tebuconazole (0.1%), T7-Control.

Evaluation of fungicides for the management of black spot of rose.

Evaluation of fungicides for the management of black spot of rose

Treatments	Disease severity	No of leaves per plant	Flower yield in g
Mancozeb (0.1%)	66.00[d]	304[b]	458[a]
Carbendazim (0.1%)	68.67[d]	394[b]	560[b]
Propiconazole (0.1%)	14.00[b]	2573[c]	2817[e]
Azoxystrobin (0.1%)	69.33[d]	642[c]	780[c]
KresoximMethyl(0.1%)	52.22[c]	1275[d]	2235[d]
Trifloxystrobin (0.1%)	4.22[a]	3417[e]	5233[f]
Control	80.00[e]	156[a]	483[a]

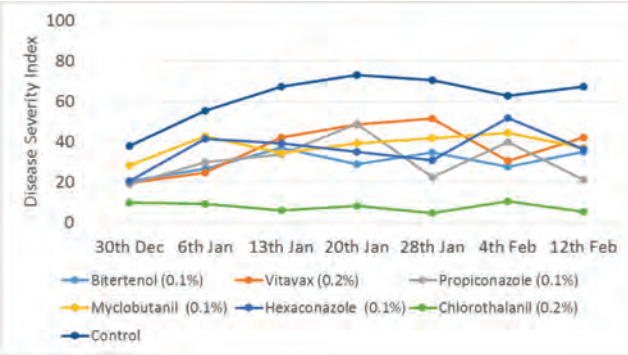
Chrysanthemum

❖ **Rust management:** The marigold type of chrysanthemum locally called as marigold type chrysanthemum is highly susceptible to rust caused by *Puccinia horiana*. In recent years, this disease is becoming a serious concern for the chrysanthemum farmers. The evaluation of fungicides under field condition showed that use of chlorothalonil at 0.2% from first pustule formation at 15 days interval kept the disease severity under control (less than 10 PDI) while in untreated plots the severity increased to 78.8 PDI. The yield was higher in chlorothalonil treated plot compared to control.

Effect of fungicides on the flower yield of chrysanthemum rust affected plants

Treatment	No of flowers*
Bitertenol (0/1%)	3519[b]
Vitavax (0.1%)	3382[b]
Propiconazole (0.1%)	4587[cd]
Myclobutanil (0.1%)	3289[b]
Hexaconazole(0.1%)	4199[c]
Chlorothalanil (0.2%)	4737[d]
Control	2961[a]

*cumulative of 10 harvests, 10 plants per plot



Effect of fungicides used for the management of chrysanthemum rust on the disease severity

Gerbera

❖ **Mass production of the parasitoid, *Encarsia transvena* for the management of whiteflies in polyhouse:** Production of *Encarsia* on three host plants were evaluated in polyhouse and net cages. Insect production rates differed in three host plants over four cropping periods (June – February) with tomato and tobacco being the better host plants (F range= 0.10- 22.10; df= 2, 27; p values range= 0.001- 0.75), confirming the trend observed last year (F range=0.124 - 9.00; df= 2, 27; p values range= 0.001- 0.967).The parasitization efficiency of *Encarsia* was 20.0 % on tobacco, 15.7 % on tomato and 13.6 % on brinjal under polyhouse condition.

Tuberose

❖ *B. subtilis* applied as bulb treatment and as soil application in the form of vermicompost (5 t/ha) enriched with *B. subtilis* (5 kg) recorded the lowest gall index (1.0) and highest yield of flower (2.7 kg) and bulb (9.4 kg) per plot.

Bio-efficacy of liquid formulations of biopesticides in the management of *Meloidogyne incognita* infecting tuberose

Treatment	Root Length (cm)	Shoot Length (cm)	Root Weight (g)	Shoot Weight (g)	Flower yield (Kg)/plot	Bulb yield(Kg) /plot	Total no. of flowers /plot	Total no. of bulbs / plot	Gall index
T1	19.00	46.00	396.30	62.20	2.21	6.97	2.33	249	1.2
T2	21.00	49.33	411.13	67.13	2.53	8.18	2.57	302	1.1
T3	27.67	54.67	630.40	86.27	2.70	9.36	2.73	317	1.0
T4	17.33	39.00	300.73	46.60	1.90	5.94	1.88	296	1.5
T5	19.67	47.67	439.23	58.00	2.41	7.58	2.8	260	1.1
T6	15.67	28.33	176.47	33.07	1.75	3.61	1.87	205	2.5
CD@5%	4.47	10.42	11.54	10.64	0.07	1.95	1.76	16.1	0.57

T1 – bulb treatment – *B. subtilis* 10 g /l; T2 – T1 + application of 2.5 t of vermicompost enriched with 2.5 kg *b. subtilis;* T3 – T1 + application of 5 t of vermicompost enriched with 5 kg *B. subtilis;* T4 - application of 5 t of vermicompost; T5- carbofuran (1 kg a.i./ha); T6 – control

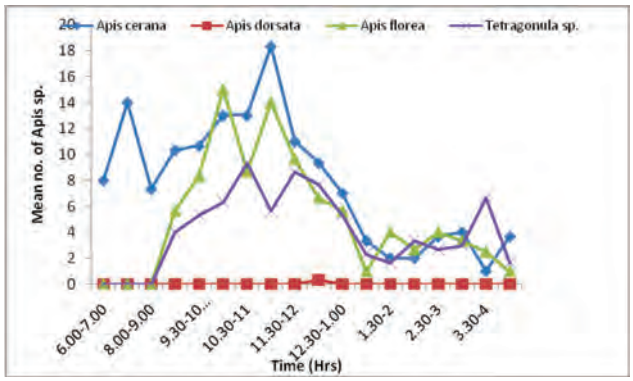
3.4.4. Molecular entomology

- Mitochondrial cytochrome oxidase-I (COI) from five species were sequenced and the comparison of the triplicate sequences for respective mango leaf hopper species showed no mismatches. Sequence analysis revealed that 69 characters were variable and 74 characters were parsimony informative. No nuclear copies were amplified as indicated by the absence of stop codons within the sequences and the base composition was almost similar with no indels. All sequences generated in this study were deposited in NCBI-GenBank *I. clypealis* (HQ268815), *I. niveosparsus* (HQ268816), *A. brevistylus* (HQ268817), *I. nagpurensis* (HQ268818) and *A. atkinsoni* (HQ268819).
- The macro evolutionary pattern of aphids (Hemiptera: Aphididae) was studied employing nuclear and mitochondrial DNA sequences The total number of taxa included for CO-I, CO-II and EF-1α were 182, 146 and 186 respectively. The total length of the combined dataset for above three markers was 2126 nucleotides. The final nuclear EF-1α sequences consisted of 791 nucleotides, of which 323 were variable sites and 255 were parsimony informative sites. In case of mitochondrial genes, a total of 1336 bases, which included 658 bases and 678 bases of CO-I and CO-II, respectively were obtained. The mitochondrial dataset did not have any indels and ambiguous base calls. Both these regions contained 665 variable sites and 546 parsimony informative sites. Regarding the Ti/Tv ratios, CO-I, CO-II and EF-1α showed a predominance of transition with ratios of 1.78, 2.55 and 2.90, respectively. The partition homogeneity test and ILD test did not produce significant phylogenetic conflicts between the individual and the combined datasets ($0.12 \leq P \leq 0.92$) and were suitable for phylogenetic reconstruction.
- The miRNAome from *Thrips palmi* Karny and *Aphis gossypii* Glover was carried out using high-throughput sequencing. Miranalyzer pipeline identified a total of 10 novel miRNAs from *T. palmi* for the first time, with their predicted precursor secondary structures. The length of the novel miRNAs ranged from 21-24 nucleotides with a preference of Uracil (60%) followed by Cytosine (20%) at the 5' end. Among these ten miRNAs, five were located in the 5' arm while the other five arose from 3' arm.
- MiRanalyzer pipeline was used to predict novel miRNA precursor molecules from *A. gossypii* by mapping them on *A. pisum* reference genome. The precursor molecules were extracted from genomes. In the next step, secondary structures were predicted for precursors of potential candidate novel miRNAs by using m-Fold web server with default parameters, miRNAs whose precursor's secondary structure having free energy equal or less than -20 kcal per mol were considered as novel miRNAs. Three novel miRNAs were identified from *A. gossypii.*

❖ **Cloning and characterization of nematicidal Bt genes effective against the nematodes infesting horticultural crops:** A total of fifty Bt isolates collected from various sources were used for screening for the presence of nematicidal crystal protein genes. Two primers pairs (Cry5 and Cry55) were used for PCR screening along with reference strain which is positive for both *cry5* and *cry55* genes. Study of crystal morphology revealed that majority of crystal proteins were amorphous and bi-pyramidal in nature, SDS-PAGE analysis of the crude protein mixture showed a prominent crystal protein band. In the PCR analysis, 13 isolates were found positive with *cry5* specific primers and 23 isolates were found positive with *cry 55* specific screening primers. Further five PCR fragments were sequenced, two PCR products were found identical to *cry5B* and three were found identical to *cry55a* genes (99%). In preliminary bioassays with M*eloidogyne incognita* juveniles (J2), 100% mortality was observed in five out of ten isolates screened and inhibition on egg hatching was observed in nine isolates.

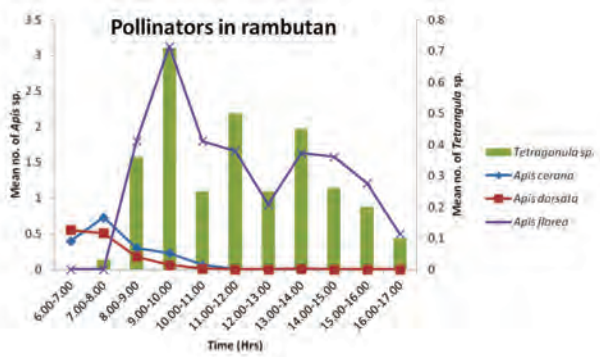
Studies on pollinators

❖ **Bee pollination and bee keeping under humid tropics of Kodagu:** Insect pollinators including 7 Hymenopterans, 7 Dipterans and 3 Coleopterans were recorded on avocado flowers. Among the pollinators in avocado orchard, Hymenopterans constituted the major group (52.6%), followed by Dipterans (39.6%) and Coleopterans (7.6%). *Apis cerana* was the major pollinator (17.6%) among Hymenoptera followed by *Apis florea* (11.3%). *Apis dorsata* was not recorded. *A. cerana* foraged from 6.00 am till 12.00 noon. The peak foraging period for *A. florae and Tetragonula* sp. was from 9.00 am -12.00 noon in avocado. Syrphids constituted the major pollinators (20.5%) followed by the *Musca* sp. (19.1%). Among the Dipterans, the mean number of visits/30min/bunch was 9.19 for syrphids followed by 8.53 visits/30min/bunch *for Musca* sp.



Pollinator activity in avocado

❖ Pollinators observed in rambutan (*Nephelium lappaceum* L.) during flowering season were, *Apis cerena, Apis florea, Apis dorsata, Tetragonula* sp., unidentified butterflies, ants and wasps. The bee species, *Apis florea* was the predominant among all the visitors and peak foraging time was 9.00 to 11.00 hrs. The total number of *A. florea* was 47.9 /panicle / day which was 63.9% of the total visitors. The total number of *A. cerena* was 4.3/ per panicle / day and the peak foraging hours was between 6.00-8.00 am. It is present to the tune of 5.8% of the total visitors.



Entomopathogenic nematodes

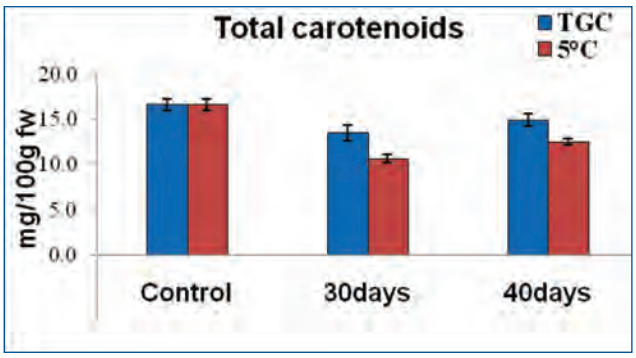
❖ **Bioefficacy of entomopathogenic nematodes on major insect pests of horticultural crops:** Two native strains of entomopathogenic nematodes (EPN) *Heterorhabditis indica* were isolated from mango orchards and cucumber grown in polyhouse at ICAR-IIHR, Bengaluru. The bacterial symbiont associated with *H. indica* was identified as *Photorhabdus luminescens* subsp. *laumondii*. They caused 100% mortality of *Helicoverpa armigera* within 48 hrs *in vitro*. The LC_{50} was 4.83 and 6.17 infective juveniles (IJs)/ larva for the two strains, respectively. These strains were also effective against *Spodoptera litura* and the LC_{50} was 4.36 and 5.34 IJs/larva.

3.5. Crop utilization and farm mechanization

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

Fruits

- In mango, among the different surface coatings, methyl cellulose and poly vinyl alcohol were found to be beneficial in delaying the ripening rate of 'Alphonso' mangoes stored at room temperature (RT) and 13°C compared to untreated fruits.
- A process was developed for conservation of raw 'Neelum' fruits into snack food by blending with Alphonso mango pulp. The carotenoid content, water activity (a_w) and yield in the infused mango slices ranged from 8.42 to 22.22 mg/100g, 0.693 to 0.737 and 38.64 to 50.20% respectively.
- Temperature conditioning of 'Alphonso' fruits was done before storage at 5° C and compared with the continuous storage at 5° C. The visible chilling injury in terms of surface pitting and browning after 30 and 40 days of storage was observed in 44 and 56% of fruits, respectively in continuous storage at 5° C. However, in the temperature conditioning storage it was observed in only 5% of fruits after 40 days of storage, respectively. The fruits developed good colour, TSS and carotenoids besides lower malondialdehyde, electrolyte leakage (EC) and better glutathione reductase activity. Fatty acid unsaturation was also more in gradient temperature conditioning. Protein carbonyl formation was less in gradient storage. Gene expression of glutathione reductase, peroxidase, and fatty acid desaturase were also lower in gradient storage fruits.



Total carotenoid content of ripened fruits after storage 5° C and at gradient temperature storage conditions (GTS) for 30 and 40 days

- In Pomegranate cv. Bhagwa, peels constituted 36.33±1.58% of fruit weight and seeds 18.26± 1.61%. The juice recovery was 41.19±2.50% on fruit weight basis and 69.25±2.96% on aril weight basis. Peel powder showed an antioxidant activity of 709 µg GAE/g. Solvent extraction using water + ethanol (30:70 ratio) was found to be the best for extraction of bioactive compounds from pomegranate peel. The pomegranate peel extract was suitable for fortification of fruit juices like pomegrante, banana, and noni or their blends in different ratios. At optimum extract concentrations, 1-2%, the fruit juices/blends were highly acceptable with enhanced antioxidant activity and other nutritional qualities.
- Corrugated fibre board of non telescopic type, size 400x300x100 mm of 4kg capacity, 5 ply rate thickness, having bursting strength 20 kg/cm^2, that withstood drop and vibration testing was found suitable for packaging, storage of guava and road transportation.
- Packing with 2% calcium chloride treated cabbage shreds in Cryovac® PD 961 to obtain an equilibrium modified atmosphere with 10-12% O_2 and 6-8% CO_2 extended the shelf life of karonda for 16 days at 8° C. Integrating the pretreatment with packaging enhanced the cellular calcium levels, reduced the polyphenol oxidase activity and malonedialdehyde. Head space volatiles such as methyl disulfide, 4-methylisothiazole, methyl trisulfide, methyl methylthiomethyl disulfide, dimethyl tetrasulphide, phenyl ethyl isothiocyanate were reduced during storage of the produce.
- Among the avocado collections PA-IV-5, PA-VII-1, PA-II-1 and PA-II-4, the major phenolic acids in the fruit pulp were *trans*-cinnamic and ferulic acid; chlorogenic acid in the skin, followed by vanillic and protocatechuic acids; in avocado seeds vanillic, protocatechuic and *trans*-cinnamic acids were predominant. Catechin was the predominant flavonoid in avocado pulp, while in avocado skin and seeds, catechin, hesperitin and quercetin, and additionally rutin were the major flavonoids.
- Chemical profiling of pummelo collections CHES P-8, CHES 35, CHES P37, CHES P38, CHES P-45 and CHES Selection 3, revealed that predominant phenolic acids in fruit juice were

trans-cinnamic and *p*-coumaric acids (higher in CHES P-8) and the flavonoids were umbelliferin, rutin and naringenin.

- Rambutan collections CHES-R-32, CHES-R-34 and xxI/2 contained more of the vanillic, protocatechuic and *trans*-cinnamic acids and the flavonoid rutin.
- Avocado processing waste was found to be 46.88%, which comprised of 27.16% peel and 19.72% seed on whole fruit weight basis. The seeds were white initially which turned reddish orange on drying or injury.
- In *kagzi* lime, the processing waste was 35.42%, which constituted 17.75% peel, 1.09% seeds and 16.58% rags.
- The jackfruit 'Nagenahalli local' variety ware comprised of 43.07 to 49.28% rind and perianth and 8.81 to 7.30% central core. The proximate analysis of the dried waste showed that it contains 39.71±1.44g/100g carbohydrates, 1.59± 0.07mg/100g carotenoids, 14.80±5.54 g/100g crude fibre, 3.26 ±1.57g/100g pectin and 2.46± 0.07 mg/100g antioxidant activity.
- Containment of browning is an important aspect for minimal processing of tender jackfruit as it affects the acceptability of product in the market. The exposed surface of jackfruit becomes brown due to enzymatic reaction. Prevention of browning has been achieved by dipping the small cut pieces of tender jackfruit in solution of 1% citric acid for 15 minutes.
- Development of amla blended juice with bottle gourd, ash gourd and their combinations was attempted at various combinations by keeping the concentration of other additives constant. The blend consisting of 70% amla and 30% bottle gourd was judged best for taste and overall acceptability of the product.

Amla-bottle gourd blended juice

Pomegranate peel powder

- Star gooseberry (*Phyllanthus acidus* Skeels), is known as '*Narkoli*'in Odisha. It bears fruits thrice in a year i.e., during March-April, June-July and Oct-November and is a rich source of vitamin C (150-200 mg/100g of edible portion) and minerals. However, it has limited market as fresh fruit due to high acidity and astringency. Fruits are highly perishable in nature and can hardly be stored for 2-3 days at room temperature. An attempt was made to prepare processed product like 'preserve' out of the fruits of star gooseberry. The final sugar concentration in the product was 68-70%.

Star gooseberry preserve

Vegetables

- In colour capsicum cultivars 'Bachata' (Yellow type) and 'Inspiration' (Red type), shrink wrapping of fruits with semi permeable films could store them for 11 and 8 days respectively at ambient temperature (26-32°C) with a weight loss of 5-6% as compared to 14-20% weight loss in non-wrapped capsicum for the same period in CFB boxes. The storage life was further extended to 5 weeks by storing them at 8°C without any shriveling and with a weight loss of <5% in both cultivars.

Shrink wrapping of capsicum

- In muskmelon, osmotic treatment of fruit slices in 60° Brix syrup at 40, 50 and 60°C temperatures for 1-4 hours resulted in significant variations in mass transfer values which ranged from water loss (WL) of 23.06 to 53.71%, solid gain (SG) of 5.76 to 16.33% and weight reduction (WR) of 14.36 to 48.47% in slices osmosed for 1-4 h.

- In beet root slices, significant variations were observed in mass transfer values which ranged from water loss (WL) 28.62 to 52.36%, solid gain (SG) 5.05 to 16.44% and weight reduction (WR) 21.96 to 35.86 % in slices osmosed in 60° Brix of syrup at 40, 50 and 60°C for 1-3 h. Yield in osmo-dried samples ranged from 18.68 to 38.76% while it was 11.05% in untreated samples.
- In an effort to develop bitter gourd juice recipes without using sugar, combination of bitter gourd, cucumber, coriander and lime juice showed good taste with reduced bitterness. The active principles responsible for health benefits in bitter gourd have been characterized.
- In moringa cv. Bhagya, among the different drying methods, solar tunnel dried leaf powder possessed high total carotenoids (2.49 mg/g), chlorophyll a (5.0 mg/g), chlorophyll b (2.01 mg/g), phenols (39.29 mg GAE/g) and ascorbic acid (479.46 mg/100g) compared to hot-air and shade dried leaf powder. Mineral estimation showed that moringa leaf powder contained significant amount of macro minerals and trace elements.
- Chemical proofing of ivy gourd showed that *p*-hydroxy benzoic acid was the major phenolic acid in ivy gourd varieties Arka Neelachal Sabuja and Arka Neelachal Kunkhi, while *trans*-cinnamic, salicylic and chlorogenic acids were found in moderate amounts; the flavonoid rutin was present in very high amounts. The variety Arka Neelachal Kunkhi had significantly higher concentrations of all the phenolic compounds and flavonoids compared to Arka Neelachal Sabuja.
- Market samples of betel leaves from Karnataka harboured *Salmonella*, *E. coli* and *Listeria* spp. *Salmonella* could survive in the produce till the end of its shelf life without a significant reduction in the initial population.

Flowers

- Essential oils, viz., patchouli, geranium, rosemary, eucalyptus and clove botanicals when evaluated as an alternative to chemical floral preservatives showed that patchouli oil at 250 ppm concentration was effective in extending the vase life of tuberose var. Local Double by 3 days and chrysanthemum var. White Reagan by 4 days over other treatments and control.
- In Gerbera, among different packages evaluated for storage and transportation of cut flowers, single ply CFB sheet (10x45cm) was found the more suitable in achieving 100% prevention of stem bending and breakage during storage at room temperature (26-28°C).
- Antioxidant activity of herbal tea of *R. damascene* dried petals stored at room temperature (26-29°C) in PE bags of 300 gauge when evaluated at 3 month intervals indicated that initial antioxidant activity of 228mg/g dry weight decreased to 116mg/g dry weight when stored for 12 months.

Mushrooms

- Mushroom fortified ready to use upama powder was standardized and subjected to sensory evaluation by 66 responders, 39.39% of them rated it as very good, 48.48% as good and 2.12% as average. The nutritional analysis of mushroom fortified upma mix showed a drastic reduction of fat and carbohydrate content and a significant drastic increase in protein and fiber content as compared to non fortified sample. The mineral analysis of the samples showed an increase in Ca, Mg, K, Fe, Mn, Cu, Zn and N in the mushroom fortified samples as compared to control non fortified samples.

Medicinal Crops

- **Studies on Withanolide extraction and root storage:** The microwave assisted solvent extraction yielded higher Withanolide content from Ashwagandha roots, compared to the traditional method. Dried Ashwagandha roots when packed in polythene bags (air tight conditions) at room temperature can be stored for ten months without significant reduction in the quality.
- **Study on shelf life of roots for Withanolide content:** Microwave assisted solvent extraction yielded higher Withanolide content quantified by HPLC than traditional method. Three types of material were used viz., completely shredded dry root in to small pieces, commercial sample of 5-7 cm length pieces and dry root powder, Material was stored for 10 months and monthly analysis was made. The results indicated that dry root storing in polythene bag (air tight condition) at room temperature was more stable with less reduction in quality even after 10 months of storage.

Betelvine

- **Storage studies in betelvine:** Betel leaves (Hesaraghatta local) packed in CFB boxes with polyethylene lining (100 gauage) were stored at 5°C, 8°C and room temperature (27.4-32.5°C, 35-66% RH). The freshness of betel leaves could be maintained for 18 days at 12°C and 4 days at room temperatures by PE lining with a weight loss of only 8.9 and 2.5 % respectively compared to 48 and 23 % weight loss by the second day when stored without PE lining.
- Round thermocol boxes (100mm dia.), with gel pack were best suited for the packing and storage of betel leaves (Hesaraghatta local) at ambient conditions (29°C and RH of 34%).
- **Microbiological studies**: Market samples of betel leaves from Karnataka were confirmed to harbour *Salmonella enterica*, *E. coli* and *Listeria* spp. But *Salmonella* and *Listeria* were not detected in on farm samples, indicating that contamination occurs during post harvest operations, handling and storage. *Salmonella* can survive on the leaves till the end of their shelf life (7 days), without any reduction.

3.5.2. Farm Mechanization

- A mango dipping tool was developed to treat the Alphonso mangoes with Arka Saka Nivirak (a formulation developed at IIHR to prevent internal break down disorders @ 125 ml per litre) in the tree itself. To control spongy tissue, fruits need to be dipped twice with this solution at 40-60 % maturity stages at 10 days intervals. The tool had a long SS pipe for holding a plastic container filled with the solution and supported by a circular holder and a 'U' shaped frame fitted in the pole. It was designed and fitted in such a way that the plastic container was hinged and was always positioned horizontal during operation. It helped in avoiding spilling of the solution and dipping mangoes conveniently at different heights. The pole could reach a height of 15 – 18 feet. About 15 seconds was required to treat one or two fruits at a time. A six feet pole was also provided to treat the mangoes at the lower and peripheral levels.

Dipping tool for mango to control spongy tissue

- **Solar tunnel drier for dehydration of horticultural produce:** Solar tunnel dryer of 6 x 3 x 2.7 m (L x W x H) with galvanized frame structure was constructed on a concrete floor with necessary foundation and covered with 200 micron UV-stabilized LDPE sheet. Two fin type fresh air inlets of 0.6 x 0.3 m size were installed at the rear side of the drier at 0.15 m height from ground level for entry of fresh air. Two exhaust fans each of 9'diameter and 50 watt capacity were installed at the front top side of the drier at 2 m height from ground level for removal of moisture laden air from the dryer. About 20 – 30 per cent reduction in time was recorded, when compared to open yard sun drying to attain the safe moisture content for *amla* segments and onion slices. Chemical analysis indicated that the quality of solar tunnel dried products was superior to open sun dried products. The payback period for *amla* is six months and for nine months for onion.

Solar tunnel drier

- **Power operated water melon seed extractor:** A watermelon seed extractor was developed using the engineering properties such as physical and textural properties of the matured fruit and seeds. The seed extractor consist of systems for (i) watermelon cutting, (ii) watermelon seed extraction, (iii) seed and pulp separation and (iv) power and power transmission. The extractor was evaluated with three types of scrapers namely stainless steel, wooden and nylon; two cutting planes viz., transverse and longitudinal planes

and three rotational speeds viz., 50, 100 and 150 rpm. The best performance was observed with transverse cutting, nylon scraper at a speed of 100 rpm. The best values for capacity, extraction efficiency, seed loss, seed damage, germination percentage and vigour index were 1.98 kg of seeds/h, 99.49 %, 0.19 %, 0.26 %, 97.04 % and 3284 respectively. The total cost of the seed extractor was Rs. 55,000. The cost of extraction of 1 kg of watermelon seeds was Rs. 28.65 against Rs. 600 by manual method.

❖ **Manually operated onion grader:** A manually operated onion grader was developed for grading rose onions into three grades based on these sizes. The machine has a feed hopper, tray with holes suitable for grading onions, collection trays, handle and chain for oscillating the tray. The tray has a dimension of 1500 x 750 x 250 mm (L x W x H), and first half portion of trays has holes of 25 mm and second half portion of the tray has holes of 30 mm. The grading was done in three grades as < 25 mm, 25-30 mm and > 30 mm size. The marketable size being 25-30 mm. The overall grading efficiency was 82 % and grading capacity was 1 tonne/h. The grader saves 15% operational cost compared to manual operation cost.

❖ **Outdoor mobile mushroom cropping chamber:** The average temperature in the mobile chamber for mushroom cultivation varied from 24-25.8°C as compared to 25-27°C under ambient conditions. The humidity in mobile chamber varied from 75-88% as compared to 63-77% under ambient conditions during April to June. The BE during this period varied from 64% (April), 28.22% (May) and 34.83% (June).

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

3.6.1. Economics of Production, Marketing and Trade

Assessing the economic impact of adoption of tuberose hybrid, Arka Prajwal in West Bengal

- In the state of West Bengal, tuberose is grown on an area of 5168 hectares, accounting for 21% of the total area under flower crops, with a production of around 121871 lakh sticks. Nadia district with 2088 hectares has 40% of the tuberose area in the state with more than 50% area under Arka Prajwal. The economic impact of adoption of Arka Prajwal was evaluated at individual farm level taking the costs, returns, profitability and resource use efficiency and at the aggregate level (district/state) by using the capital budgeting method.
- **Economic Impact at individual farm level**: Arka Prajwal has gained popularity over the last decade and is cultivated in a two year cycle. It is harvested mainly for loose flowers. Siliguri, Assam, Bihar, Nepal and Bangladesh are the major markets. The cost of cultivation is Rs. 4,43,900/ha and with an average yield of around 22 t loose flowers/ha, the cultivators realize gross returns of Rs. 8 to 13 lakhs and a net return of Rs.3.86 to 8.6 lakhs/ha with a Benefit to Cost ratio in the range of 1.87 to 2.97.



Field view of Arka Prajwal in Krishnanagar, Nadia district of West Bengal.

- **Economic Impact of adoption of Tuberose Arka Prajwal at aggregate level:** Based on the two year cycle of the crop, with over 50% adoption rate of Arka Prajwal between the period 2011 to 2015, the total discounted net benefit accrued to the state was estimated at Rs 640 crores. The aggregate total economic impact in terms of discounted net benefit accrued to the economy based on the sample survey and data collected from Tamil Nadu, Uttar Pradesh and West Bengal, is around Rs.880 crores, thus justifying the investment into breeding better hybrids/ varieties in flower crops.

Export performance of processed fruit and vegetable products – country wise analysis

- During 2001-2015, export of mango pulp registered a significant positive growth of 5.67 per cent in quantity and 10.43 per cent in value. All the major importing countries - Saudi Arabia, UAE, Netherlands, Yemen, UK, Germany and Canada registered positive and significant growth both in quantity and export earnings. UAE, Kuwait and USA recorded positive growth in value but registered negative growth in quantity. The major importers of mango pulp from India are Saudi Arabia (29.31%), Yemen Arab Republic (19.08%), Netherlands (8.19%), UAE (6.5%), Kuwait (3.74%) and UK (2.56%). The highest export earnings, are from Saudi Arabia (26.93%), Netherlands (11.88%), Yemen (14.22%), UAE (6.43%), USA (4.10), UK (3.83%) and Kuwait (4.04%). Saudi Arabia continues to be the major importer of mango pulp from India. The share of Netherlands, UK, Yemen, and Canada increased during 2003-04 to 2014-15.
- **Export performance of mango pulp – country wise instability analysis:** Export of mango pulp from India to different countries was stable (CVt=16-17%), but export to UK, Germany, UAE, Kuwait and Netherlands was unstable (CVt>25%).

Instability in export of mango pulp

Country	Instability Index (CVt) (%)	
	Qty	Value
Saudi Arabia	17.61	21.18
UAE	32.59	29.92
Netherlands	29.13	25.09
Kuwait	32.90	35.66
Yemen	22.63	16.87
USA	15.06	16.47
UK	50.16	39.65
Germany	35.00	29.37
Canada	10.32	18.67
All countries	15.90	17.28

- **Cost of export of mango pulp:** A survey of exporters of mango pulp in TN, AP and Karnataka indicated that in case of variety Totapuri, cost of the raw material was the main item of cost (60%) followed by aseptic bag packing, processing, ocean freight, internal transportation and documentation. In case of variety Alphonso, the raw material cost accounted for more than 70 per cent of the total cost of export of mango pulp.
- **Export realization from mango pulp in aseptic bag:** In case of Totapuri, the export earnings were highest from USA followed by Europe, Saudi Arabia, UAE and Sudan, while the USA contributed the maximum to the export earnings followed by Europe and UAE in the case of Alphonso. The net profit by export of Alphonso mango pulp in aseptic bag worked out to Rs.11728/t to USA and Rs.8277/t to Europe. In case of Totapuri, the net profit was Rs.9263/t for USA, Rs.3188/t for Europe, Rs.2639/t for Saudi Arabia and Rs.2095/t for UAE. The net realization was the lowest from Sudan due to very high (Rs.46076/t) cost of export. The BCR was the highest for USA at 1.20 for Totapuri and 1.16 for Alphonso. UAE recorded the lowest BCR of 1.02 for Alphonso and Sudan registered the lowest BCR of 1.04 for Totapuri.
- **Constraints in export of mango pulp:** The major constraints in export of mango pulp identified by surveying exporters of mango pulp in Tamil Nadu, Andhra Pradesh and Karnataka are listed below
- **Production constraints** – Poor harvesting/ packing practices, inadequate / irregular supply of mango fruits, fluctuation in price of raw material / mango pulp and insufficient credit facility from banks.
- **Constraints in processing** - Voltage fluctuation, shortage of labour, delayed and reduced disbursement of subsidy for mango ripening chambers.
- **Constraints in export of mango pulp** - Fluctuation in exchange rate, payment default by the merchandise exporters / importers, cost increase in the logistics arrangements, high duty (12.13%) on packing material like MS drums and OTS (Open Top Sanitary) cans and procedural delays in claiming the duty exemptions.

Economics of factor productivity and production efficiency in horticultural crops

- **Papaya:** Using Cobb Douglas type of production function, men, labour and nutrient nitrogen were identified as the key factors that influence papaya production significantly and positively. There is a scope to improve the income of farmers by increasing these inputs. Nearly 53.3 % of farms were found to perform at an optimum scale of production in the constant returns zone with an efficiency level >=0.90 or more, while the average efficiency score was 0.798. The remaining 46.7 % of farms, which do not operate at the maximum efficiency level, could reduce the input level by 20.20% to maintain the same level of papaya production. None of the farms operated above the optimum scale of production. The average allocative efficiency score achieved was only 0.439. Only 7% of the farmers achieved the allocative efficiency score of 0.9 or above. The average economic efficiency is 0.355, which suggests that farmers producing papaya are yet to achieve the economic efficiency. Optimum resource allocation revealed that the number of plants of papaya plants has to be reduced from 1815/ha from the present 1864/ha. Similarly the optimum use of men labour (man days/ha), women labour (women days/ha), FYM (t/ha), N (kg/ha), P (kg/ha), K (kg/ha) are 196.24, 251.6, 21.8, 571.52, 950.92 as against the present levels of 139, 398, 34, 471, 798 and 726, respectively.
- **Tomato:** The production of tomato in India increased from 4.24 million tonnes in 1991-92 to 19.40 million tonnes in 2013-14 at a compound growth rate of 6.72% per annum. This is mainly because of expansion in area at the rate of 4.93% rather than an increase in productivity (1.70%), indicating a tremendous scope to increase the production further through adoption of hybrids since the area under hybrids is still low in India.

3.6.2. Statistics Research

Development of statistical models for horticultural crops research

- **M-estimation:** A methodology for attaching the desired weights to multiple outlier observations/ replications while analyzing designed experimental data on brinjal showed that the probability of type I error decreased from 7.22-2.51%, coupled with an increase in confidence level from 92.78 to 98.99%. The robust analysis of variance for Huber's M-estimation for eight different traits in brinjal experiments resulted in reduction of 38 to 42% EMSS and confidence level increased from 92.78 to 97.57%, whereas Andrew's M-estimation for the same characters resulted in reduction of 54.22 to 56.55% EMSS and increase in confidence level from 92.78 to 98.99%. Efficacy of different M-estimation procedures evaluated based on error variance indicated reduction in error sum of square across eight different traits in brinjal, except for two characters wherein data did not follow sin wave pattern. It was observed that by adopting a suitable M-estimation procedure, a researcher, could arrive at required inference about the treatment differences, without removing an outlier replication.
- **Prediction model:** A logistic mechanistic growth model developed along with biological measures of intrinsic growth rate and carrying capacity indicated that the severity of grapes yellow rust disease could be predicted to an extent of 91%. A non-linear logistic model was used to work out the area under disease progression curve for describing population dynamics for yellow rust in grapes and the values across a 18 standard week period showed a range of 27.5 to 48.5 for the year 2015, when plants were pruned in April.
- **Multivariate analysis of china aster genotypes:** Diversity indices based on Ward's method were worked out for biometrical analysis of 42 China aster genotypes across 13 traits. Results showed that there were four distinct clusters and 18 combinations of genotypes having the farthest distance.

3.6.3. Computer applications

Development of database and program modules for horticultural crops

- **Database development (Onion and Pomegranate):** Data such as area, nutritional levels, propagation, soil, climate and planting system, land preparation, method of planting, sowing, etc were collected for development of backend data in case of onion. Data on general aspects of pomegranate crop such as area, varieties, propagation, planting, nutrient requirements, irrigation methods, soil and climate, harvesting, etc. have been collected from different sources like National Horticultural Board, DOGR, NRC on Pomegranate, Agropedia, etc.

Decision support system for fruits and vegetables (Pomegranate and Onion)

Decision Support System (Pomegranate and Onion)

- **Pomegranate:** A Decision Support System on pomegranate has been developed as a web application with graphical user interface for general crop information, disease management, plant protection and disorder identification modules to provide diagnosis and solutions for pomegranate cultivation.
- **Onion:** A web application has been developed for Onion production with solutions for farmers and other stake holders on disease diagnostics, disorder identification, crop management modules and general crop profile.

3.7. Extension Research

3.7.1 Improving knowledge and skills of stakeholders for enhancing productivity of horticultural crops and impact assessment

❖ **Assessment and refinement of ICAR-IIHR technologies through farmers' participatory demonstrations:** Demonstration of different vegetable and flower crop varieties/hybrids of the institute were undertaken at twelve locations with the collaboration of KVK, Hirehalli and KVK, Gonikoppal, in Tumkur and Kodagu Districts of Karnataka. ICAR-IIHR varieties/hybrids of different crops, recorded yield increase of 14.0 to 58.3 %, over the local varieties/hybrids.

Crop	ICAR-IIHR Varieties/Hybrids	Yield t/ha		(%) increase
		Demonstration Plot	Local Varieties/ Hybrids	
Dolichos beans	Arka Amogh	15.2	11.4 (Hebbal Avare)	25.0
Tomato	Arka Rakshak	72.0	51.0 (US 901)	29.1
Tomato	Arka Rakshak	85.0	64.8 (Emerald)	23.7
Tomato	Arka Rakshak	64.0	55.0 (Laxmi)	14.0
French Bean	Arka Suvidha	9.8	6.8 (Local)	30.6
Chilli	Arka Kyathi	29.3	23.0 (Bullet)	22.7
Coriander	Arka Isha	12.0	7.0 (Local)	58.3
Marigold	Arka Bangara	10.6	7.4 (Syngenta Hybrid)	30.1

Studies on rate of adoption of ICAR-IIHR technologies

❖ The rate of adoption of the ICAR-IIHR, micronutrient formulations, 'Banana Special' and 'Vegetable Special' by farmers, over the previous five years was studied. The net rate of adoption (%) of Banana Special, was found to increase at an average of 6.3 times every year, while the net rate of adoption of 'Vegetable Special' (%) increased at an average of 2.1 times every year.

Socio-Economic Issues Associated With Litchi Cultivation

❖ A questionnaire based survey was conducted to identify the socio-economic issues associated with litchi cultivation amongst thirty growers of Kodagu district of Karnataka. The survey revealed that the motivational factors associated with litchi cultivation were profitability, ease of crop management, favorable climate/weather conditions for litchi cultivation, high market demand for the produce, availability of skilled manpower and less pest/disease incidence. The growers required training / guidance on propagation methods, information on improved varieties/superior cultivars, management of fruit cracking, canopy management, improving pollination, integrated nutrient/pest/disease management, availability of export markets, value addition, handling, storage and packing of produced and rejuvenation of old orchards.

3.7.2 Impact of capacity building of trainees on the adoption of ICAR-IIHR technologies including identification of future training needs

❖ The training needs of African delegates, who visited ICAR-IIHR in a study-cum-exposure visit as part of their fourth Indo-US-African Triangular International Training Programme on 'New Dimensions in Extension Management'' organized by National Institute for Agricultural Extension Management (MANAGE), Hyderabad from July 16 to September 13, 2015 were assessed. The trainees listed the post harvest handling of produce and value addition as their foremost need followed by the integrated disease/pest/nutrient management and marketing of produce.

❖ A comprehensive questionnaire to determine the impact assessment of training programmes organized by ICAR-IIHR was developed. The questionnaire was administered to 100 agricultural officer trainees of Kerala state, who attended various training programmes conducted by ICAR-IIHR. In the area of fruits and plantation crops, training on orchard management (58.59 %) received the top priority while training on pest management (35.35%) received the least priority. In the area of protected cultivation of vegetable and ornamental crop production, training on fabrication and erection of structures (43.10%) received the top priority while training on irrigation and drainage management (27.27%) received the least priority.

Training needs of agricultural officers of Kerala in fruits and plantation crops

Training Needs	Rank Based Quotient
Orchard management	58.59
Canopy architecture	49.83
Packaging of produce	48.15
Post harvest and value addition	44.11
Marketing of produce	40.07
Disease management	38.38
Integrated nutrient management	38.38
Pest management	35.35
Average	44.10

Training needs of agricultural officers of Kerala in protected cultivation of vegetable and ornamental crops

Training Needs	Rank Based Quotient
Fabrication and erection of structures	43.10
Design of polyhouses/green houses/shadenet structures	42.09
Seed production	41.75
Design of structures for different geographical locations	41.75
Land preparation and seedling transplantation	41.08
Intercultural operations	41.08
Seed bed preparation, seed sowing and raising of seedlings	40.74
Vegetable harvesting, preservation and marketing	40.74
Knowledge on right shade nets and nylon meshes	39.39
Soil and fertilizer management	37.37
Vector management	37.37
Choice of crop for optimum income	37.37
Knowledge on type of mulching (reflective/non-reflective/biodegradable/non-biodegradable)	37.71
Nutrient management	36.70
Insect and disease control	36.03
Selection of quality seeds and seedlings	34.01
Irrigation and drainage management	27.27
Average	**38.56**

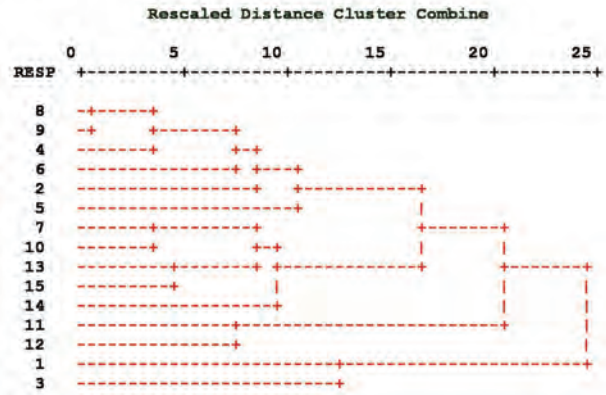
3.7.3 Improving the livelihood security of farm women through appropriate horticultural innovations

- Demonstrations were conducted in twelve villages of Chikkaballapura and Tumakuru districts of Karnataka covering one hundred and twenty eight farm women, on various horticultural interventions viz., organic crop production technologies, nutrient enrichment of composts, integrated pest/disease management modules in vegetables and mixed cropping in areca gardens. These interventions could increase in the net income of farm women to the tune of 34.4%.

French bean (Arka Suvidha) cultivated as an intercrop in areca gardens

3.7.4 Group dynamics and social networks among women's Self Help Group (SHG) member's involved in economic activities

- Womens SHG's have been formed with the objective of taking up income generating activities collectively. An important aspect that determines the success of any SHG is the interaction amongst the group members in a given social situation. In order to study this, data on the socio-personal-psychological profile and parameters related to group dynamics were collected from a group (15 members) of respondents from Tumakuru district of Karnataka. The diagrammatic representation (dendrogram prepared by the Wards method), of the clustering behaviour of the group members reveals three broad clusters within the group and a high level of similarity amongst the group members.



Dendogram showing the socio-personal-psychological similarity among the SHG members

4. All India Coordinated Research Projects

The ICAR- All India Coordinated Research Project (AICRP) on Fruits, headquartered at ICAR-IIHR, Bengaluru, has the mandate of identification and release of fruit varieties and hybrids through multi-locational testing (MLT), maintaining duplicate germplasm, evaluation and augmentation of germplasm with National Active Germplasm Sites (NAGS) evaluation of input-use-efficient technologies and assessment of plant health management strategies under different agro-climatic zones. It is also mandated with the assessment of post-harvest losses of banana and mango in major growing areas and demonstration of promising fruit crop technologies in tribal areas. Presently, forty five centers operate under the ICAR-AICRP on Fruits (28 SAU-based centers, 13 ICAR-institute based centers, 3 CAU-based centers and 1 private centre). Research on various aspects of mango is carried out in fourteen centers, guava in thirteen centers, banana and citrus in eleven centers each, grapes, litchi and sapota in five centers each, papaya in eight centers and jackfruit in six centers. Besides the ICAR-AICRP on Fruits, several All India Coordinated Research Projects on various horticultural crops are in operation in ICAR-IIHR. The details of activities carried under different AICRP projects during the period under report are mentioned below.

Project	Aspect	Crops / Species / Activity
All India Coordinated Research Project on Arid Zone Fruits	Crop Improvement	Anona and Pomegrante
	Crop Production	Custard apple and Fig
All India Coordinated Research Project on Vegetables	Crop Improvement	Chilli, Bell pepper, Brinjal,Okra, Onion, Garlic, French bean,Cowpea, Garden Pea, Dolichos, Bottle gourd, Bitter gourd and Ridge gourd
	Crop Production	Amaranth and Chilli
	Plant Pathology	Survey and surveillance of diseases of important vegetable crops in farmers field
	Seed Production	Bottle gourd and pumpkin
All India Coordinated Research Project on Floriculture	Crop Improvement and Germplasm Maintenance	Tuberose, Gladiolus, Carnation, Chrysanthemum, China Aster, Marigold and Ornamental flowering shrubs
	Crop Production	Marigold
	Plant Pathology	Disease diagnostics in bulbous ornamentals
All India Coordinated Research Project on Medicinal & Aromatic Crops and Betelvine	Crop Improvement	Betelvine
All India Coordinated Research Project on Mushrooms	Mushroom Production	*Pleurotus* spp.
All India Coordinated Project on *Heliconia*	Collection and Evaluation of Germplasm	*Heliconia* spp.
All India Coordinated Research Project on Biological Control of Crop Pests and Weeds	Biological control	Insect pests of horticultural crops
All India Network Project on Pesticide Residues	Pesticide Residue Studies	Grapes- Chlorpyrifos and Carbendazim Brinjal - Spirotetramat Chilli-Ethion, Imidacloprid, Quinalfos, Triazofos, Fipronil and Carbendazim Capsicum- Ethion and Carbendazim Cauliflower- Acephate, Quinalfos and Tiazofos Tomato- Tebufenpyrad and Carbendazim Okra - Acephate and Imidacloprid Cabbage - Acephate, Oxadiargyl and Carbendazim Bitter gourd and Cucumber - Carbendazim

Significant highlights of the All India Network Project on Pesticide Residues

Crop	Pesticide	Half-life (days)		Residue persistence (days)	
		X *	2X **	X *	2X **
Cauliflower	Carbendazim 50% WP	5.5	-	20	-
Okra	Carbendazim 50% WP	5.6	-	20	-
Bitter gourd	Triazofos 40 EC	1.6	1.7	10	15
	Acephate 75SP	4.0	4.1	25	25
	Chlorpyrifos 20EC	3.5	4.0	20	25
	Quinalfos 25EC	0.9	1.1	07	10
	Ethion 50EC	2.3	3.4	20	25
	Profenofos 50EC	1.7	2.0	10	15
	Cypermethrin 10EC	3.0	3.7	15	20
	Imidaclorpid 17.8 SL	2.8	4.1	10	20
	Carbendazium 50%WP	2.7	-	25	-
Cucumber	Triazofos 40 EC	1.6	2.0	10	15
	Acephate 75SP	4.1	5.0	20	25
	Chlorpyrifos 20EC	2.0	2.3	15	15
	Quinalfos 25EC	1.6	2.0	05	07
	Ethion 50EC	4.1	4.5	25	25
	Profenofos 50EC	1.5	2.3	10	15
	Cypermethrin 10EC	3.0	3.6	15	20
	Carbendazium 50%WP	3.3	-	25	-
Capsicum	Cypermethrin 10EC	4.0	4.3	25	25
	Spiromesifen 22.9SC	1.1	1.7	15	20
	Carbendazium 50%WP	2.8	-	25	-
Okra	Imidacloprid 17.8SL (In soil)	2.0 -	2.0 -	07 -	10 -
Tomato	Carbendazium 50%WP	3.2	-	25	-
	Spiromesifen 22.9SC	3.0	3.7	10	15
Brinjal	Imidacloprid 17.8SL (In soil)	5.2 -	5.2 -	10 -	15 -
	Chlorpyrifos 20EC	1.3	-	10	-
	Carbendazium 50%WP	3.5	-	30	-
Cabbage	Carbendazium 50%WP	3.0	-	25	-
Green chilli	Carbendazium 50%WP	3.5	-	30	-
	Imidacloprid 350SC	5.0	5.0	15	20
Grapes	Spirotetramat 150 OD	3.9	5.3	15	20
Pomegranate	Fluopyram	7.6	7.6	15	15
	Tebuconazole	5.7	6.1	15	15
	Fluopyram 200SC (In soil)	4.6 -	6.0 -	10 -	10 -
	Tebuconazole 200SC (In soil)	4.8 -	6.2 -	10 -	10 -
Mango 400 SC	Fluopyram After 3rd spray application After 4th spray application	 5.2 4.3	 5.4 4.5	 10 15	 10 15
	Tebuconazole After 3rd spray application After 4th spray application	 3.9 4.0	 4.0 4.0	 10 10	 10 15

X* - Recommended dose, 2X- Double the recommended dose**

5. Transfer of Technology

The Institute has a multi-dimensional approach in extension for effective transfer of technologies to various stakeholders. Accordingly the Division of Extension and Training, ICAR-IIHR, Bengaluru organized need based advanced trainings on horticultural technologies, large scale demonstrations, disseminated and popularized various technologies through mass media, group approaches, exhibitions, field visits, field days, interfaces, seminars, stakeholders meet, interaction meetings, consultations etc. The Agricultural Technology Information Centre (ATIC) at the Institute also provided extension services through its single window concept. Dissemination and popularization 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. The details are given below.

5.1 Training Programmes

5.1.1 ICAR-IIHR, Hesaraghatta

The Division of Extension and Training organized 36 on-campus and 8 off-campus trainings on various technologies with the active participation of scientists of other divisions. A total of 1837 trainees across the country underwent training programmes and were benefited. The details of the trainings are given below;

On-Campus Trainings

Title	Date(s)	Number of participants
Training on hand pollination technique in custard apple hybrid Arka Sahan	Apr 16	15
ICM in protected cultivation of vegetables and fruit crops for the farmers and horticultural officers, Govt. of Karnataka	Apr 23-24	54
Scientific nursery management practice for vegetable crops for vegetable nurserymen of Karnataka	Apr 25	228
Protected cultivation of high value vegetables and ornamental crops for the farmers of Andhra Pradesh	Apr 28-May 2 Jun 16-20	23 20
Advances in production technologies of horticultural crops for farmers of Manipur	Jun 02-06	19
Entrepreneurial training on mushroom spawn production and cultivation	Jun 18-26, Sep 03-11, Dec 31, 2015-Jan 08, 2016	31 27 34
Advances in production technology of horticultural crops	Jul 06-11 Aug 25-28 Sep 21-24 Oct 05-08 Oct 14-17 Nov 03- 06 Dec 01-04 Dec 08-11 Dec 16-19 Jan 11-14 Jan 19-22 Jan 27-30	19 28 22 30 28 18 24 20 23 26 19 20

Title	Date(s)	Number of participants
Protected cultivation of vegetable crops, PHM of flowers and mushroom cultivation and ornamental crops for agricultural officers from Kerala	Jul 20 Aug 04-07	30 25
S.S.Grade Staff engaged in administration office and other division/sections performing the duties of messenger attendant and miscellaneous work related to reception /ATIC/canteen etc.	Oct 05-07	63
Alternate cropping system and integrated crop management (ICM) in protected cultivation of vegetable crops	Oct 16	30
Protected cultivation of vegetable and ornamental crops	Oct 19-21	27
Precision farming practices (micro-irrigation, mulching, fertigation and IPM etc,) fruit, vegetable and flower crops	Nov 16-21	20
Integrated plant protection and ICM in protected cultivation of vegetable crops for the polyhouse and nethouse farmers of Bengaluru Rural and Urban Districts of Karnataka	Dec 11	72
Post-harvest management and value addition of horticultural crops	Jan 04-09 Feb 22-27	24
Training cum exposure programme on Hi-tech horticulture for district development managers of NABARD Karnataka	Jan 11-12	35
Pollen cryopreservation in vegetable crops for shuttle breeding and hybrid seed production	Jan 18- 23	6
National level exposure visit and training on hi-tech cultivation of horticultural crops	Jan 23-25	23
Protected cultivation of high value vegetables and ornamental crops	Feb 01-06	24
Tropical mushroom production technology	Feb 08-12	15
Precision farming practices (micro-irrigation, mulching, fertigation IPM etc.,) in fruit, vegetable and flower crops	Feb 15-20	23

Off-Campus Trainings

Title	Place	Date(s)	Number of participants
Biopesticides awareness and training programme	Virinjipuram, Vellore District, Tamil Nadu	Jun 18	100
Banana crop production technology	G.Gollahalli, Kanakapura Taluk	Jun 19	56
Nematode management using bio-pesticides under protected cultivation	Chikkaballapur	Jun 25	102
Training on management of orchards through Arka Microbial Consortium and micronutrients for the farmers	Attibele	Jul 30	21
Advances in management of important vegetable crops	Sankalagere, Channapattana Taluk	Aug 14	52
Management of mango crops for farmers	Aralakuppe, Magadi Taluk	Jan 12	51
Management of vegetable crops for farmers	Sankalagere, Channapattana Taluk	Feb 19	50
NICRA - climate resilient technology day cum training programme	Kadur	Feb 28-29	260

5.1.2. CHES, Chettalli

The station organized four on-campus and one off-campus trainings as given below benefiting trainees

On-Campus Trainings

Title	Date
Nursery management	Aug 18
Backyard poultry farming	Oct 20
Exposure visit of tribal village school student and teachers	Nov 21
Spice crops	Dec 15

Off-Campus Trainings

Title	Date
Disease management of poultry birds	Nov 12

5.1.3 KVK, Gonikoppal

The Krishi Vigyan Kendra organized 58 trainings as per the mandate of KVKs benefiting1948 trainees.

Type of Training	No.	Number of Participants
On-Campus	19	566
Off-campus	39	1382
Total	**58**	**1948**

5.1.4 KVK, Hirehalli, Tumakuru

The Krishi Vigyan Kendra organized 69 trainings on various technologies in the fields of horticulture and allied subjects.

Type of Training	No.	Total
On-Campus	29	706
Off-Campus	40	1142
Total	**69**	**2148**

5.2 Field Demonstrations

ICAR-IIHR, Bengaluru

Title	Location	No. of Demons-trations
Awareness cum demonstration on rejuvenation of mango orchards	Linganahalli, Hesaraghatta Hobli	01
Method demonstration of soil and water sampling	Linganahalli, Hesaraghatta Hobli	01
Nematode management with bio-nematicides in horticultural crops	Linganahalli, Hesaraghatta Hobli	01
ICAR-IIHR manual and animal drawn onion seeders and ICAR-IIHR tractor operated raised bed former cum onion seeder	Kadur, Chikamagalur	01
Banana special spray	Gollahally, Kanakapura Taluk	24
Demonstration of ICAR-IIHR onion de-topper	Kadur, Chikamagalur	
Demonstration on bunch feeding in banana	Gollahally, Kanakapura Taluk	21
Display and demonstration of ICAR-IIHR farm machinery	GKVK, Bengaluru	01
Demonstration of ICAR-IIHR animal drawn onion seeder	Reakalakuntapalli, Chikaballapur	01
Display and demonstration of ICAR-IIHR farm machinery	KVK, Hirehalli	01
Demonstration on use of bionematicides in polyhouses	Bashettihalli, Shidlaghatta Taluk	26
Demonstration on use of mango special	Aralukuppe, Magadi Taluk	23
Display and demonstration of machinery and equipments for cultivation of onion	Narasipura Village, Kadur Taluk	01
Display and demonstration of ICAR-IIHR farm machinery	V.C. Farm, Mandya	01
Use of fruit fly traps and mango special	Maralkuppe, Magadi Taluk	16
Introduction of Arka Suvidha French bean, Arka Mangala Yard long bean Arka Rakshak tomato	Sankalagere, Channapatna Taluk	10
Demonstration of carnation variety ‘Arka Flame’	KVK, Hirehalli and UAS, Dharwad	01

KVK, Gonikoppal

A total of 80 field demonstrations on thirteen aspects were organized in nine villages of Kodagu district.

KVK, Hirehalli

A total of 79 field demonstrations on five aspects were organized in eighteen villages of Tumakuru district.

5.3 Field Days

Title	Date & Place
ICAR-IIHR, Bengaluru	
Interstate farmers meet and field day for showcasing improved varieties and F_1 hybrids of vegetables and precision farming of vegetables for the farmers from Karnataka,Tamil Nadu, Andhra Pradesh and Telangana	09.09.2015, IIHR, Bengaluru
Integrated farming system and vegetable crops	08.12.2015, Shri S.C. Thimmaiah, Nallur Village, Ponnampet
Effect of *Bacillus* biopesticides on nematode management in gerbera and carnations under protected conditions	Doddaballapura
Tomato hybrid Arka Rakshak	26.12.2015, Shri Ramachandrappa, Hanur Village, Chamarajanagar
CHES, Chettalli	
Seminar cum field day on rambutan	10.10.2015, Chettalli
Awareness programme on off-season litchi cultivation in South India	10.12.2015, Chettalli
KVK, Gonikoppal	
Field day cum expert scientist-farmers interface programme on vegetable varieties and F_1 hybrids	11.06.2015, Chikkaluvara Village, Somwarpet Taluk
Field day on integrated farming system and vegetable crops	08.12.2015, Nallor Village, Virajpet, Kodagu
Field day on banana-paired row system of planting	16.12.2015, KVK Gonikoppal Athur Farm
KVK, Hirehalli	
Drought resistant varieties in different crops (Ragi, Redgram, Aerobic Paddy and Cow pea)	26.10.2015, D.Nagenahalli, Koratagere Taluk, Tumakuru
Navane (Foxtail millet) - HMT-100-1	06.11.2015, Karemadhenahalli,Sira Taluk, Tumakuru
High density banana planting (Grand Naine)	07.11.2015, Puttayyanapalaya, Tumakuru

5.4 Farmers-Scientists Interface Meetings

Event/Occasion	Date	Place	No of participants
ICAR-IIHR, Bengaluru			
Interaction meeting with grape growers of Theni	Apr 13	Theni, Tamil Nadu	25 farmers
Interaction meeting and field visit on ICAR-IIHR technologies for the farmers	Jul 22	Linganahalli, Hessarghatta Hobli	50 farmers
Interaction with farmers and the stake holders under RKVY project	Jul 27-28	Hosur and Dindigul, Tamil Nadu	150 farmers and entrepreneurs
Scientists and farmers interaction meet under NICRA	Aug 01	Kadur Taluk, Chikmangalur	140 farmers
Awareness program on 'Prime Minister Crop Insurance Program for Farmers'	Dec 20	Doddatumkur, Doddaballapura Taluk	60 farmers
	Mar 23	Alur, Bengaluru North	20 farmers
Jai Kissan-Jai Vigyan	Dec 29	Linganahalli, Hessarghatta Hobli	50 farmers
Awareness program on grape cultivation	Feb 18	Linganahalli, Hessaraghatta Hobli	30 farmers
Training systems in grapes	Feb 22	Linganahalli, Hesaraghatta Hobli	25 farmers
Awareness program on 'Prime Minister Crop Insurance Program for Farmers' and 'Use of bio-fertilizers in crop production'	Mar 02	Doddatumkur, Dodbalapura Taluk	15 farmers
	Mar 24	Hesaraghatta, Bengaluru North	70 farmers
Interaction meeting with grape growers of Cumbam Valley	Mar 23	Odaipatti, Theni, Tamil Nadu	25 farmers
CHES Bhubaneswar			
Research – Extension - Farmer interface meetings	Jul-Aug, 2015	10 districts of Odisha	-
CHES Chettalli			
Brain storming session and exhibition on avocado	May 27	CHES, Chettalli	-
Workshop on *Garcinia* species	Aug 20	CHES, Chettalli	-

5.5 Exhibitions

Organized/Participated	Venue	Period
ICAR-IIHR, Bengaluru		
Exhibition in connection with Horti Sangam 2015	Motiharbihar, Odisha	Apr 10-12
Mango Mela	Lalbagh, Bengaluru	May 29-31
Allalasandra Lake Festival	Yelahanka, Bengaluru	Jun 07
Kharif Kissan Sammelan-2015	Muzaffarnagar	Jun 27
Agri Tech India 2015, Bengaluru	IEC, Bengaluru	Aug 21-23
3rd International symposium on *Phytophthora*	IIHR Bengaluru	Sep 09-12
Krishi Mela -2015	UAHS, Shimoga	Oct 03-06
Launching of phenomics national facility under NICRA	IIHR,Bengaluru	Nov 01
Krishi Mela 2015	UAS, Bengaluru	Nov 19-22
Thotagaarike-Mela (Horticulture Fair-2015)	UHS, Bagalkot	Dec 19-21
ICAR Pavilion in the Indian Science Congress-2016	Mysore	Jan 03-07
Kisan Mela cum Exhibition of ICAR-CPCRI Centenary Celebrations	CPCRI, Kasargod	Mar 12
Krishi Unnathi Mela	New Delhi	Mar 19-21
CHES Bhubaneswar		
Agri Fair	Motiharbihar, Odisha	Apr 10-12
Agri Fair	CRRI, Cuttack	Apr 23
Regional Agriculture Fair	KVK, Muzaffarnagar	Jun 27
Agri Fair	KVK, CIFA.	Jul 20
Agri Fair	Motiharbihar, Odisha	Aug 20-21
Agri Fair	OUAT, Bhubaneswar	Jan 27-28
Agri Fair	OUAT, Bhubaneswar	Feb 10-11
Inter-state Agri-Hort Fair	Baragarh, Sambalpur, Odisha	Feb 20-22
State Level *Krishi Mahotsava*	Baramunda, Bhubaneswar	Mar 11-14
CHES Hirehalli		
Jackfruit Diversity Fair cum Exhibition-2015	KVK, Hirehalli	Jun 27
Kharif Awareness Programme	KVK, Hirehalli	Aug 07
Jai Kisan Jai Vigyan		Dec 29
Rabi Awareness Programme	KVK, Hirehalli	Jan 23
KVK Gonikoppal		
Avocado Day	CHES, Chettalli	May 27
Krishi Abhiyana Programme	Kudige, Sowmwarpet	Aug 12
Rambutan Day	CHES, Chettalli	Oct 10
Swasraya Bharath - Science and Technology	Calicut	Oct 19- 21
Krishi Mela	Forestry College, Ponnampet	Nov 23
Litchi Day	CHES, Chettalli	Dec 10
ICAR Pavilion in the Indian Science Congress-2016	University of Mysore, Mysore	Jan 04-07

Organized/Participated	Venue	Period
Krishi Vigyan Kendra, Hirehalli		
Jackfruit Diversity Fair cum Exhibition-2015	CHES/KVK, Hirehalli	Jun 27
Kharif Awareness Programme	KVK, Ramanagara	Aug 05
Kharif Awareness Programme	KVK, Hirehalli	Aug 07
Krishi Mela -2015	UAHS, Shivamogga	Oct 03-06
Krishi Mela - 2015	UAS, Bengaluru	Nov 19-22
Jai Kisan Jai Vigyan	KVK, Hirhalli	Dec 29
ICAR Pavilion in the Indian Science Congress-2016	Mysore	Jan 03-07
Rabi Awareness Programme	KVK, Hirehalli	Jan 23
Krishi Unnathi Mela	New Delhi	Mar 19-21

5.6 TV and Radio Programmes

Scientists of the Institute gave 30 radio and 26 television programs on the technologies developed by the Institute and other related topics of horticulture.

5.6.1 Radio Programs

The following radio programs were given by the scientists of the Institute.

Topic	Date	Station
Scientific paddy cultivation	05.06.2015	AIR, Madikeri
Mandates and activities of KVK, Gonikoppal	13.06.2015	AIR, Madikeri
Disease management in black pepper	16.06.2015	AIR, Madikeri
Back yard poultry rearing	18.06.2015	AIR, Madikeri
Scientific Bordeaux mixture preparation	20.06.2015	AIR, Madikeri
Scientific disease management in piggery	25.06.2015	AIR, Madikeri
Jackfruit mela 2015	27.06.2015	Radio Siddhartha, Tumakuru
Varieties and production technology of green leafy vegetables released by ICAR-IIHR, Bengaluru	30.07.2015	AIR, Bengaluru
Organic production of vegetable crops	31.07.2015	AIR, Bengaluru
Importance of vaccination against foot and mouth disease in animals	08.08.2015	AIR, Madikeri
Disease management in piggery	11.08.2015	AIR, Madikeri
Ginger cultivation in Kodagu	12.08.2015	AIR, Madikeri
Safe use of pesticides	14.08.2015	AIR, Madikeri
Importance of use of Arka Microbial Consortium in wilt management in black pepper	16.08.2015	AIR, Madikeri
Improved cultivation practices for different varieties and hybrids of brinjal	09.09.2015	AIR, Bengaluru
Maturity standards in onion crops, harvesting and scientific storage	16.10.2015	AIR, Bengaluru
Mixed cropping systems in coconut garden	27.10.2015	AIR, Bengaluru
Scientific piggery farming	21.11.2015	AIR, Madikeri
Disease management in black pepper	23.11.2015	AIR, Madikeri

Topic	Date	Station
Importance of soil testing and health card	05.12.2015	Radio Siddhartha, Tumakuru
Scope and potential of litchi cultivation	10.12.2015	AIR, Madikeri
Cultivation of RET medicinal plants	11.12.2015	AIR, Bengaluru
Chrysanthemum cultivation	12.01.2016	AIR, Bengaluru
SAC meeting 2016	02.02.2016	Radio Siddhartha, Tumakuru
IIHR seed kit - kitchen gardening	14.02.2016	Radio Siddhartha, Tumakuru
Rose cultivation	17.02.2016	AIR, Bengaluru
Protected cultivation of carnation	02.03.2016	AIR, Bengaluru
Terrace gardening	10.03.2016	Radio Siddhartha, Tumakuru
Lime cultivation	13.03.2016	AIR, Bengaluru
Pre and post pruning operations in the vineyard	17.03.2016	AIR, Bengaluru

5.6.2 Television Programs

The following television programs given by the scientists of the Institute were telecast on different channels.

Topic	Date	Station
Advanced production technology and improved varieties of chilli	19.06.2015	DD Chandana
Seed treatment methods in paddy	20.06.2015	TV-1
Jackfruit diversity fair cum exhibition-2015	27.06.2015	Praja Pragathi TV
	09.07.2015 & 10.07.2015	DD Chandana
Disease control and management in pigs	04.07.2015	DD Chandana
Kharif awareness programme -2015	07.08.2015	DDK, Bengaluru
Leafy vegetable varieties released by ICAR-IIHR, Bengaluru	04.09.2015	DD Chandana
New varieties of brinjal and their production technology	09.09.2015	DD Chandana
Recently developed improved vegetable varieties of ICAR-IIHR	10.09.2015	DD Chandana
ICAR-IIHR improved variety of palak, Arka Anupama	13.10.2015	DD Chandana
Mango ripening chamber	20.11.2015	DDK, Bengaluru
IIHR farmer friendly technologies	21.11.2015	DDK, Bengaluru
Horticultural entrepreneurship through selected Horti. technologies	22.11.2015	SAMAYA 24x7
Importance of soil testing and soil health card	05.12.2015	Praja Pragathi, Tumakuru
Scope and potential of litchi cultivation	10.12.2015	DD Chandana
Improved onion varieties and production	19.12.2015	DD Chandana
Vegetable cultivation during summer	29.12.2015	DDK, Bengaluru
Improved variety of French bean and vegetable cowpea	31.12.2015	DD Chandana
Field day on Arka Rakshak	06.01.2016 & 07.01.2016	DD Chandana
Pruning in custard apple hybrid Arka Sahan	07.01.2016	DD Chandana
Pomegranate cultivation	14.02.2016	Praja Pragathi, Tumakuru
Prime Ministers *Fasal Bima Yojana* by Honourable Prime Minister of India Shri Narendra Modi	27.02.2016	DDK, Bengaluru
Management of papaya cultivation	15.03.2016	DDK, Bengaluru
Field demo of vegetable varieties/ F_1 hybrids	31.03.2016	DD Chandana

5.7 Agricultural Technology Information Centre (ATIC)

The Agricultural Technology Information Centre (ATIC) was visited by 2,825 growers seeking information on crop-specific problems, improved crop production technology aspects, solutions to real-time farming situations and ICAR-IIHR technology commercialized products and their usage. In addition, knowledge sharing with growers from different parts of the country on production of horticultural crops through telephony/ internet was also undertaken. Impact assessment of adoption of micronutrient specials, banana and vegetable was carried out. A revenue of Rs. 47.12 lakhs was realized through sale of products/literature and other services.

Product / Publication	Quantity	Revenue Generated (Rs)
Products	45245 Kgs	45,42,647.00
Publications	9230 Nos.	1,69,898.00
TOTAL		**47,12,545.00**

5.8 Vegetable Breeder Seed Production Programmes

The vegetable seed production unit organized vegetable breeder seed production programmes at ICAR-IIHR campus, Hesaraghatta, IIHR-IVRI campus, Yelahanka and in farmers fields under Seed Village Concept. During this year, a total quantity of 18239 kgs seeds was produced which includes 56 open pollinated vegetable varieties and hybrids.

Seed production in farmer's fields

5.9 Sale of Quality Seeds and Planting Material

5.9.1 ICAR-IIHR, Hesaraghatta

A total quantity of 17132.48 kg of vegetable seeds was sold to public/private sector organizations and farmers.

Crop	Variety & Quanity (Kg)
Tomato	Arka Vikas (190.1), Arka Saurabh (6.1), Arka Meghali (63.3), Arka Alok (4.3), Arka Abha (11.4), Arka Samrat (F_1) (22.1), Arka Rakshak (F_1) (71.0)
Chilli	Arka Lohit (152.1), Arka Suphal (13.3), Arka Harita (F_1) (13.9), Arka Meghana (F_1) (45.7), Arka Kyati (F_1) (2.3)
Brinjal	Arka Shirish (31.2), Arka Kusumakar (124.9), Arka Nidhi (2.9), Arka Keshav (2.5), Arka Neelkanth (83.7), Arka Anand (F_1) (32.2)
Watermelon	Arka Manik (34.5), Arka Muthu (7.2)
Roundmelon	Arka Tinda (9.6)
Muskmelon	Arka Jeet (3.5)
Longmelon	Arka Sheetal (0.2)
Bush squash	Patty Pan (3.2)
Pumpkin	Arka Suryamukhi (546.6), Arka Chandan (3.6)
Bottle gourd	Arka Bahar (199.0)
Bitter gourd	Arka Harit (11.3)
Ridge gourd	Arka Sujat (11.2), Arka Sumeet (6.1)
Okra	Arka Anamika (1627.2)

Crop	Variety & Quanity (Kg)
Onion	Arka Kalyan (303.9), Arka Niketan (405.9), Arka Pragathi (15.8), Arka Bindu (275.3), Arka Pitamber (0.3), Arka Bheem (171.7), Arka Lalima (F_1) (190.7), Arka Kirthiman (F_1) (318.4)
Cowpea	Arka Suman (525.4), Arka Garima (209.7), Arka Samrudhi (90.0)
Yard long bean	Arka Mangala (1173.8)
Garden pea	Arka Ajit (17.9), Arka Sampoorna (1.6), Arka Karthik (51.6)
French bean	Arka Komal (901.9), Arka Suvidha (1771.3), Arka Anoop (761.9), Arka Sharath (3861.8)
Veg. Amaranth	Arka Suguna (793.7), Arka Arunima (147.6), Arka Varna (38.8), Arka Samraksha (8.0)
Palak	Arka Anupama (168.9)
Dolichos	Arka Jay (935.4), Arka Amogh (24.6), Arka Sowmya (46.0), Arka Sambhram (52.6), Arka Swagath (372.9)
Garden pea	Arka Priya (33.1), Arka Apoorva (47.9)
Coriander	Arka Isha (77.4)
Total	**17,132.48**

Papaya Seed Production

Variety	Quantity	
	Production (g)	Supply (g)
Arka Prabhath	380	414
Arka Surya	587	568

Planting Material Distribution

Crop	Variety (in Nos.)
Mango	Alphonso (2954), Mallika (844), Dasheri (825), Raspuri (1120), Amrapali (255), Totapuri (1450), Banganapalli (1440), Kesar (25), Langra (73), Arka Aruna (99), Arka Puneeth (70), Arka Anmol (82), Arka Neelkiran (70), Himayat Pasand (190), Arka Udaya (120)
Guava	Arka Mridula (1405), Arka Kiran (1340), Arka Rashmi (422)
Sapota	Cricket Ball (1439), Hybrid (8)
Annona	Arka Sahan (9747), Balanagar (983)
Drumstick	7579
Pomegranate	Bhagwa (369)
Curry leaf	837
Jackfruit	633
Fig	1796
Papaya	Arka Prabhath (1911), Arka Surya (2717).
Lime	119
Grape	Dogridge (53)
Jamun	764
Palms plant	9
Duranta (rooted plants)	100
Red ginger	22

5.9.2 CHES, Hirehalli

Crops	Variety (in Nos.)
Arecanut	Hirehalli Tall (11328)
Betelvine	Hirehalli Local (1690), Mysore Chigru (750), Pavagada Local (1225)
Jack Fruit	Palur-1 (110), Toobugare Red (103)
Avocado	Seedlings (74)
Drum Stick	PKM-1 (3806)
Grape Rootstock	Dogridge (577)

5.9.3 KVK, Gonikoppal

Crops	Variety (in Nos.)
Coffee	S -274 (18000)
Arecanut	Theerthalli (4050)
Black Pepper	Panniyur-1Hybrid (3300)
Fodder	CO-3 (10000), CO-4 (1000), NB-21 (500), Sampoorna (205)

5.10 Supply of Farm Machinery

A revenue of Rs. 4,46,108/- was generated by the supply of the following machineries/drawings to various firms. A MoU was signed for commercialization of machineries developed.

Technology transferred	Name of the firm/organization
Lime harvesters – 200 Nos.	Horticulture Research and Extension Station, Vijaypur, Tidagundi (PO), UHS, Bagalkot
Mushroom spawn production machinery	Mr. T. Karthikeyan, Chennai
Manual drawn onion seeder	M/s Team Flame
Animal drawn onion seeder	M/s Team Flame
Spawn production machinery	M/s 4s Foods, Chennai
Power operated garlic bulb breaker	M/s Team Flame
Mango harvester-100 Nos	ATIC, ICAR-IIHR, Bengaluru
Lime harvester-100 Nos.	ATIC, ICAR-IIHR, Bengaluru
Mango dipping tool-100 Nos.	Maharashtra State Mango-Cashew Board, Ratnagiri
Sale of Harvesters	Various exhibitions

5.11 Sale of Mushroom Spawn and its Impact

Technology aspect	Quantity/Value
Spawn sold during the period April 2015-March 2016	36.44 tons
Revenue generated for the institute	Rs. 20,44,138
Estimated impact	
Mushroom produced through 36.44 tons spawn @ 3 Kg fresh mushroom per Kg of spawn	109.32 tons
Employment generated @ 150 mandays/ton/annum	16398 mandays (45 people employed for one year)
Protein produced @ 2% of fresh weight	2.186 tons
Land used for production @ 0.1HA / ton	10.93 h
Paddy/ wheat straw recycled @ 0.5 kg fresh mushrooms/1 kg dry straw	218.64 tons
Spent Mushroom Substrate (SMS) obtained for recycling as vermi-compost	174.91 tons

5.12 On Farm Trials

Name of the Trial/Technology	Village	No. of Trials
KVK, Gonikoppal		
Assessment of ginger variety IISR Mahima for higher yield	Konangeri, Hudikeri	05
Assessment of planting system in Nendran banana	Nalloor, Balele, Athur	05
Assessment of foot rot disease management in black pepper	Ponnampet, Balyamandoor, Hudikeri	05
Assessment of alternative medical approach for treatment of bovine fibro papiloma/warts and induction of para-immunity in cows	Nalkeri, Hanchinadu, Badagarakeri	10
KVK, Hirehalli		
Assessment of arecanut-French bean intercropping system for high soil fertility and higher income	Tanaganahalli, Kadernahalli	07
Evaluation of technology for management of pomegranate wilt	Kothanur, Mangalawada	07
Assessment of red gram: green gram (1:4) as an intercrop in mango orchard for climate resilient agriculture	Baichanahalli, D.Nagenahalli,Vaddarahalli	07

Visit of Hon'ble Union Minister of Agriculture and Farmers Welfare to Agri Fair organized by CHES, Bhubaneswar

Visit of Hon'ble Minister of State for Agriculture to ICAR-IIHR stall during Kharif Kisan Sammelan at KVK, Muzzafarnagar

Field visit by Hon'ble DG, ICAR and DDG (HS) ICAR

Distribution of biopesticides during the training programme at KVK, Virinjipuram, Tamil Nadu

Distribution of biopesticides to polyhouse growers during the training programme in Chikkaballapur

6. Education, Training and Capacity Building

6.1 Post-Graduate Education

Imparting Ph.D. (Horticulture) and Ph.D. (PHT of horticultural crops), as an outreach program of IARI, New Delhi and facilitating the research guidance and course work of students of various universities as per MoU are the main activities. ICAR-IIHR has MoU with reputed universities such as ICAR-IARI, New Delhi; UAS, Bengaluru & Dharwad; UHS, Bagalkot; TNAU, Coimbatore; Sri Krishnadevaraya University, AP; Sher e-Kashmir University of Agricultural Science & Technology, UAHS, Shimoga; Gandigram Rural Institute Deemed University, Tamil Nadu; Jawaharlal Nehru Krishi Viswa Vidyalaya, M.P; Jain University, Bengaluru, and Dr. Y.S.R. Horticultural University (Formerly APHU) for imparting higher education in horticultural sciences. Scientists of the Institute have been recognized as faculty/guides by these universities and offer various courses and guide students for their research work.

6.1.1 List of PG courses offered

Course No	Course Title	Course Leader
III Trimester of 2014-15 academic session for IARI/IIHR students		
HORT 621 / FLA 673	Growth and development of horticultural crops (3+2)	Dr. V. Ravindra
VSC 622	Biotechnology for vegetable crops improvement (3+1)	Dr. E.S. Rao
VSC 621	Breeding of self-pollinated vegetable crops (3+1)	Dr. K. Madhavi Reddy
PHT 622	Value addition in ornamental crops (1+1)	Dr. Sangama
PGS 506	History of agriculture (1+0)	Dr. M.R. Hegde
GP 604	Innovative approaches in plant breeding (2+1)	Dr. Tejaswini
GP 605	Breeding for stress resistance (3+0)	Dr. D.H. Sukanya
PL PATH 513	Disease resistance in plant (2+0)	Dr. S. Sriram
PL PATH 604	Molecular basis of host pathogen interaction (2+1)	Dr. M. Krishna Reddy
MBB 703	Advances in molecular breeding and genomics (3+0)	Dr. Vageesh Babu
PP 603	Principles of plant physiology II (3+0)	Dr. K.S. Shivashankara
SSAC 510	Management of problem soils and waters (3+1)	Dr. L.R. Varalakshmi
I Trimester of 2015-16 academic session for IARI/IIHR students		
FSC 602	National horticultural problems and current issues in fruit production (4+0)	Dr. Reju M. Kurian
HORT 601 / PHT 601 / FLA 670	Export oriented horticulture (3+1)	Dr. D.V.S. Rao
VSC 601	Hi-tech vegetable farming (3+1)	Dr. S.S. Hebbar
PHT 603	Advances in food processing and quality management (3+1)	Dr. I.N.D.Gowda
PGS 501	Library and information services (0+1)	Mr. Prasad, S
PGS 502	Technical writing and communication skills (1+1)	Dr. Venkattakumar,R
PGS 505	Agricultural research, research ethics and rural development programmes (1+0)	Dr. B. Balakrishna
PP 602	Responses of plants to abiotic stresses	Dr. R.M. Bhatt
PP 601	Techniques in plant physiology (1+2)	Dr. R.H. Laxman

Course No	Course Title	Course Leader
	II Trimester of 2015-16 academic session for IARI/IIHR students	
FSC 611	Breeding of fruit crops (4+1)	Dr. M. Sankaran
VSC 611	Breeding of cross-pollinated vegetable crops (3+1)	Dr. R. Veera Gowda
FLA 611	Commercial floriculture (3+1)	Dr. H.P. Sumangala
FLA 621	Advanced breeding of ornamental crops (3+1)	Dr. C. Aswath
PHT 612	Post harvest management of horticultural crops (3+1)	Dr. D.V. Sudhakar Rao
PHT 614	Principles and practices of food handling and packaging (2+1)	Dr. C.K. Narayana
FSC 691	Seminar (1+0)	Dr. J. Satisha
VSC 691	Seminar (1+0)	Dr. A.T. Sadashiva
FLA 691	Seminar (1+0)	Dr. C. Aswath
PHT 691	Seminar (1+0)	Dr. H.S. Oberoi
PL PATH 691	Seminar (1+0)	Dr. M. Krishna Reddy
SSAC 691	Seminar (1+0)	Dr. A.N. Ganeshamurthy
PP 691	Seminar (1+0)	Dr. K. S. Shivasankara
GP 691	Seminar (1+0)	Dr. A. Rekha
MBB 691	Seminar (1+0)	Dr. Vageesh Babu, H
FSC 691	Seminar (1+0)	Dr.P.Sampath Kumar
PL PATH 504	Principles of plant pathology (3+0)	Dr. S. Sriram
MBB 601	Molecular breeding (3+0)	Dr. D. Lakshmana Reddy
MBB 511	Biotechnology lab-II (0+3)	Dr. Usha Rani
MB 507	Food microbiology (3+2)	Dr. K. Ranjitha
AG504	Principles and practices of water management (3+1)	Dr. Anil Nair
PP504	Hormonal regulations of plant growth and development (3+1)	Dr. K.K. Upreti
	Academic session 2015-16 for UHS (B) students	
HST 601 (Ph.D)	Applied regression analysis (2+1)	Dr. R. Venugopalan
FLA 601 (Ph.D)	Advances in flower production technology of flower crops (2+1)	Dr. Rajiv Kumar
BCI 606 (Ph.D)	Emerging trends in seed quality enhancement (2+1)	Dr. K. Bhanu Prakash
PMA 603 (Ph.D)	Advances in breeding of medicinal & aromatic crops (2+1)	Dr. K. Hima Bindu
FSC 605 (M.Sc)	Breeding of fruit crops (2+1)	Dr. M. Sankaran

6.1.2 PG student's admission for the academic year 2015-16

The second batch of ICAR-IIHR, Ph.D. programme commenced on 08.08.2015 with 16 students (three in Fruit & Horticulture Technology, six in Vegetable Science, four in PHT of horticultural crops and three in Floriculture & Landscape Architecture) admitted as an outreach program of ICAR-IARI, New Delhi.

6.1.3 Allotment of students to research guides

Name	Discipline	Research guide
❖ **ICAR-IARI Students**		
Jagadeesha Mulagund	FHT	Dr. M. R. Dinesh
Shaili Kumari	FHT	Dr. B. N. S. Murthy
Subhash Chander	FHT	Dr. P. Sampath Kumar
Amarjeet Kumar Rai	VSC	Dr. A. T. Sadashiva
Manish Kumar	VSC	Dr. K. Madhavi Reddy
Prasanth K.	VSC	Dr. B. Varalakshmi
Bommesh J.C	VSC	Dr. M. Pitchaimuthu
Ajay Kumar Pandav	VSC	Dr. R. Veere gowda
Vinod Jatav	VSC	Dr. A. T. Sadashiva
Sunil Kumar	FLA	Dr. Rajiv Kumar
Narendra Singh Bhandari	FLA	Dr. C. Aswath
Bhanu murthy K.C	FLA	Dr. Sujatha Nair
Pallavi Neha	PHT	Dr. D. V. Sudhakar Rao
Jayasheela D.S	PHT	Dr. C.K. Narayana
Chethan Prasad H.P	PHT	Dr. R. B. Tiwari
❖ **UHS (B) PG Students**		
Ms. Alfia	M.Sc. (FSC)	Dr. C. Vasugi
Ms. E.Nandhini	M.Sc. (VSC)	Dr. K. Padmini
Ms. A. Kalaiarasi	M.Sc. (FLA)	Dr. M. V. Dhananjaya
Ms. S. Pavitra	M.Sc. (FLA)	Dr. M. V. Dhananjaya
Ms. K.N. Shilpa	M.Sc. (FLA)	Dr. Anuradha Sane
Ms. M.R. Vinuta	M.Sc. (FLA)	Dr. Tejaswini
Ms. P.M. Aprana	M.Sc. (PSMA)	Dr. M.A. Suryanaryana
Ms. S. Narmatha Dayana	M.Sc. (PSMA)	Dr. K. Hima Bindu
Ms. V. S. Karthik Nayaka	M.Sc. (PHT)	Dr. Shamina Azeez
Ms. Deepa Pujar	Ph.D. (FSC)	Dr. C. Vasugi
Mr. G.M. Vinay	Ph.D. (FSC)	Dr. T. Sakthivel
Mr. G. N. Manjesh	Ph.D. (PSMA)	Dr. Hima Bindu
Mr. Shivakumar	Ph.D. (FLA)	Dr. Tejaswini
Mr. T. Manujunath	Ph.D. (PHT)	Dr. I.N.D. Gowda
❖ **DRYSRHU PG Students**		
A. Ganesh	M.Sc. (Horti.) Fruit Science	Dr. G. Karunakaran
G. Sandhya Rani	M.Sc. (Horti.) Fruit Science	Dr. M. Sankaran
Sunitha Patil	M.Sc. (Horti.) Fruit Science	Dr. J. Satisha
H.K. Swetha	M.Sc. (Horti.) Fruit Science	Dr. Kanupriya
Dhananjay V. Naik	M.Sc. (Horti.) Vegetable Science	Dr. K. Padmini
Tejashwini Rathod	M.Sc. (Horti.) Vegetable Science	Dr. S. S. Hebbar
D. Priyanka Gandhi	M.Sc. (Horti.) FLA	Dr. Usha Bharathi
K. Raja Babu	M.Sc. (Horti.) FLA	Dr. H.P. Sumangala
S. Swagath Kumar	M.Sc. (Horti.) FLA	Dr. Anuradha Sane
K.T. Tanusha	M.Sc. (Horti.) FLA	Dr. S. Sangama
M.R. Manoj	M.Sc. (Horti.) PSMA	Dr. M.A.Suryanarayana

6.1.4 IIHR scientists as Faculty/Guide/Advisor to other universities

The following scientists have been recognized as faculty/guide/advisor by various universities for guiding M.Sc./Ph.D. students.

- Dr. Anil Kumar Nair - Co-guide for one M.Sc. (Hort.) student and one Ph.D. (Hort.) student of UHS, Bagalkot.
- Dr. Dhananjaya, M.V. - Chairman of advisory committee of one Ph.D. and 2 M.Sc. students of UHS, Bagalkot and member of advisory committee of 2 M.Sc. students of UHS Bagalkot.
- Dr. Hebbar, S.S. - Guide for one M.Sc.(Hort.) student of UHS, Bagalkot and Co-Guide for one Ph.D. student registered to GRI, Dindigal.
- Dr. Hima Bindu, K. - Member of advisory committee for one M.Sc. student of UHS, Bagalkot, and one from UAHS, Shimoga.
- Dr. Laxman, R.H. - Guide for one Ph.D. student from Jain University, Bengaluru.
- Dr. Leela Sahijram - Member, advisory committee for one each Ph.D. (Hort.) scholars from UHS, Bagalkot and UAS, Bengaluru and two from Institute of Wood Science Technology (IWST), Bengaluru.
- Dr. Padmini, K. - Guide for one M.Sc. (Vegetable Science) student each of UHS, Bagalkot and Dr. YSRH University, Venkataramaguddam.
- Dr. Shivashankara, K.S. – Guide for one Ph.D. student each from Kuvempu and Jain Universities.
- Dr. Sreenivasa Murthy, D. - Major advisor for two M.Sc. students of UAS, Bengaluru.
- Sujatha A. Nair- Guide for two Ph.D. students and member of Advisory committee of two Ph.D. students.
- Dr. Suryanarayana, M.A. - Guide for one M.Sc. student and one Ph.D. student of UHS (B) and one M.Sc. student from Dr. YSRHU, V.R.Gudem.
- Dr. Upreti, K. K. - Guide for one Ph.D. student of Kuvempu University, Shimoga and member advisory committee for four Ph.D. and one M.Sc. students of UHS, Bagalkot.
- Dr. Vageeshbabu S. Hanur - Chairman for one Ph.D. student of JNTU, Hyderabad and Member, Advisory Board for a Ph.D. student each of IWST, and UHS, Bagalkot.
- Dr. Vasugi, C. - Guide for one M.Sc. student and one Ph.D. student from UHS, Bagalkot.
- Dr. Veere Gowda, R - Guide for one M.Sc. (Hort.), student of UHS Bagalkot and member of the advisory committee of one Ph.D. (Hort.) student of UAS, Bengaluru, three M.Sc. (Hort.) students of UHS Bagalkot and one M.Sc. (Agri), in Seed Technology student of UAS, Bengaluru.

6.1.5 Award of M.Sc. and Ph.D. degrees

The following students pursuing their post graduate studies under the guidance of IIHR scientists were awarded degrees:

Student	University	Degree	Thesis title	Name of the guide
Mr. S.R. Shivuprasad	Kuvempu University, Shimoga	Ph.D.	Phenological and biochemical changes associated with off season flowering and regular bearing habits in mango	Dr. K.K. Upreti
Mr. Ansar Hussain	UHS, Bagalkot	Ph.D. (Hort.)	Assessment of ploidy levels and tracing half-sib parentage using DNA markers in carnation (*Dianthus caryophyllus* L.)	Dr. M.V. Dhananjaya
Ms. Reshmi Upreti	Jawaharlal Nehru Technological University, Hyderabad	Ph. D. in Bio-technology	Host - Pathogen (*Ralstonia solanacearum*) - bacterial endophyte interaction in tomato	Dr. Pious Thomas
Mr. Manjesh	UHS, Bagalkot	M.Sc.	Investigations on morphological, biochemical and molecular variability in Kalmegh (*Andrographis paniculata* Nees.)	Dr. K. Hima Bindu
Mr. Ratan Das	UHS, Bagalkot	M.Sc. (Hort.)	Molecular characterization and population structure analysis for purple blotch disease resistance in onion (*Allium cepa* L.) genotypes	Dr. R. Veeregowda

6.1.6 Thesis evaluation

- Dr. J.B. Mythili evaluated a Ph.D. thesis of Ms. P. Vijayalakshmi entitled 'Screening of aromatic rice's for NUE and identification of genes associated with nitrogen use efficiency in rice" from Department of Biotechnology, JNTU.

6.1.7 IIHR Scientists as External Examiners

- Dr. T.M. Gajanana acted as external examiner for conducting thesis viva voce of one Ph.D. student in the Department of Agribusiness Management, UAS Dharwad.
- Dr. Sudha Mysore acted as external examiner for conducting thesis viva voce of five M.Sc. students in the Department of Agricultural Economics, UAS Raichur
- Dr. J.B. Mythili served as external member, qualifying examination of a Ph.D. student, UAS Dharwad.

6.2 Training and Capacity Building

6.2.1 Trainings attended

Category	No. of trainings planned for 2015-16 as per Annual Training Plan	No. of employees undergone training during 2015-2016	% realization of trainings planned during 2015-16
Scientist	19	14	74
Technical	13	37	285
Administrative & Finance	2	5	250
Skilled Supporting Staff	0	63	NA
Total	34	119	129

- Dr. A. Carolin Rathinakumari participated in the one week training programme on 'Certification Course on Solar PV Integration Level-1' – organised by Nirvana Foundation, Bengaluru, 20-25 Jul, 2015.
- Mr. M. Senthilkumar attended the three months professional attachment training at Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam from 01 Jul, 2015 to 30 Sep, 2015.
- Ms. Susmita C. underwent three months professional attachment training at Centre for Cellular & Molecular Biology (CCMB), Hyderabad on 'Cloning of plant defense response associated rice genes for overexpression and under expression studies' from 03 Aug, 2015 to 04 Nov, 2015.
- Dr. E. Sreenivasa Rao participated in the Capacity building workshop for strengthening the management and monitoring of confined field trials of regulated GE crops held at UAS, Bengaluru, organised by BCIL, New Delhi, 06 Nov, 2015.
- Dr. Prakash Patil attended Management development programme on leadership development at ICAR-NAARM, Hyderabad from 30 Nov, 2015 to 11 Dec, 2015.
- **Training Programme on MS-Office to Technical Staff of IIHR:** A training programme on MS-Office was conducted by AKMU during 17-19, March 2016. Twenty six participants from 13 divisions/sections attended the programme. The training programme was inaugurated by Dr. M.R. Dinesh, Director, ICAR-IIHR. During the three days of the programme, basic features of MS-Office applications viz., MS-Word, MS-Excel and MS-Power Point were taught to the trainees.
- **Training Programme for Non-Metric / ITI casual laborers (Temporary status):** A three-day training programme was organized for "Non-Metric/ITI casual laborers (Temporary status)" during 5-7, October 2015. Among the 63 participants there were 49 from IIHR, 10 from Central Horticulture Experimental Station, Chettalli and 4 from KVK, Gonikoppal. The participants were imparted training on behavioral etiquettes with senior officers and colleagues, values and ethics, office procedures, vigilance and RTI, basic knowledge of computers/typing, works in finance section, farm management (crop

harvest and disposal, sales counter operations, safeguarding institute properties), gardening and nursery management, lab-related work (log book maintenance, handling of chemicals, maintenance of chemicals and glass wares), management of guest house/ hostel work in library (maintenance of magazines/ newspaper records, shifting/shorting of publication as per category of publication), maintenance of spray and other equipments, tractor and heavy vehicle maintenance etc. The participants were also apprised of different activities, achievements and technologies of the institute. Additionally all the participants were taken to demonstration and experimental fields, sales units and various labs. The average knowledge gain of the participants was 34 % from this training programme. Dr. B. Balakrishna, Mr. Alok Kumar and Dr. R. Venkattakumar organized this programme.

HRD fund allocation and utilization

RE 2015-16 for HRD (Lakh Rs.)			Actual Expenditure for HRD (2015-16)	% Utilization
Plan	Non plan	Total		
12	0	12	12	100

6.2.2 Trainings imparted

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

- Two M.Tech. (Agrl. Engg.) students in Processing and Food Engineering from UAS, Bengaluru.
- Two M.C.A. Students of P.E.S. College of Engineering, Bengaluru.
- Six B.Tech. (Agrl. Engg.) students, College of Agricultural Engineering, Madakasira, Anantapur.
- Six B.Tech. (Agrl.Engg.) students, College of Agricultural Engineering, Sanga Reddy.
- Two B.Sc. (Agri Biotech) Students for their project work.
- One PG student from Kuvempu University.
- Five B.Sc. (Biotech) students from UAS, Hassan.
- Two students of BE Biotechnology, Acharya Institute of Technology Bengaluru.
- One M.Sc. student from Sam Higginbottom Institute of Agriculture, Technology and Science, Allahabad.
- Two M.Sc. students of Dhanalakshmi Srinivasan College of Arts and Science for Women, Perambalur.

6.3 Winter School organized

ICAR-Winter School on 'Advanced Breeding Strategies for Biotic and Abiotic Stress Tolerance in Vegetable Crops' was organized at ICAR-IIHR, Bengaluru from 8 to 28 October 2015.

Participants of the ICAR-Winter School

6.4 ARS probationers who underwent three months professional attachment training

Name of the Scientist	Name of the Parent Institute	Name of the Guide
Mr. Hanume Gowda	ICAR- Central Tuber Crops Research Institute, Sreekariyan, Thiruvanthapuram	Dr. K. Madhavi Reddy, Division of Vegetable Crops
Ms. Swosti Suvadarsini Das	ICAR- Indian Institute of Soil & Water Conservation, Dehradun, Uttarakhand	Dr. C. Vasugi, Division of Fruit Crops
Mr. Paresh Baldeorao Chakhande	ICAR- Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh	Dr. T.S. Aghora, Division of Vegetable Crops
Mr. Darshan Manikrao Kadam	ICAR- Indian Institute of Soil & Water Conservation, Dehradun, Uttarakhand	Dr. Reju M Kurian, Division of Fruit crops
Mr. Chaudhari Ganesh Vasudeo	ICAR- Vivekananda Parvatiya Krishi Anusanhan Sansthan, Almora, Uttarakahand	Dr. M. Pitchaimuthu, Division of Vegetable Crops
Ms. Divya Parisa	ICAR Central Island Agricultural Research Institute, Port Blair	Dr. S.S. Hebbar, Division Vegetable Crops
Jotirmayee Lenka	ICAR- Central Institute for Subtropical Horticulture, Rehman Khera P.O, Kakori, Lucknow, Uttar Pradesh	Dr. R.B. Tiwari, Division of Post-Harvest Technology
Ms. Gayatri Bandaru	ICAR- Indian Institute of Oil Seeds Research, Rajendranagar, Hyderabad, A.P.	Dr. Uma Maheshesweri, Division of Entomology & Nematology
Ms. P. Preethi	ICAR- Indian Institute of Soil & Water Conservation, Dehradun, Uttarakhand	Dr. J. Sathisha, Division of Fruit Crops
Ms. Panjavarnam	ICAR- Central Plantation Crops Research Institute, Kasaragoad, Kerala	Head, Division of Fruit Crops
Dr. Nithya Chandran	ICAR- Indian Agricultural Research Institute, New Delhi	Dr. R. Asokan, Division of Biotechnology
Mr. Nayan Deepak	ICAR- Indian Agricultural Research Institute, New Delhi	Dr. K.V. Ravishankar, Division of Biotechnology
Mr. Khapte Pratapsingh Suresh	ICAR- Central Arid Zone Research Institute, Jodhpur, Rajasthan	Dr. T.H. Singh, Division of Vegetable Crops
Dr. Hammylliende Telanga	ICAR Research Complex for NEH Region, Umiam, Meghalaya	Dr. A. Rekha, Division of Fruit Crops
Mr. Sudheer Kumar Annepu	ICAR- Directorate of Mushroom Research, Chambaghat, Solan	Dr. Meera Pandey, Division of Plant Pathology
Mr. Paresh Chakhande	ICAR- Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh	Dr. R. Veere Gowda and Dr. T.S. Aghora, Division of Vegetable Crops
Mr. Keshav Kant Gautham	ICAR - Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh	Dr. B. Varalakshmi, Division of Vegetable Crops
Mr. Paresh Chaukhande	ICAR- Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh	Dr. R. Veere Gowda, Division of Vegetable Crops
Ms. Nitika Gupta	ICAR- Directorate of Floricultural Research, Pune	Dr. M. Krishna Reddy, Division of Plant Pathology

Name of the Scientist	Name of the Parent Institute	Name of the Guide
Mrs. Rohini M.R.	ICAR- Directorate of Medicinal and Aromatic Plants Research, Boriavi	Dr. T. Vasantha Kumar, Section of Medicinal Crops
Mr. Prabhulinga Tenguri	ICAR- Central Institute for Cotton Research, Nagpur	Dr. R. Asokan, Division of Biotechnology
Dr. S.Vijaya Rakesh Reddy	ICAR- Central Institute for Arid Horticulture, Bikaner	Dr. C. Vasugi, Division of Fruit Crops, Dr. D.V. Sudhakar Rao, Division of Post-Harvest Technology Dr. K.S. Shivashankar, Division of Plant Physiology & Bio chemistry
Mr. K. Gangadhara	ICAR- Central Institute for Arid Horticulture, Bikaner	Dr. M. Pitchaimuthu, Division of Vegetable Crops
Mr. Mohd Abas Shah	ICAR- Central Potato Research Institute, Shimla	Dr. K.G. Pillai, Division of Vegetable Crops
Mr. Bhukya Narshima Swamy	ICAR-Vivekanand Parvatiya Krishi Anusandhan Sansthan, Almora, Uttarakhand	Dr. K. Madhavi Reddy, Division of Vegetable Crops
Ms. Sirisha Tadigiri	ICAR-Central Tuber Crops Research Institute, Tiruvananthapuram	Dr. R. Umamaheshwari, Division of Entomology
Ms. B.G.Sangeetha	ICAR-Central Tuber Crops Research Institute, Tiruvananthapuram	Dr. R. Asokan, Division of Biotechnology
Mr. Nakul Gupta	ICAR-Indian Institute of Vegetable Research, Varanasi	Dr. K. Bhanupraksh, Section of Seed Science & Technology

6.5 Field Experience Training (FET) of ARS Probationers

The Division of Extension and Training, ICAR-IIHR and KVK Hirehalli, IIHR facilitated the Field Experience Training of a batch of ARS probationers of the 103rd FOCARS programme of ICAR-NAARM, Hyderabad. The FET participants were placed in the Kolihalli village of Tumakuru District and necessary technical guidance and logistic support were provided to them.

ARS probationers of the 103rd FOCARS of ICAR-NAARM, Hyderabad at Kolihalli, Tumakuru District

7. Awards and Recognitions

7.1 Awards

- Dr. P.C. Tripathi and Dr. Kanupriya were awarded the "Young Scientist Award" by Mehta Foundation, Salem.
- ICAR-IIHR stall was awarded the first prize in the *Krishi Mela* held at University of Agricultural Sciences, Bengaluru during Nov. 19-22, 2015.

Dr. B Narayanaswamy, Principal Scientist receiving the best stall award

- Dr. B. Narayanaswamy was conferred "The Best Extension Worker Award" by University of Agricultural Sciences (Bengaluru) Alumni Association.
- Dr. A.T. Sadashiva was awarded the "Dr. Kalayya Krishnamurthy National Award" for Best Agricultural Research for the year 2014-15 during the golden jubilee celebrations of University of Agricultural Sciences, Bengaluru.

Dr. A.T. Sadashiva receiving the Dr. Kalayya Krishnamurthy National Award for Best Agricultural Research-2014-15 from Dr. A.S. Kiran Kumar, Chairman ISRO

- Dr. R. Asokan was awarded the "XIX Sukumar Basu Memorial Award" of ICAR-IARI, New Delhi.

Dr. R. Asokan receiving the XIX Sukumar Basu Memorial Award from the Honourable President of India

- Dr. C. Aswath was conferred the "Dr. B. P. Pal Best Scientist Award" by National Academy of Biological Sciences, Chennai.
- Dr. T. Manjunatha Rao was awarded the "Horticultural Society of India Gold Medal in Floriculture 2015".
- Dr. M.S. Rao was conferred the "Award of Excellence (Scientific Category)" during the 49th Foundation Day of ICAR-IIHR.
- KVK Gonikoppal, bagged the "Best Display Award of Avocado" during the Avocado Day organized at CHES, Chettali on May 27, 2015.
- Dr. A. Carolin Rathinakumari was awarded the "Gold Medal in the discipline of Agricultural Engineering" by the National Design and Research Forum, The Institution of Engineers (India), Bengaluru, for the development of a watermelon seed extractor.
- Dr. Leela Sahijram was awarded the "Reviewer Excellence Award" by the Indian Journal of Agricultural Science and Legume Research.

7.2 Best Paper/ Poster/ Presentation Awards

- The article 'Comparison of DRIS ratio norms of selected fruit crops' by Raghupathi, H. B., Ganeshamurthy, A. N. and Ravishankar, H. was adjudged, as the best paper published in The Indian Journal of Horticulture during 2014 by Horticultural Society of India.
- Agricultural communication needs of farmers with mobile phones in Kodagu district of Karnataka by Saju George and Veerendra Kumar - Best Paper Award by the National Council of Development Communication.

- Antioxidant potential of the under-utilized fruit karonda in relation to its phenolics by Shamina Azeez, P. C. Tripathi, G. Karunakaran, K. S. Shivashankara and T. K. Roy - Best Oral Presentation Award in the 6th International Conference on Emerging Technologies in Food and Nutrition for Health Management, organized by 3rd IIFANS- Bengaluru, May 14-15, 2015.
- *Vengaya vidhai vidhakkum eyandhiram* by G. Senthil Kumaran, A. Carolin Rathinakumari and R. Veere Gowda - Second Prize for Best Research Paper in the 1st National Conference on Agricultural Scientific Tamil, Chennai, June 13-14, 2015.
- Protray step seeder for vertical farming by A. Carolin Rathinakumari, G. Senthil Kumaran, P. Dayananda and V. Pushpalatha - Second Prize for Poster Presentation in the International Conference on Vertical Farming, Bengaluru, November 02-03, 2015.
- H.P. Sumangala received the best concept award for the live demo of the Concept-Allotment Gardens -A new way of building green infrastructures in cities, during the Landscape Fest held at Lalbagh, Bengaluru, November 11-15, 2015.
- Changing communication preferences of pepper and coffee farmers in Kodagu District of Karnataka by Saju George and Veerendra Kumar, K.V. - Best Oral Presentation in the 8th GCRA International Conference on Innovative Digital Application for Sustainable Development, organized at University of Agricultural Sciences, January 05-07, 2016.
- Doubled haploid in chili by Singh, T.H. - Best Poster Presentation Award in the National Seminar on Chilli and Turmeric: Challenges and Opportunities, UHS, Bagalkot, January 08-09, 2016.
- Evolving French bean variety for resistance to mungbean yellow mosaic virus (MYMV) by Aghora, T. S., Mohan, N., Ravishankar, K.V., Krishna Reddy, M., Samuel, D. K. and Susmita, C. - First Prize in the technical session climate on change- biotic stress at National Symposium on Vegetable Legumes for Soil and Human Health, organized at IIVR, Varanasi, February 12-14, 2016.
- Priti Sonavane - Third Prize for Poster Presentation at 6th International Conference on Plant, Pathogens and People, New Delhi, February 23-27, 2016.
- Yellows and corm rot in gladiolus: Incidence, identification and characterization of *Fusariumoxysproum* f. sp. *gladioli* by Gupta, N., Prabha, K., Kadam, G.B., Sriram, S. and N. K. Chandran - Best Poster Award in the 6th International Conference on Plant, Pathogens and People, New Delhi, February 23-27, 2016.

7.3 Recognitions

7.3.1. Professional Societies

- Dr. M. R. Dinesh, Dr. A.T. Sadashiva and Dr. Kanupriya were admitted as Fellows of Horticultural Society of India (HSI), New Delhi.
- Dr. P.C. Tripathi and Dr. Kanupriya were admitted as Fellows of Confederation of Horticultural Associations of India (CHAI), New Delhi.
- Dr. M. Krishna Reddy and Dr. S. Sriram were admitted as Fellows of Indian Phytopathological Society, New Delhi.
- Dr. A.N. Ganeshamurthy was elected as Fellow of the Indian Society of Soil Science.
- Dr. P.E. Rajasekharan was admitted as Fellow of Indian Association for Angiosperm Taxonomy (FIAT).
- Dr. M. Krishna Reddy was elected as President of Association of Pest Managament in Horticultural Ecosystems, Bengaluru.
- Dr. P.E. Rajasekharan was elected as the Councilor (South India). Indian Society for Plant Genetic Resources (ISPGR), New Delhi.
- Dr. V. Sankar was nominated as the executive councilor of Indian Society for Alliums (ISA), ICAR-DOGR, Rajgurunagar, Pune, Maharashtra.
- Dr. A.N. Ganeshamurthy delivered the 48th Professor R.V. Tamhane Memorial Lecture during the annual convention of the Indian Society of Soil Science on the occasion of the World Soil Day.
- Dr. G. Karunakaran was appointed as member of the national advisory committee for XV AZRA International Conference on Recent Advances in Applied Zoological Research, Ethiraj College for Women, Chennai.

7.3.2. Member in Editorial Boards of Journals/ Reviewer / Referee

The following scientists functioned on the editorial board of research journals

Scientist	Journal	Capacity
Dr. Aghora, T.S.	Journal of Horticultural Sciences	Editor
Dr. Rajasekharan, P.E.	Albertian Journal of Interdisciplinary Sciences	Editor
Dr. Sumangala, H.P.	Indian Society of Ornamental Horticulture	Editor
Dr. Sriram, S.	Pest Management in Horticulture Ecosystem	Associate Editor
Dr. Rekha, A.	Journal of Horticultural Sciences	Associate Editor

The following scientists were invited to peer review manuscripts submitted to research journals

Scientist	Journal
Dr. Leela Sahijram	Journal of Enzymology and Metabolism, Proceedings of the National Academy of Sciences, Biological Sciences (NASB) – India, African Journal of Agricultural Research, Journal for Biotechnology and e-JOB (Electronic Journal of Biotechnology), Journal of Horticultural Sciences
Dr. H.S. Oberoi	Bioresource Technology, Innovative Food Science and Emerging Technologies.
Dr. R. Veere Gowda	Karnataka Journal of Agricultural Sciences
Dr. Vageeshbabu S. Hanur	Current Science, Bioinfo Publications and Karnataka Journal of Agricultural Sciences
Dr. B. Varalakshmi	Journal of Horticultural Science, Agricultural Research Journal (formerly Journal of Research PAU)
Dr. P.E. Rajasekharan	Biochemical Systematics and Ecology, Science and Tech,Sky Journal of Soil Sciences and Environmental Management
Dr. P.C. Tripathi	Journal of Spices and Medicinal Crops, Karnataka Journal of Agriculture Sciences and Journal of Horticultural Sciences
Dr. Anuradha Sane	Karnataka Journal of Agricultural Sciences
Dr. H.S.Yogeesha	Journal of Horticultural Sciences, Journal of Agricultural Sciences and Karnataka Journal of Agricultural Sciences
Dr. P. Sampath Kumar	Journal of Horticultural Sciences and Journal of Agriculture & Food Chemistry
Dr. V. Sankar	Indian Journal of Horticulture Sciences and Journal of Horticultural Sciences.

7.3.3. Member in Institute Management Committees / Others

- Dr. Aghora, T S. participated 27th meeting of Institute Management Committee of ICAR- IIVR as a member.
- Dr. E. Sreenivasa Rao was nominated as member of Institute Management Committee (IMC) of ICAR-DOGR with effect from 24-6-2015.
- Dr. E. Sreenivasa Rao was nominated as member of Scientific Advisory Committee of NHRDF, Pune for the period 2015-2017.
- Dr. B. Varalakshmi was nominated as member of the 1st Task Force Committee constituted by PPV&FRA, New Delhi for finalization of the DUS test guidelines of Amaranth, Palak and Ridge gourd..
- Dr. Veere Gowda, R. was nominated as member of the onion development and market stabilisation committee by Department of Horticulture, Govt. of Karnataka.
- Dr. Veere Gowda, R. was invited by the Department of Biotechnology, GoI, to evaluate research projects submitted by various agencies.
- Dr. Veere Gowda, R. was nominated as Nodal Scientist for Bhoosmarudhi/Bhoochetana Programme of Department of Agriculture, Govt. of Karnataka for 2015-2016.

- Dr. Veere Gowda, R. was invited as expert member for assessment of horticulture faculty of University of Agricultural Sciences (UAS) Bengluru.
- Dr. S. Sriram was nominated as member of IMC of NRC on Banana for a period of three years.
- Dr. A. K. Saxena was nominated as an expert for the selection to the post of Scientist –B in Central Silk Board, Bengaluru.
- Dr. G. Senthil Kumaran served on the Institute Management Committee of ICAR-Central Institute of Agricultural Engineering, Bhopal.
- Dr. P. C. Tripathi served as member of Institute Management Committee of NRC on Citrus, Nagpur.
- Dr. J. Satisha served as a member of Institute Management Committee of ICAR-NRC on Grapes, Pune.
- Dr. Sudha Mysore was nominated as member of RAC, ICAR-IIVR, Varanasi for a period of two years from March 2015-17.
- Dr. Sudha Mysore, was identified as member ITMC, ICAR-NRCP, Sholapur during 2015.
- Dr. Sudha Mysore was nominated as the Member Secretary for screening of agri-business incubation proposals received under National Agriculture Innovation Fund (NAIF) at ICAR-NAARM, Hyderabad.
- Dr. R. Venugopalan was nominated as a member of Scientific Advisory Committee of NHRDF, Nashik for the period 2015-17.
- Dr. G. Senthil Kumaran served as a primary member of the sectional committee on Agriculture and Food Processing Equipments, Bureau of Indian Standards.
- Dr. C. K. Narayana served as Member, Technical Committee-Advisory Board, Karnataka Comprehensive Nutrition Mission, Govt. of Karnataka for implementation the World Bank funded Scheme on Women and Child Nutrition in Raichur and Kalaburagi.
- Dr. H.S. Oberoi was appointed as an expert on the scientific panel on fruits and vegetables and their products (including dried fruits and nuts, salt, spices and condiments) of FSSAI, New Delhi.
- Dr. H.S. Oberoi has been appointed as a member of the international scientific advisory committee for "The Food Factor Conference" to be held in Barcelona, Spain during November 2-4, 2016.
- Dr. Sangama was empanelled as an expert and technical consultant on dried flowers for National Skills Foundation of India, New Delhi.
- Dr. C. Aswath, Dr. Sangama and Dr. H.P. Sumangala were invited to judge show exhibits during the horticulture shows at *Lalbagh*, Bengaluru.
- Dr. C. Aswath was member of the jury for selection of best poster awards during the international seminar on sustainable horticulture held in Aizol 14th to 16th March 2016.
- Dr. C. Aswath was invited as an expert for IRC meeting of ICAR-CCRI, Nagpur.
- Dr. J.B. Mythili was nominated as the RAC member for the Dept of Biotechnology and Microbiology, The Oxford College of Science, Bengaluru for the year 2015-16.
- Dr. C. Aswath was a member of the Board of Studies of Christ College, Bengaluru for the up gradation of the UG and PG science syllabi.
- Dr. C. Aswath served as a co-ordinator for Agriculture Biotechnology during the India Bio Expo held at Bengaluru.
- Dr. T. Manjunatha Rao attended the 5th RAC meeting of ICAR-Directorate of Floricultural Research, Pune as a member.
- Dr. T. Manjunatha Rao was invited as an external member for annual technical meeting of floriculture and landscape architecture of UHS, Bagalkot.
- Dr. M.V. Dhananjaya was nominated as a member of Karnataka state level technical advisory committee for providing technical advice on scientific cost of cultivation of horticultural crops.
- Dr. M.V. Dhananjaya was nominated as the Scientist-In-charge of Chikkaballapura district for the implementation of ICRISAT-GoK, 'Bhu-Samridhi' project.

8. Linkages and Collaborations

The Institute has collaborative research and development linkages with several national (DST, DBT, NABARD, CSIR etc.) and international (AVRDC, Bioversity International etc.) organizations 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. Scientists of the Institute actively collaborate with the state departments of horticulture/ agriculture in implementation of centrally aided schemes like RKVY, NHM, CHD, etc. Following are the external aided projects under operation at the Institute.

8.1 National Fellow Project

Title of the project	Principal Investigator	Funding agency	Budget (Rs. in lakhs)
Studies on phyto-semiochemicals involved in insect-plant interaction of major horticultural pests: Deciphering chemical cues	Kamala Jayanthi, P.D.	ICAR	33.45

8.2 National Externally Funded Projects

Title of the project	Principal Investigator	Funding agency	Budget (Rs. in lakhs)
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.	Biotechnology Industry Research Assistance Council, GOI	133.56
Investigations on the potential and feasibility of SIT for management of fruit flies in mango and cucurbits	Reddy, P.V.R	BRNS, BARC, Mumbai	21.616
Monitoring of pesticide residues at national level	Soudamini Mohapatra	CSS	69.00
Screening of RIL and BIL families of the cross *Citrullus lanatus* var. citroides X *C.lanatus* var. Arka Manik and mapping of resistance to watermelon bud necrosis virus	Sreenivasa Rao, E.	DBT	45.17
Marker assisted breeding to develop a bacterial wilt resistant chilli paprika variety (*Capsicum annuum* L.) suited for the tropical regions of India	Madhavi Reddy, K.	DBT	6.09
Introgression of begomovirus resistance genes in tomato (*Solanum lycopersicum* L.) using MAS and genomic approach	Sadashiva, A.T.	DBT	156.00
Development of high throughput nano-biosensor for the detection of *Salmonella* spp. in food	Shamina Azeez	DBT	46.518

Title of the project	Principal Investigator	Funding agency	Budget (Rs. in lakhs)
Development of genotypic markers and PCR based diagnostic assay for identification of *Phytopthora infestans* associated with late blight of tomato	Krishna Reddy, M.	DBT	21.00
Development of National database on mango (Second phase of Development of Genetic Resources Database and Information System for Mango)	Dinesh, M.R.	DBT	28.23
Development of National Database on Mango (Second phase of Development of Genetic Resources Database and Information System for Mango)	Singh, H.S.	DBT	26.38
Evaluation of indigenous strain of fungal pathogen *Beauveria bassiana* against *Helopeltis* spp on guava, cashew and tea	Ganga Visalakshy, P.N.	DBT	17.968
Identification of cytoplasmic male sterility – regulated novel open reading frames in vegetable crops by mitochondrial DNA sequencing	Lakshmana Reddy, D.C.	DBT	34.404
Preventing extinction and improving conservation status of threatened medicinal plants- *Madhuca insignis* through application of biotechnological tools	Rajasekharan, P.E.	DBT	37.416
Morphological and molecular characterization of wild and indigenous mango varieties of Indo-Burma Region (North – Eastern Region)	Ravishankar, K.V.	DBT	24.6
Development of bio-agent and mycorrhiza colonized seedlings of horticultural crops by rural women for dissemination of the technology	Rao, M.S.	DBT	14.91826
Development of suitable formulation using indigenous strains of NE India for crop improvement: A Combined Holistic Approach	Rao, M.S.	DBT	18.638
Identification and breeding of Tospovirus resistance in chillies (*Capsicum annum* L.) using molecular markers	Krishna Reddy, M.	DBT	49.00
Popularization and dissemination of technology of bio pesticide formulations among the poor and marginal (ST) farmers of weaker sections in North East region	Rao, M.S.	DST	170.734
Ensuring livelihood security of farm women through appropriate horticulture technological innovations	Narayanaswamy, B.	DST	15.51264
Design and development of a computerized protray filling, dibbling, seeding and watering machinery for vegetable nursery	Carolin Rathinakumari, A.	DST	23.241
Bio-pesticide technology interventions for livelihood improvement of scheduled caste population in Vellore, Tamail Nadu	Rao, M.S.	DST	31.83

Title of the project	Principal Investigator	Funding agency	Budget (Rs. in lakhs)
Multi-transgene stacking with PR-3, PGIP & NPR 1 gene in tomato for induction of broad spectrum fungal resistance (Concluded on 30th September, 2015)	Mythili, J.B.	DST	47.458
Outreach program on management of sucking pests of horticultural crops	Asokan, R.	ICAR	1299.00
Outreach programme on diagnosis and management of leaf spot diseases of field and horticultural crops (*An ORP on Alternaria, Colletotricum and Cercospora diseases*)	Krishna Reddy, M.	ICAR	1647.77
Outreach programme on *Phytophthora*, *Fusarium* and *Ralstonia* on horticultural and field crops	Gopalakrishnan, C., Sriram, S.	ICAR	49.52765
Undertaking the changes in host-pest interactions and dynamics in mango under climate change scenario	Kamala Jayanthi, P.D.	ICAR (NICRA)	15.00
National initiative climate resilient agricultural technology package at village level	Loganandhan, N.	ICAR (NICRA)	90.00
National initiative on climate resilient agriculture (NICRA) for XI Plan	Bhatt, R.M.	ICAR (NICRA)	721.97964
Real time pest surveillance on tomato	Sridhar, V.	ICAR (NICRA)	30.00
ICAR-Network project on transgenics in crops (NPTC) (Mango)	Ravishankar, K.V.	ICAR (Network Project)	99.10
Network Project on Transgenics in Crops (NPTC) : Development of transgenic banana Cv. Rasthali resistant to *Fusarium* wilt (2049/3036)	Usha Rani, T.R.	ICAR (Network Project)	122.15
Network Project on Transgenics in Crops (NPTC): Functional Genomics in Tomato	Sadashiva, A.T.	ICAR (Network Project)	145.00
Endophytic micro-organisms in horticultural crops (Sub-project under XII Plan of SFC of NBAIM sub-scheme AMAAS)	Pious Thomas	ICAR AMAAS (Network Project)	48.48
ICAR Network Project on organic farming in Horticulture	Anil Kumar Nair	ICAR (Network Project)	31.50
All India Network Research Project on Onion & Garlic	Veere Gowda, R.	ICAR (Network Project)	8.50
Functional genomics: *Fusarium* wilt resistance and drought tolerance in banana	Ravishankar, K.V.	ICAR (Network Project)	304.18
All India Network Project (AINP) on Pesticide Residues	Soudamini Mohapatra	ICAR (Network Project)	89.72
All India Network Project on Vertebrate Pest Management [Part C. Higher vertebrates (Monkey)]	Chakravarthy, A. K.	ICAR (Network Project)	61.45
Network project on Impact Assessment of Agricultural Research and Development	Gajanana, T.M.	ICAR (Network Project)	16.76

Title of the project	Principal Investigator	Funding agency	Budget (Rs. in lakhs)
Establishment of Referral Testing Laboratories/ Facilities at ICAR-IIHR	Debi Sharma	ICAR	200.00
Establishment of Agri-Business Incubation (ABI) centres under XII Plan Scheme "National Agriculture Innovation Fund (NAIF)"	Sudha Mysore	ICAR (Under XII Plan)	52.65
Flagship Project on "Integrated approach to eradicate pomegranate bacterial blight"	Murthy, B.N.S.	ICAR	
Supply management of perishable vegetables - onion and tomato	Gajanana, T.M.	Karnataka Agriculture Price Commission, GoK	5.05
Collection, conservation and characterization of Appemidi from Kumata, Honnavara and Yellapura regions of Uttara Kannada District	Ravishankar, K.V.	Karnataka Bio Diversity Board, GoK	5.00
Demonstration of Bio-management strategies of nematodes on European cucumber, capsicum and tomato under protected conditions in Karnataka	Rao, M.S.	NABARD	8.086
Establishment of Arka Microbial Consortium Production Unit for Promotion of Organic Farming (KVK, Gonikoppal) (Concluded on 22nd March, 2016)	Saju George	NABARD	5.00
Popularization of bio-rational technology for management of mango inflorescence hoppers	Ganga Visalakshy, P.N.	NABARD	8.72
Transfer of patentable technology of bio-pesticide consortia among Karnataka farmers for sustainable vegetable crop production	Rao, M.S.	NABARD	18.638
Developing Environment Friendly and organic means of managing major insect pests of mango cv.Totapuri in Karnataka and impact on fruit quality (Concluded on 31st July, 2015)	Shivananda, T.N.	NABARD	9.00
Network project on Agricultural Bioinformatics and Computational Biology under Centre for Agricultural Bioinformatics (CABin) (under NAIP Component-I "Establishment of National Agricultural Bioinformatics Grid (NABG)"	Asokan, R.	NAIP (ICAR)	7.37690
Network Project on "Market Intelligence"	Sudha Mysore	ICAR	37.41
Development of Model Nursery for Highly Traded / RET Medicinal & Aromatic Crops (Under National Mission on Medicinal Crops)	Sukanya, D.H.	NMPB	20.00
Molecular characterization of citrus germplasm	Aswath, C.	ICAR	2.00
Production of haploids in vegetable crops	Aswath, C.	PPP mode Amrut seeds, Nelamangala, Bengaluru	66.00

Title of the project	Principal Investigator	Funding agency	Budget (Rs. in lakhs)
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 (*Cucumis sativus*), Bottle gourd (*Lagenaria sinceraria*), Bitter gourd (*Momordica charantia*), Pumpkin (*Cucurbita moschata*) and Pointed gourd (*Trichosanthes dioca*)	Sadashiva, A.T.	PPV & FRA	37.98
DUS testing centre on Mango	Dinesh, M.R.	PPV & FRA	25.00
Establishment of DUS nodal centre at IIHR, Bengaluru for carnation	Dhananjaya, M.V.	PPV & FRA	23.37
DUS Centre (Watermelon and Muskmelon)	Sreenivasa Rao, E.	PPV & FRA	3.00
Establishment of Referral Lab/accreditation to conduct special tests for plant variety protection in horticultural crops	Aswath, C.	PPV & FRA	6.70
Development of guidelines for the conduct of test for Distinctiveness, Uniformity and Stability of Chilli, Sweet Pepper and Paprika (*Capsicum annuum* L.)	Madhavi Reddy, K.	PPV & FRA	30.00
Formulation and validation of DUS testing guidelines for amaranth, palak and ridge gourd	Varalakshmi, B.	PPV & FRA	15.00
DUS testing center for papaya and custard apple)	Vasugi, C. (Papaya) Sampathkumar,P. (Custard apple)	PPV & FRA	9.57
Formulation and validation of DUS testing guidelines for Betelvine (*Piper betle* L.)	Hima Bindu, K.	PPV & FRA	20.97
Establishment of Nodal DUS centre at IIHR for tuberose	Usha Bharathi	PPV & FRA (Network Project)	12.60717
Establishment of DUS nodal centre at IIHR, Bengaluru for China aster	Rajiv Kumar	PPV & FRA	7.05
Establishment of DUS nodal centre at IIHR, Bengaluru for jasmine	Sujatha A. Nair	PPV & FRA	11.35
Establishment of national repository of rose at IIHR	Tejaswani	PPV & FRA	55.882
DUS centre for ornamental crops (rose & chrysanthemum)	Tejaswini	PPV & FRA	9.00
Validation of DUS testing guidelines for marigold	Tejaswini	PPV & FRA	10.72
Establishment of DUS testing centre for crossandra	Manjunatha Rao, T.	PPV & FRA	18.45
Demonstration of biological control of pest and diseases and integrated crop management practices in protected cultivation of vegetables and flowers	Balakrishna, B.	RKVY, GoK	60.00
Participatory seed production and distribution system for recently released vegetable cultivars (Component 2 of Innovations in Horticulture through IIHR, Hesaraghatta) (KVK, Hirehalli)	Loganandhan, N.	RKVY, GoK	40.00

Title of the project	Principal Investigator	Funding agency	Budget (Rs. in lakhs)
Production of quality planting material of Coorg mandarin and future horticultural crops through CHES, Chettalli	Senthil Kumar, R.	RKVY, GoK	80.00
Multiplication and popularization of IIHR developed flower crop varieties for improving the livelihood status of farmers	Manjunath Rao, T.	RKVY, GoK	200.00
Production of quality planting material of Coorg manadarin (*Citrus reticulanta* Blanco) (Concluded on 31st December, 2015)	Senthil Kumar, R.	RKVY, GoK	70.00
Incompatibility studies in tuberose (*Polianthes tuberosa* L.)	Usha Bharathi, T.	SERB, New Delhi	17.20
Collaborative studies on hyperspectral response of horticultural plantations	Raghupathi, H.B.	RRSC-South, NRSC, ISRO, Dept. of S pace, GoI.	6.00

8.3 Flagship Program (Initiated in XII Plan)

Title of the project	Principal Investigator	Funding agency	Budget (Rs. in lakhs)
Management of papaya ring spot virus through breeding approaches (papaya-PRSV)	Dinesh, M.R.	ICAR	280.00
Male sterility in vegetables and flower crops	Veere Gowda, R.	ICAR	480.00

8.4 New Initiatives Program (Initiated in XII Plan)

Title of the project	Principal Investigator	Funding agency	Budget (Rs. in lakhs)
Micronutrient management in horticultural crops	Ganeshamurthy, A.N.	ICAR	680.00
Protected horticulture cultivation	Hebbar, S. S	ICAR	460.00
Socio-economic impact and PRA studies on technology adoption	Sudha Mysore	ICAR	100.00

8.5 Centre of Excellence (Initiated in XII Plan)

Title of the project	Principal Investigator	Funding agency	Budget (Rs. in lakhs)
Centre of Excellence on Betelvine	Vasantha Kumar, T.	ICAR	200.00

8.6 Consortia Research Platform (Initiated in XII Plan)

Title of the project	Principal Investigator	Funding agency	Budget (Rs. in lakhs)
Consortium Research Platform (CRP) on Borers	Reddy, P.V.R.	ICAR	2375.00
Consortium Research Platform (CRP) on Phytochemicals /High Value Compounds	Shivashankar, S.	ICAR	360.00
Consortium Research Platform (CRP) on Nanotechnology	Lakshmana Reddy. D C	ICAR	34.00
Consortium Research Platform (CRP) on Vaccines and Diagnostics	Krishna Reddy, M.	ICAR	7500.00
AGRI-CRP on Water (Efficient water management in horticultural crops)	Anil K. Nair	ICAR	31.70
Consortium Research Platform (CRP) on Agrobiodiversity (CRP-AB)	Ganeshan, S.	ICAR	
CRP-Agrobiodiversity of Vegetable Crops (Chilli, Okra & Watermelon)	Madhavi Reddy K.	ICAR	15.00
Consortium Research Platform (CRP) on Hybrid Technology (CRP-HT)	Sadashiva, A.T.	ICAR	18.80
CRP on Molecular Breeding	Pitchaimuthu, M.	ICAR	

8.7 ICAR-Funded Extramural Projects

Title of the project	Principal Investigator	Funding agency	Budget (Rs. in Lakhs)
Mapping fungicide resistance in oomycetes and powdery mildews using allele specific markers and evaluation of resistance management methods	Sriram, S.	ICAR	31.50
Genetic and molecular approaches for gall midge resistance in chilli peppers (*Capsicum annuum* L.)	Madhavi Reddy, K.	ICAR	18.21
Scaled up production, field evaluation and commercialization of Coleoptera toxic *Bacillus thuringiensis*	Asokan, R.	ICAR	31.68
Characterization and epidemiology of phytoplasmas infecting major horticultural crops	Rao, G.P. (IARI-PI) Asokan, R. (IIHR-Co-PI)	ICAR	37.99
Investigation on sooty blotch fly speck complex in mango and pathological status of *Pyricularia* species in banana and devising management strategies	Sangeetha, G.	ICAR	40.72
Micro propagation and field evaluation of 'Arka Prabhath' papaya	Pious Thomas	ICAR	28.94
SNP marker based mapping of bacterial blight genes in pomegranate (*Punica granatum* L.)	Murthy, B.N.S. (Co-PI)	ICAR	44.47

Title of the project	Principal Investigator	Funding agency	Budget (Rs. in Lakhs)
Phytochemical characterization and evaluation of biological activity of betelvine (*Piper betle* L.) leaf extracts	Hima Bindu, K.	ICAR	40.38
Trait specific characterization of indigenous and exotic pomegranate accessions to arrive at core collection for genetic improvement programme	Murthy, B.N.S.	ICAR	24.82
Developing vegetable soybean for rust resistance	Aghora, T.S.	ICAR	18.13
Augmenting germplasm and molecular resources for developing tropically adapted sweet corn genotypes	Sreenivasa Rao, E.	ICAR	20.99
Diversity assessment in jamun (*Syzygium cumini L. S*keels) genetic resources	Anuradha Sane	ICAR	26.60
Induction of embryogeny and plant regeneration through induced androgenesis/ gynogenesis in horticultural crops	Aswath, C.	ICAR	39.96
Design and development of indigenous grafting machine for vegetable crops	Senthil Kumaran, G.	ICAR	14.51
Pre-breeding for transfer of Okra Yellow Mosaic Virus and Enation Leaf Curl Virus tolerance from wild relatives to cultivated genepool K.V. Bhat - (NBPGR - PI)	M. Pitchaimuthu	ICAR	29.16

8.8 Linkages with other ICAR and Government Institutions:

Strong linkages are established with various ICAR Institutes like NBPGR, IARI, IIVR, CITH, CISH, IISR, CPCRI, NRC for Pomegranate, NRC for Citrus, NRC for Grapes, Directorate of Onion and Garlic, Directorate of Floriculture, *etc.* and other organizations like DST, DBT, IWST, PPV and FR Authority, NHB, NSC, State Seed Corporations, State Departments of Agriculture, Horticulture, Water Shed, Water Resources *etc.* for taking up collaborative and joint research programs like joint explorations for germplasm, exchange and testing of elite breeding lines, conduct of biotechnology research, developing DUS guidelines and conduct of training and awareness programs. The Institute also extends laboratory facilities for analysis and testing of products, and shares parental lines on payment basis to various Universities, State and National Seed Corporations for further commercialization.

8.9 Linkages with private sector:

The Institute has strong linkages with the private sector particularly with seed companies and pesticide companies. Seed companies approach the Institute for exchange of seed material/ germplasm for research and purchase of potential parental lines for further commercialization. Pesticide companies take up testing of their new products as paid up trials. The Institute also extends laboratory facilities for analysis and testing of products on payment basis to various stake holders.

9. Publications

9.1 Research Papers

Published in Refereed Journals

1. Acharya, G. C., Paul, S. C., Chakrabarty, R. and Ray, A. K. (2015). Effect of organic and inorganic sources of nutrients on soil fertility status of arecanut (*Areca catechu*) in North-East India. *Ind. J. Agril. Sci.* **85**:1335-1341.

2. Amreen Taj, Rao, T. M., Ansar, H., Sriram, S. and Rajiv Kumar. (2016). Response of gladiolus (*Gladiolus hybridus*) genotypes to two diverse cultures of *Fusarium* and their agronomic performance. *Ind. J. Agril. Sci.* **86**(3):331-339.

3. Anand, C Reddy, Sudarshini Venkat, Singh, T. H., Madhavi Reddy, K. and Lakshmana Reddy, D. C. (2015). Isolation, characterization and evolution of NBS-LRR encoding disease-resistance gene analogs in eggplant against bacterial wilt. *European J. Pl. Path.* **143**(3):417-426.

4. Anju Bajpai, Muthukumar, M., Israr Ahmad, Ravishankar, K.V., Parthasarthy, V. A., Bhuwon Sthapit, Ramanatha Rao, Verma, J. P. and Rajan, S. (2016). Molecular and morphological diversity in locally grown non-commercial (heirloom) mango varieties of north India. *J. Environ. Biol.* **37**:221-228.

5. Anuradha Upadhyay, Satisha, J., Smita R. Maske, Narendra, Y. Kadoo and Vidya, S. Gupta. (2015). Expression of stable reference genes and SPINDLY gene in response to gibberellic acid application at different stages of grapevine development. *Biologia Plantarum*, **59**(3):436-444.

6. Asha, K. M., Anuradha Sane and Rajiv Kumar (2016). Characterization of chrysanthemum (*Dendrathema grandiflora*) as per DUS guidelines. *Indi. J. Agril. Sci.* **86**(1):103-112.

7. Asokan, R., Chaitanya, B. N., Rebijith, K. B., Krishna Kumar, N. K., Viraktamath, C. A. and Ramamurthy, V. V. (2015). COI based molecular identification of mango leaf hoppers (Hemiptera: Cicadellidae) in India. *Ind. J. Biotech.* **14**:260-263.

8. Balakrishna, B., Atheequlla, G A., Aiyasha, G. F. and Shankaraiah. (2015). Perception of farmers on climate change and its likely impact on horticultural crops. *Global J. Res. Analysis.* **4**(9):2277-8160.

9. Bharathkumar, M. V., Sadashiva, A. T., Sanjay Kumar and Thontadarya, R. N. (2016). Heterosis for fruit quality parameters in tomato (*Solanum lycopersicum* L.). *Ind. J. Ecology*. **43**(1):195-201.

10. Bhat, R. M., Rashmi, Nageswar Rao, A.D.D.V.S., Laxman, R. H. and Singh, T. H. (2014). Seed germination and seedling growth in *Solanum* species to water stree under in vitro condition. *Veg. Sci.* **8**(2):262-267.

11. Bhatt, R. M., Laxman, R. H., Singh, T. H., Divya, M. H., Srilakshmi and Nageswar Rao, A.D.D.V.S. (2014). Response of brinjal genotypes to drought and flooding stress. *Veg. Sci.* **41**(2):116-124.

12. Bhattacherjee, A. K., Dikshit, A., Chethan Kumar, P., Pandey, D. and Tandon, D. K. (2016). Profiling nutraceuticals in bael [*Aegle marmelos* (L.) Correa] at various stages of fruit development. *J. Horti. Sci. Biotech.* DOI.org/10.1080/14620316.2015.1133537.

13. Biswajit Mondal, Adhikari, R. N., Patil, S. L., Raizada, A., Prabhavathi, M., Ramajayam, D. and Loganandhan, N. (2014). Assessment of on-farm employment generation through natural resource conservation activities in the semi-arid region, *The Andhra Agric. J.*, **61**(4):921-926.

14. Biswajit Mondal, Loganandhan, N., Reddy, K. K. and Channabasappa, K. (2015). Decomposition analysis of output change under watershed management interventions in semi-arid regions, *Ind. J. Soil Conservation*, **43(**1):110-114.

15. Boopal K. and Hanur, V. S. (2015). Enhanced synthetic diet for rearing *H. armigera* under laboratory conditions. *J. Entomol. Zool. Stud.*, **3**:165-167.

16. Boopal, K., Hanur, V. S., Arya, V. V. and Reddy, P. V. R. (2014). Phenotypic assessment of Bt *Cry2A* transgenic tomato resistant to neonate larva of *Helicoverpa armigera*. *Curr. Trends Biotechnol. Pharm*., **8**:124-129.

17. Carolin Rathinakumari, A. and Manohar Jesudas, D. (2015). Design and development of tractor operated onion set planter. *Ind. J. Agril. Sci.* **85**(8):1138-41.

18. Carolin Rathinakumari, A. and Manohar Jesudas, D. (2015). Optimization of design and operational parameters of cell type metering unit for planting onion sets. *Int'l J. Tropl. Agri.* **33**(2-2):807-816.

19. Carolin Rathinakumari, A. and Manohar Jesudas, D. (2015). Physical and mechanical properties of onion sets (*Allium cepa*. L.). *Int'l J. Tropl. Agri.* **33**(2-2):817-823.

20. Carolin Rathinakumari, A., Channabasamma, B. B. and Senthil Kumaran, G. (2015). Physical and mechanical properties of garlic bulbs and cloves (*Allium sativum* L.) relevant to development of garlic bulb breaker. *Int'l J. Tropl. Agri.* **33**(2-4):1881-1887.

21. Chaitanya, B. N., Asokan, R., Sita, T., Rebijith, K. B. and Krishna Kumar, N. K. (2016). Double stranded RNA mediated silencing of sodium channel and ultra spiracle genes in *Aphis gossypii* (Hemiptera: Aphididae). *Annals of the Entomological Society of America*, **109**:92-98.

22. Channabasamma, B. B., Carolin Rathinakumari, A. and Senthil Kumaran, G. (2015). Design, development and performance evaluation of garlic bulb (*Allium sativum* L.) breaker for planting material production. *Ind. J. Agril. Sci.* **85**(9):1158-61.

23. Chauhan, H., Bagyaraj, D. J., Selvakumar, G. and Sundaram, S. P. (2015). Novel plant growth promoting rhizobacteria – prospects and potential. *Applied Soil Ecol.* **95**:38-53.

24. Choudhary, B. R., Pandey, S., Rao, E. S. and Sharma, S. K. (2015). DUS characterization of muskmelon varieties. *Ind. J. Agr. Sci.* **85**(12):1597-1601.

25. Debnath, S., Bauri, F. K., Bandyopadhyay, B., Misra, D. K., Mandal, K. K., Murmu, I. and Patil, P. (2015). Identification of optimum leaf area index (LAI) for high density planting of banana cv. Martaman in Gangetic Alluvium region of West Bengal, *J. Crop and weed* **11**(2):63-66.

26. Deepa Samant, Mandal, S., Singh, H. S., Vishal Nath and Kurian, R. M. (2015). Effect of *in situ* rainwater harvesting and mulching on growth, yield and fruit quality in mango var. Arka Neelachal Kesri in Eastern India. *J. Hortl. Sci.* **10**(1):99-101.

27. Dinesh, M. R., Rajan, S., Sanjay Kumar Singh, Singh, I. P., Ravishankar, K. V., Parthasarathy, V. A., Bhuwon Sthapit, Ramanatha Rao, V. and Sandya, B. S. (2015). Heirloom/seedling mango varieties of India–potentialities and future. *Ind. J. Pl. Genet. Reour.* **28**:139-152.

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9.3 Books /Book Chapters

9.3.1. Books

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9.4 Popular Articles

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11. Prashanth, J. M., Shashidhara, K. N. and Loganandhan, N. (2015). Dryland horticulture (Kannada), *Sharath Krishi Magazine*, Bengaluru, June 2015, pp.28-29.

12. Prashanth, J. M., Shashidhara, K. N. and Loganandhan, N. (2015). Climate forecast based agriculture (Kannada), *Sharath Krishi Magazine*, Bengaluru, June 2015, pp.32-33.

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30. Vishal Nath, Amrendra Kumar, S. D., Pandey and Tripathi, P. C. (2015). Litchi in winter season-a way forward. *Indian Horticulture.* **60**(2):26-27.

31. Vishal Nath, Amrendra Kumar, S. D., Pandey and Tripathi, P. C. (2015). Litchi in winter season-a reality. *ICAR News.* **21**(1):4.

9.5 Technical Bulletins/ Folders

9.5.1. Technical Bulletins

1. Chandra Prakash, M. K. and Reena Rosy Thomas. (2015). *Expert System on Tomato*, ICAR-IIHR, Bengaluru.

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K. N. and Srinivas Reddy, K. M. (2015). Jack fruit - A Versatile Fruit, ICAR-IIHR, Bengaluru.

3. Kundan Kishore, Singh, H S., Deepa Samant, Srinivas, P., Mandal, S. and Sangeetha, G. (2015). Performance of promising guava and sapota varieties in tropical eastern region of India.

4. Narayanaswamy, B., Rao, M. S. and Umamaheswari, R. (2015). Management of nematodes in fruit crops (Kannada), ICAR-IIHR, Bengaluru.

5. Narayanaswamy, B., Rao, M. S. and Umamaheswari, R. (2015). Management of nematodes in ornamental crops (Kannada), ICAR-IIHR, Bengaluru.

6. Narayanaswamy, B., Rao, M. S. and Umamaheswari, R. (2015). Management of nematodes in vegetable crops (Kannada), ICAR-IIHR, Bengaluru.

7. Narayanaswamy, B., Rao, M. S. and Umamaheswari, R. (2015). Management of nematodes in protected cultivation (Kannada), ICAR-IIHR, Bengaluru.

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11. Reena Rosy Thomas and Chandra Prakash M. K. (2015). Expert System on Mango, ICAR-IIHR, Bengaluru.

12. Sadashiva, A. T., Aghora, T. H., and Ankegowda, S. J. (2016). PPVFRA Guidelines for Kodagu district horticultural crops (Kannada), KVK Gonikoppal.

13. Sadashiva, A.T., Veere Gowda, R., Madhavi Reddy, K., Aghora, T. S., Mohan, N., Varalakshmi, B., Pitchaimuthu, M., Singh, T. H., Shankar Hebbar, Anil Kumar Nair, Susmita Cherkuri, Ramya, M., Senthil Kumar and Nage Gowda, N. S. (2016). Field demonstration of improved vegetable varieties/ hybrids and cultivation practices, ICAR-IIHR, Bengaluru.

14. Saju George, Veerendrakumar, K. V., Prabhakar, B. and Devaiah, K. A. (2016). Recent production technologies in black pepper production (Kannada), KVK Gonikoppal.

15. Saju George, Veerendrakumar, K. V., Prabhakar, B. and Devaiah, K. A. (2016). Calendar of operations for important horticultural crops of Kodagu (Kannada), KVK Gonikoppal.

9.5.2. Folders

1. Aswath, C., Rajiv Kumar, Rao, T. M., Dhananjaya, M. V., Sridhar, V., Sriram, S. and Sudha, M. (2015). Polyhouse cultivation of gerbera. ICAR-IIHR, Bengaluru.

2. Aswath, C., Rajiv Kumar, Rao, T. M., Dhananjaya, M. V., Sridhar, V., Sriram, S. and Sudha, M. (2015). Polyhouse cultivation of gerbera (Hindi). ICAR-IIHR, Bengaluru.

3. Hanumanthe Gowda, B., Ramesh, P. R., Prashanth, J. M., Shashidhar, K. N., Shivananda, T. N. and Loganadhan, N. (2015). Mavige baruva kanda korakadha hathoti kramagalu, KVK, Hirehalli.

4. Hanumanthe Gowda, B, Ramesh, P. R., Shashidhar, K. N., Loganadhan, N., Prashanth, J. M. (2015). Roga mattu keetagala nirvahaneyalli Savayava parikaragala upayoga, KVK, Hirehalli.

5. Madhavi Reddy, K. (2015). Production technology of chilli. ATIC Pocket Dairy Series-1. ICAR-IIHR, Bengaluru.

6. Madhavi Reddy K. 2015. Production technology of bell pepper. ATIC Pocket Dairy Series-2. ICAR-IIHR, Bengaluru.

7. Narayanaswamy, B., Hegde, M. R. and Saju George. (2015). Nursery - A way of sustainability for women. ICAR-IIHR, Bengaluru.

8. Narayanaswamy, B., Saju George and Hegde, M. R., (2015) Vermicomposting. ICAR-IIHR, Bengaluru.

9. Rajiv Kumar, Rao, T. M., Sridhar, V. and Sriram, S. (2015). China aster cultivation. ICAR-IIHR, Bengaluru.

10. Rajiv Kumar, Rao, T. M., Sridhar, V. and Sriram, S. (2015). China aster cultivation (Hindi). ICAR-IIHR, Bengaluru.

11. Ramesh, P. R., Selvakumar, G., Shashidhara, K. N., Loganandhan, N. Hanumanthe Gowda, B. and Praveen Kumar (2015). Technology on production of fermented Arka cocopeat, KVK, Hirehalli.

12. Ramesh, P. R., Shashidhar, K. N., Loganadhan, N., Jagadish, K. N. and Prashanth, J. M. (2015). Foliar application of Arka banana special for balanced nutrition and higher yield in banana, KVK, Hirehalli.

13. Ramesh, P. R., Shashidhar, K. N., Loganadhan, N., Prahanth, J. M., Shivananda, T. N. and Jagadish, K. N. (2015). Foliar application of Arka mango special for balanced nutrition and higher yield in mango, KVK, Hirehalli.

14. Ramesh, P. R., Hanumanthe Gowda, B., Shashidhara, K. N., Shivananda, T. N., Prashanth, J. M. and Loganandhan, N. (2015). Integrated management of mango fruit fly, KVK, Hirehalli.

15. Ramesh, P. R., Hanumanthe Gowda, B., Shashidhara, K. N., Shivananda, T. N., Prashanth, J. M. and Loganandhan, N. (2015). Foliar application Arka citrus special for balanced nutrition and higher yield in Citrus crop. KVK, Hirehalli.

16. Aghora, T. S., Mohan, N., Krishnamurthy, P. N. and Sadashiva, A. T. (2016). *French bean Ki Utpadan Takniki* (Hindi). Translated by Anil Kumar Nair and Jagadeesan A. K., ICAR-IIHR, Bengaluru.

17. Madhavi Reddy. (2016). *Mirchi Ki Utpadan Takniki* (Hindi). Translated by Anil Kumar Nair and Jagadeesan A. K., ICAR-IIHR, Bengaluru.

18. Madhavi Reddy. (2016). *Shimla Mirch Ki Utpadan Takniki* (Hindi). Translated by Anil Kumar Nair and Jagadeesan A. K., ICAR-IIHR, Bengaluru.

19. Srinivasa Rao, E., Pichaimuthu, M. and Anil Kumar Nair. (2016). *Kharbuja Evam Tarbuj Ki Utpadan Takniki* (Hindi). Translated by Anil Kumar Nair and Jagadeesan A. K., ICAR-IIHR, Bengaluru.

20. Panneerselvam, P., Selvakumar, G. and Ganeshmurthy, A.N. (2016). *Sabjiyon Ke Tikau Utpadan Ke liye Arka Sukshmanaviya Mishran* (Hindi) translated by Anil Kumar Nair and Jagadeesan A.K. (Eds), ICAR-IIHR, Bengaluru.

9.6 Extension Bulletin/Reports/ Boucher:

9.6.1. Extension Bulletin

1. Compendium of lectures on mushroom spawn production for IIHR training.

2. Compendium of lectures on mushroom cultivation for IIHR training.

9.6.2. Reports

1. Patil, P. and Naduthodi, N. (2015). Proceedings of 2nd Group Discussion of All India Coordinated Research Project on Fruits -2015. (Tech. Doc. No. 112).

2. Patil, P., Naduthodi, N., Shivashankara, K. S., Reddy, P.V.R. and Sankaran, M. (2015). Annual Report of All India Coordinated Research Project on Fruits (2014-15) (Tech. Doc. No. 113).

3. Patil, P., Naduthodi, N. and Singh, P. (2015). National Consultation Meet on Sapota-Background Report. (Tech. Doc. No. 114).

4. Patil, P. and Naduthodi, N. (2015). Technical Manual of ICAR-AICRP on Fruits. (Tech. Doc. No. 115).

5. Patil P, Naduthodi N, and Sujatha, S. (2016). Research Report of All India Coordinated Research Project on Fruits. (Tech. Doc. No. 116).

6. Singh, S., Rao, C N., Deka, S., Sonalkar, V., Datkhile, R., Kadam, U. K., Rani, U., Sarada, G., Kaur, G. and Patil, P. (2016). Monograph of Insect and Mite Pests of Citrus in India. AICRP on Fruits, ICAR-IIHR, Bengaluru (Tech. Doc. No. 115), pp. 128.

7. Ganeshamurthy, A. N., Kalaivanan, D. and Malarvizhi, M. (2015). Soil, water and tissue testing for horticultural crops to enhance quality, productivity and input use efficiency, ICAR-IIHR, Bengaluru.

10. Research Projects

List of Ongoing Institute Projects(2015-16)

Division of Fruit Crops

HORTIIHRCIL2015(Common for all projects)

010: Genetic improvement of fruit crops for improved productivity, quality and resistance to biotic and abiotic stresses. Project Leader: Murthy, B.N.S.

Sub projects

010(1): Improvement of mango for yield and quality. PI: Dinesh, M.R.

010(2): Improvement of jamun and sapota for dwarf tree stature and higher productivity. PI: Rekha, A.

010(3): Evaluation of under-utilized fruits for yield, quality and adaptability. PI: Saktivel, T.,

010(4): Improvement of jack fruit for quality and productivity. PI: Prakash Patil,

010(5): Breeding papaya for PRSV tolerance. PI: Dinesh, M.R.

010(6): Incorporation of bacterial blight resistance in pomegranate. PI: Murthy, B.N.S.

010(7): Breeding purple passion fruit and strawberry for superior traits. PI: Murthy, B.N.S.

010(8): Improvement of guava for yield and quality**.** PI: Vasugi, C.

010(9): Rootstock and mildew resistance breeding in grapes. PI: Saktivel, T.

010(10): Improvement of annona for yield and quality. PI: Saktivel, T.

010(11): Improvement of pummelo and grape fruit for yield and quality. PI: Sankaran, M.

011(12): Radiation induced mutation breeding in papaya (*Carica papaya* L.) (CHES, Hirehalli) 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: Kurian, R. M.

011(4): Optimizing water and nutrient management (Papaya, guava, mango, sapota, annona and grapes). PI: Manjunath, B.L.

011(5): Fruit based cropping systems. PI: Chandrakant M Awachare

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. PI: Sadashiva, A.T.

020(2): Breeding hot & sweet peppers (*Capsicum annuum* L.*)* for biotic and abiotic stress resistance integrating marker-assisted selection (MAS) 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, pumpkin 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 peas for biotic and abiotic stresses and Dolichos for yield and quality attributes through marker-assisted selection (MAS). PI: Susmitha Cherukuri

020(8): Breeding onion for resistance to biotic and abiotic stresses with high 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 gourd vegetables (ridge gourd, bitter gourd and bottle gourd) for resistance to biotic stresses integrating maker-assisted selection (MAS). PI: Varalakshmi, B.

020(12): Breeding cucumber varieties/hybrids for resistance to biotic stresses through marker-assisted selection. PI: Pitchaimuthu, M.

021: **Development and refinement of production technology of vegetable crops. Project Leader: Hebbar, S.S.**

Sub-Projects

021(1): Water management and rain fed production in vegetable crops. PI: Nair, A.K.

021(2): Organic farming in vegetable crops. PI: Nair, A.K.

021(3): Protected cultivation and precision farming in vegetable crops. PI: Hebbar, S.S.

Division of Ornamental 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 nematodes. 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: Dhananjaya, M.V.

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: Rao, T. M.

030(8): Breeding jasmine for high flower yield, concrete and resistance to Eriophyid gall mite (*Aceria jasmini)* and blossom midge (*Contarinia maculipennis*). PI: Sumangala, H.P.

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(1): Enhancing cut foliage production through cultural interventions. PI: Sujatha A.Nair

031(2): Adaptability and utilization of ornamentals for landscaping. PI: Sumangala (Concluded on 30th April, 2015)

Division of Post-Harvest Technology

040: Development of post-harvest technologies for loss reduction and utilization of perishable horticultural crops. 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): Postharvest management and value addition of cut flowers, fillers and foliage of ornamental crops. 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 leaves, fenugreek leaves). PI: Ranjitha, K.

040(4): Design and development of storage systems for fresh fruits and vegetables. PI: Bhuvaneswari, 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 added products. PI: Narayana, C.K.

040(7): Studies on the preservation of fruits by hurdle processing and development of nutritionally enriched 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

Division of Plant Pathology

050: Diagnostics and integrated management of viral diseases of tropical horticultural crops. Project Leader: Krishna Reddy, M.

Sub-Project

050(1): Development of diagnostics and molecular characterization of bacteria, virus, viroid and phytoplasma infecting horticultural crops. PI: Krishna Reddy

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. PI: Saxena, A.K.

051(4): Host-pathogen interactions with special reference to fungal wilts of fruit crops. PI: Sriram, S.

051(5): Integrated management of pre and post-harvest diseases of fruits and vegetables (mango, banana & capsicum). PI: Saxena, A.K.

051(6): Integrated management of bacterial diseases of horticultural crops (pomegranate, tomato & brinjal). PI: Gopalakrishnan, C.

051(7): Identification and field evaluation of new bioagents for the integrated disease management of alternaria blight in tomato and onion. PI: Girija Ganeshan (Concluded on 30th June, 2015)

051(8): Integrated disease management of foliar diseases of ornamental crops. PI: Sriram, S.

053: Genetic improvement and development of production and utilization technology of tropical mushrooms. Project Leader: Meera Pandey

Sub-Project

053(1): Development and utilization of mushroom technology as a biological tool for sustainable nutrition, health and green environment. PI: Meera Pandey

Division of Entomology and Nematology

060: Integrated Insect pest management in tropical horticultural crops. Project Leader: Chakravarthy, A.K.

Sub Projects

060(1): Surveillance and management of fruit crop pests. PI: Reddy, P.V.R.

060(2): Development of IPM for the major pests of cucurbitaceous vegetables. PI: Ranganath, H. R.

060(3): Monitoring and management of insecticide resistance in major pests of horticultural crops. PI: Sridhar, V.

060(4): Bio-intensive management of mealy bugs in horticultural crops (papaya and guava).PI: Ganga Visalakshy, P.N. (Concluded on 31st December, 2015)

060(6): Bio-intensive management of white flies in horticultural crops (brinjal, tomato, gerbera, etc.). PI: Pillai, G.K.

060(7): Development of neem cake/ neem seed powder based formulations for the management of major insect pests of vegetable crops. PI: Ranganath, H. R.

060(8): Development of forewarning models for sucking pests and thrips borne viral diseases on chilli. PI: Prasannakumar, N.R.

063: Integrated Nematode Management in tropical Crops. Project Leader: Rao, M.S.

Sub-Projects

063(1): Studies on the management of nematode induced disease complexes in horticultural crops (banana, papaya, capsicum, carrot, onion, gerbera and gladioli). PI: Rao, M. S.

063(2): Evaluation of bioefficacy of entomopathogenic nematodes for biological control of insect pests in horticultural crops. PI: Umamaheshwari, R.

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 accessions for tolerance to high temperature stress. PI: Bhatt, R.M.

070(4): Physiological studies on impact of low-moisture and high temperature stresses in capsicum (*Capsicum annum* L.). PI: Bhatt, R.M.

070(5): Biochemical and molecular assessment of chilling injury in mango. PI: Shivashankara, K.S.

070(6): Isolation of natural antioxidants from mango processing waste. PI: Rao, V.K. (Concluded on 30th June, 2015)

070(7): Biochemical studies on jelly seed formation in Amrapali mango. PI: Shivashankar, 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(3): Multivariate foliar chemical composition and nutrient contour maps for developing diagnostic norms for fruit crops. PI: Raghupathi, H.B.

080(4): Nutrient dynamics (N, P, K) of conventional and speciality fertilizers under drip fertigation in horticultural crops. (banana, papaya, tomato and brinjal). PI: Varalakshmi, L R.,

080(5): Effect of salinity / nutrients on growth and yield of rose under polyhouse cultivation. PI: Shivananda, T.N.

080(6): Development and standardization of soilless cultivation of vegetables on Arka Fermented Cocopeat under protected conditions. PI: Kalaivanan, D.

081: Addressing environmental and food safety in horticultural crops. Project Leader: Ganeshamurthy, A.N.

Sub-Projects

081(1): Pesticide residue studies in fruits and related environment. PI: Soudamini Mohapatra

081(3): Development of microbial consortium for sustainable production of horticultural crops and improving soil health. PI: Selvakumar, G.

081(6): Microbial bioconversion of horticultural wastes for enhanced plant nutrient mobilization and disease suppression. PI: Selvakumar, G.

081(7): Nutrient dynamics and management of horticultural crops under salt stress conditions (banana and onion). PI: Varalakshmi, L.R.

081(8): Evaluation of chemical pesticide residues in exotic vegetables. PI: Debi Sharma

Division of Extension and Training

090: Improving knowledge and skill of stakeholders for improving productivity of horticultural crops and impact assessment of adopted technologies. Project Leader: Venkattakumar, R.

Sub-Projects

090(1): Identification of research and extension gaps for varieties and technologies of IIHR through PRA. PI: Balakrishna, B. (Concluded on 31st May, 2015)

090(2): Impact of capacity building of trainees on adoption of IIHR technologies including identification of future training needs. PI: Achala Paripurna

090(3): Assessment and refinement of IIHR technologies through farmers participatory demonstrations. PI: Achala Paripurna

090(4.1): Application of innovative extension, information and communication methodologies for transfer of technology in horticulture. PI: Narayanaswamy, B. (Concluded on 31st May, 2015)

090(4.2): Development of an information system for AICRP on tropical fruits. PI: Reena Rosy Thomas. (Concluded on 30th June, 2015)

090(6): Group dynamics and social networks among women SHG member's involved in economic activities. PI: Nita Khandekar

Division of Plant Genetic Resources

100: Plant genetic resources management in horticulture crops. Project Leader: Ganeshan, S.

Sub-Projects

100 (1): Mapping hotspot areas of horticultural gene pool, distribution and database development. PI: Ganeshan, S.

100(2): Optimization of germplasm domestication strategies for introducing new species of horticultural importance for crop diversification. PI: Ganeshan, S.

100(3): Development of complementary conservation strategies for horticulture PGR's (recalcitrant seed, pollen and *in vitro* material). PI: Rajasekharan, P.E.

100(4): Identification of zygotic seedlings in polyembryonic varieties of mango using molecular approaches. PI: Anuradha Sane

100(5): DNA fingerprinting and genetic diversity analysis of horticultural crops germplasm. PI: Anuradha Sane

100(6): Studies on monitoring and screening of introduced plant material for pest and disease incidence and pollinator diversity in horticultural germplasm. PI: Anushma, P.L.

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

Division of Biotechnology

110: Development, refinement and use of biotechnological approaches for horticultural crop improvement and production. Project Leader: Akella Vani

Sub-Projects

110(5): Development of resistance gene analogs (RGA's) in eggplant against bacterial wilt and their validation. PI: Lakshman Reddy, D.C.

110(6): Application of data mining techniques in horticultural biotechnology. PI: Radhika, V.

110(7): Development of transgenic pomegranate cv. Bhagwa for bacterial wilt resistance. PI: Nandeesha, P.

110(7.1): Genetic transformation of pomegranate for bacterial blight resistance.

110(7.2): Cloning *Xa21* gene of rice development of construct and transformation of pomegranate cv Bhagwa electroporation for resistance to bacterial blight. PI: Akella Vani

110(8): Developing transgenic fruit crops resistant to PRSV in papaya and tristeza in citrus. PI: Akella Vani

110(9): Developing transgenic vegetable crops resistant to viruses in tomato against peanut based bud necrosis virus & combined resistance to PBNV & TLCV & watermelon against watermelon bud necrosis virus. PI: Akella Vani

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(12): Introgression of *cry1f* Bt gene into brinjal. PI: Vageeshbabu, H.S.

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: Nandeesha, 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 cv. Arka Prabhat for enhancing shelf life. PI: Vageeshbabu S. Hanur

Section of Medicinal Crops

120: Genetic improvement of medicinal crop. Project Leader: Vasantha Kumar, T.

Sub-Projects

120(1): Identification of high yielding lines of *Aloe vera* for leaf and gel yield. PI: Vasantha Kumar, T.

120(2): Evaluation of *Coleus forskholii* hybrids for tuber yield and forskolin content. PI: Hima Bindu, K.

120(3): Identifying high yielding and high L-dopa lines in *Mucuna species.* PI: Hima Bindu, K.

120(4): Evolving kokum (*Garcinia indica*) lines for yield and chemical content. PI: Vasantha Kumar, T.

120(5): Evolving ashwagandha varieties for high root yield and active ingredient. PI: Sukanya, D.H.

120(6): Genetic improvement of *Centella asiatica* for yield and quality. PI: Sukanya, D.H.

120(7): Genetic amelioration of kalmegh (*Andrographis paniculata* Nees) for yield and quality. PI: Hima Bindu, K.

121(1): Standardizing organic farming technology for export value medicinal crops (*Aswagandha, Kalmegh and Coleus forskohlii*). PI: Suryanarayana, M.A.**(**Concluded on 30th September, 2015)

121(2): Chemical characterization of antifungal plant compounds and synthesis of some novel fungicides active against pathogens of horticultural crops. PI: Eugene Sebastian, J.N. (Concluded on 30th September, 2015)

Section of Seed Science and Technology

130: Development and refinement of efficient seed production and plant propagation technologies in key horticultural crops. Project Leader: Yogeesha, H.S.

Sub-Projects

130(1): Studies on precision production practices for enhancement of seed yield and quality. PI: Yogeesha, H.S. (Concluded on 31st May, 2015)

130(2): Restoration of fertility in interspecific F_1 hybrid between *Solanum melongena* and *Solanum macrocarpon*. PI: Padmini, K.

130(5): Biochemical and molecular investigations in relation to seed quality assurance in vegetable crops. PI: Bhanuprakash, K.

130(6): Ultra low and low moisture drying as a cost effective technique to extend seed longevity of horticultural crops under ambient storage. PI: Yogeesha, H.S.

Section of Agricultural Engineering

140: Mechanization of production and processing of horticultural crops. Project Leader: Senthil Kumaran, G.

Sub-Projects

140(1): Development of cultivation systems and machinery for mechanization of vegetable crops. PI: Carolin Rathinakumari, A.

140(2): Development of cultivation systems and machinery for mechanization of fruit crops. PI: Senthil Kumaran, G.

Section of Economics and Statistics

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

150(1): Assessing the socio-economic impact of horticultural technologies on crop diversification, farm income, employment and trade PI: Sudha Mysore

150(2): Economics of post harvest loss, marketing efficiency, price analysis and export. PI: Gajanana, T.M.

150(3): Economics of factor productivity and production efficiency in horticultural crops. PI: Sreenivasa Murthy, D.

150(4): Development of statistical modeling for horticultural crops research. PI: Venugopalan, R.

150(5): Development of database and program modules for horticultural crops PI: Chandra Prakash, M.K.

150(6): Development of decision support system on horticultural crops. PI: Reena Rosy Thomas

Central Horticultural Experiment Station, Chettalli

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: Senthil Kumar, R.

Sub-Projects

170(1): Collection and evaluation of under-utilized fruits for humid tropics. PI: Senthil Kumar, R.

170(2): Evolving stable hermaphrodite types of papaya from Coorg Honey Dew. PI: Senthil Kumar, R.

170(3): Refinement of technologies for improved productivity of Coorg mandarin. PI: Senthil Kumar, R.

170(4): Demonstration and impact of CHES and IIHR technologies. PI: Reddy, T.M. (Concluded on 30th June, 2015)

170(5): Pest management of major and emerging pests of citrus. PI: Jayanthi Mala, B.R.

170(6): Studies on bee pollination and bee keeping under humid tropics. PI: Jayanthi Mala, B.R.

170(7): Performance evaluation of vegetable cultivation in humid tropic region of Coorg. PI: Sankar, V.

170(8): Management of Coorg mandarin decline. PI: Priti Sonavanne

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. Project Leader: Singh, H.S.

Sub-Projects

180(1): Collection, evaluation, characterization, conservation and documentation of germplasms of fruit crops of Eastern India. PI: Kundan Kishore

180(2): Identification of varieties/hybrids and local elites of fruit crops suitable for Eastern India. PI: Kundan Kishore

180(3): Collection, evaluation, characterization, conservation and documentation of germplasm of underutilized cucurbits. PI: Poonam Naresh and Bharathi, L.K.

180(3.1): Collection, evaluation, characterization, conservation and documentation of germplasms of teasel gourd. PI: Poonam Naresh and Bharathi, L.K.

180(3.2): Conservation and maintenance of germplasms of underutilized cucurbits. PI: Poonam Naresh and Bharathi, L.K.

180(4): Improvement in dioecious *Momordica* species. PI: Poonam Naresh and Bharathi, L.K.

180(4.1): Improvement in dioecious *Momordica* species through inter specific hybridization. PI: Poonam Naresh and Bharathi, L.K.

180(4.2): Manipulation of planting time for round the year availability of *Momordica suboica* Bharathi in Eastern India. PI: Poonam Naresh and Bharathi, L.K.

180(5): Collection, evaluation and improvement in *Capsicum spp.* for desired characters. PI: Poonam Naresh.

180(5.1): Collection and evaluation of hot chilli lines from different geographical regions of North Eastern India and identification of elite lines for pungency and resistance to leaf curl virus and anthracnose. PI: Poonam Naresh.

180(5.2): Collection and evaluation of chilli lines for salt and moisture stress tolerance. PI: Poonam Naresh.

180(6): Collection, evaluation and improvement in *Maringa* and leafy vegetables of Eastern region for desired characters. PI: Acharya, G.C.

180(6.1): Collection and evaluation of *Moringa* germplasms for leaf iron content, earliness and pod quality. PI: Acharya, G.C.

180(6.2): Collection and evaluation of leafy vegetable germplasms for foliage yield, growth rate and stem tenderness. PI: Acharya, G.C.

180(7): Collection, evaluation and improvement of legume vegetables for desired characters. PI: Meenu Kumari

180(7.1): Collection and evaluation of *Dolichos* beans for photo-insensitiveness and pod quality. PI: Meenu Kumari

180(7.2): Collection and evaluation of *Popat* bean (*Dolichos lablab* var. *lignosus*) for economically important agronomical traits. PI: Meenu Kumari

180(7.3): Collection and evaluation of *Rikia* bean for yield and economic important traits. PI: Meenu Kumari

180(8): Development of production technologies of fruit crops. PI: Deepa Samant

180(8.1): Field trial on the effectiveness of IIHR micronutrient formulations for increasing fruit yield of mango variety 'Banganapalli'. PI: Deepa Samant

180(8.2): Promotion of uniform, early and higher flowering and fruiting in Arka Neelachal Kesri mango using paclobutrazol (PBZ). PI: Kundan Kishore

180(8.3): Observational trial on canopy height reduction in grown-up aonla trees planted at 5 m X 5 m spacing. PI: Deepa Samant

180(8.4): Effect of planting density on growth, yield and quality of guava var. Lucknow-49. PI: Deepa Samant

180(8.5): Canopy architecture modification by trellising for enhancement of productivity and quality in mango variety 'Arka Neelachal Kesri'.PI: Kundan Kishore

180(8.8): Development of organic production technology for mango in Eastern India. PI: Srinivas, P.

180(8.9): Canopy regulation and flowering initiation in mango through PBZ and KNO_3. PI: Kundan Kishore

180(8.10): Minimal processing of vegetable jackfruit for ready to cook product. PI: Deepa Samant

180(8.11): Standardization of branch bending for enhancing yield in guava. PI: Deepa Samant

180(9): Management of insect pests in fruit and vegetable crops. PI: Singh, H.S

180(9.1): Monitoring and management of selected insect pests in fruit crops. PI: Singh, H.S

180(10): Monitoring and management of diseases in fruit crops. PI: Sangeetha, G.

180(10.1): Seasonal abundance and severity level of diseases of major fruit crops. PI: Sangeetha, G.

180(10.2): Management of major diseases in mango. PI: Sangeetha, G.

180(10.3): Establishing the pathogenicity for a new kind of spotting disease occurring on banana and its management. PI: Sangeetha, G.

180(11): Bio-prospecting of agriculturally important micro-organisms. PI: Srinivas, P.

180(11.1): Bio-prospecting of agriculturally important micro-organisms under various horticultural cropping system for their potential exploitation for disease management, plant growth promotion and soil enrichment. PI: Srinivas, P.

180(12): Monitoring and management of major diseases in vegetable crops. PI: Mandal, S.

180(12.1): Management of downy mildew of cucurbits. PI: Mandal, S.

180(12.2): Evaluation of available brinjal lines against bacterial wilt disease. PI: Mandal, S.

Number of Ongoing In-house Projects/Sub-projects

Name of the Division/Section	No. of Projects	No. of Sub projects
Fruit Crops	2	17
Vegetable Crops	2	14
Ornamental Crops	2	11
Post Harvest Technology	1	9
Plant Pathology	3	8
Entomology and Nematology	2	9
Plant Physiology and Biochemistry	1	6
Soil Science and Agricultural Chemistry	2	10
Extension and Training	1	5
Plant Genetic Resources	1	9
Biotechnology	1	14
Medicinal Crops	2	9
Seed Science and Technology	1	4
Agricultural Engineering	1	2
Economics and Statistics	1	6
CHES, Chetttalli	1	8
CHES, Bhubaneswar	1	12
Total	**25**	**153**

11. Commercialization of Technologies

The Institute Technology Management Unit (ITMU) at ICAR-IIHR has been upgraded as a Zonal Technology Management Centre (ZTMC) for South Indian Horticulture, catering to 11 sister horticultural sciences institutes of ICAR.

The SH-ZTMC has been helping other sister institutes in ITMU related activities, filing patents, price fixation for technologies and other clarifications related to technology commercialization.

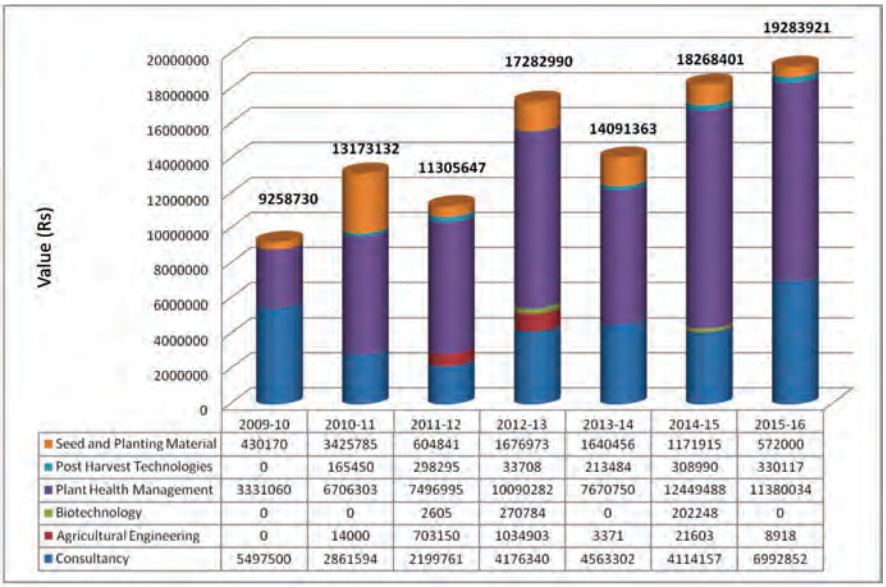
11.1 Technology Transfer

The Institute Technology Management Unit (ITMU) played a major role in commercializing the technologies developed at the Institute. During the year 2015-16, 29 technologies were transferred to 60 companies and 3 KVKs and an amount of Rs. 1,23,24,844/- including a royalty of Rs. 33,775/- was generated as income from utilization of IP assets. The details are given below.

Theme area based technology commercialization through licensing of IP assets

Theme area	Licensee		No. of technologies commercialized	Income from IP assets (Rs)
	Companies	KVK's		
Seed and planting material	2	---	3	5,72,000/-
Biocontrol agents and Biofertilizers	44	---	5	1,04,84,883
Crop protection technologies	3	3	08	8,95,151/-
Post harvest technologies	9	---	11	3,30,117/-
Farm implements and machineries	2	---	2	8,918/-
Grand total	**60**	**3**	**29**	**1,23,24,844/-**

The Consultancy Processing Cell (CPC) deals with providing consultancy services like imparting specialized training, testing of new molecules, issuing phyto-sanitary certificates, paid-up trials, testing of samples for virus, bacteria, fungi, insect pests, field visits and recognizing R&D centers. The institute earned an amount of Rs.69,92,852/- during the financial year 2015-16, through consultancy services.



Income from IP assets (2009-2015)

11.2 Patents Filed

Ref No.	Date	Patent
6930/CHE/2015	16.12.2015	A method for sustained *in vitro* micropropagation of papaya with the management of interfering endophytes
201641001693	18.01.2016	A process for the production of alkyl coumarate concentrate from *Ipomoea carnea* subsp. *fistulosa*

12. RAC, IRC, IMC - Major Recommendations

12.1 Research Advisory Committee

The composition of RAC of ICAR-IIHR is as follows:

Chairman : Dr. Gautam Kalloo

Members : Dr. D.P. Singh
Dr. N.K. Singh
Dr. D.M. Hegde
Dr. K. Krishnaiah
Dr. R.T. Patil
Dr. S.K. Mallhotra, ADG (Hort-I)
Mr. A. Shivanna (non-official)
Mr. A. Dongare (non-official)
Director, ICAR-IIHR, Bengaluru

Member-Secretary : Dr. B.N.S. Murthy

The second meeting of full committee was held under the Chairmanship of Prof. Gautam Kalloo, Former DDG (Hort.), ICAR & Ex-Vice Chancellor, JNKVV, Jabalpur at ICAR-IIHR, Bengaluru on 8th April, 2015 and at CHES-Bhubaneswar on 10th April, 2015. Dr. T. Janakiram, ADG (Hort-I), ICAR, Dr. D. P. Singh, Former ADG (Hort), ICAR., Dr. R. T. Patil, Former Director, CIPHET, Ludhiana, Dr. K. Krishnaiah, Former Director, DDR., Dr. D.M. Hegde, Former Director, DOR, Dr. N. K. Singh, National Professor, B.P. Pal Chair, Mr A. Shivanna. IMC member, ICAR-IIHR, Mr. B. Dongare, IMC member, ICAR-IIHR, Dr. T. Manjunatha Rao, Acting Director, ICAR-IIHR and Dr. B.N.S. Murthy, Member Secretary, RAC attended the meeting. All the scientists of the Institute also participated in the deliberations. All the Heads of Divisions, sections and stations of the Institute presented the ongoing research activities, achievements and future line of work. The RAC reviewed the work in progress at the Institute. A field visit to all the experimental farms was organised for the benefit of the committee. The RAC deliberated on the work in progress and thrust areas of research keeping in view the mandate and vision of the Institute and made recommendations. The recommendations along with the comments of Director, IIHR, Bengaluru were sent to ICAR, New Delhi for approval. The approved recommendations have been circulated to all for follow up. Following are the ICAR approved recommendations made by the committee.

ICAR approved RAC recommendations

- Line breeding studies using wild relatives to be taken up in important horticultural crops.
- Biotic and abiotic stresses/climate change attributes along with yield and quality should be considered. Male sterility system in vegetable and ornamental crops to be identified/intensified.
- Further, in biotechnology projects the programs to be drawn based on present day needs and emphasis should be given on the promotion of molecular breeding-MAS/gene pyramiding and genomics.
- The work on under-utilized and/or indigenous horticultural crops is very vital. The accession collected are to be maintained and the generated information be shared with all the stake holders. Production and supply of planting material of promising genotypes to the farmers should be taken up on priority in order to promote the technology. This activity be brought under network mode.
- The production technology research must concentrate on maximising the productivity on a remunerative and sustainable basis with emphasis on factor productivity, reducing input costs, drudgery and increase of labour use efficiency.
- Standardization of organic, soilless culture and roof-top production technologies for horticultural crops to be given priority along with peri-urban horticulture.
- Studies on population dynamics of pests and pathogens, forecasting models for economically important pathogens/insects to be taken up with special attention on monitoring of invasive pests, pest risk analysis, country wide sensitization and development of management methods. Study should also be concentrated on climate change and emergence of new pests and diseases in horticultural crops with ultimate aim of developing IPM packages.
- A centre of excellence in PHT of horticultural crops be created at IIHR with pilot plant for multi fruit processing, packaging and storage so that

value added products developed by IIHR and other ICAR institutes can be demonstrated to upcoming entrepreneurs as central facility.

- Extension division may take up village adoption by integrating required horticultural technologies and work out the rate of diffusion of various technologies along with socio-metric studies. Greater emphasis be given on conduct of demonstrations, field days in horticultural crops keeping in view potential areas, yield gaps involving KVK's. Aiming at effective transfer of technology, tools like crop wise development of mobile applications, handy extension bulletins with illustrations/images of pests, disease and the nutrient deficiency along with a brief account of management methods should be promoted.
- The farm and PHT machines developed at institute be multiplied and shared for use as well as their popularisation example-ferttree drill, jack fruit de-skinner and cutter from CHES Bhubaneswar, as well as all the recently developed machineries from ICAR-IIHR Bengaluru. The use of non-conventional energy be given importance.

Director's Comments

- The recommendation is noted for compliance. Line breeding studies and male sterility systems will be taken up in different horticultural crops. The biotechnology projects will be reoriented giving more emphasis on molecular breeding/ gene pyramiding and genomics.
- The work on underutilized fruits, vegetables and indigenous ornamental plants will be intensified. Promising accessions will be multiplied and supplied to farmers.
- Standardisation of organic, soilless culture and roof-top/vertical growing technology will be initiated/intensified in different horticultural crops as per the recommendations of RAC giving importance to factor productivity aspect.
- Population dynamics and pest surveillance work will be given special attention and IPM packages covering emerging pests will also be developed as suggested by RAC.
- Efforts will be made to create such a facility to take up various activates related to PHT.
- Villages will be adopted for demonstrating various technologies on horticultural crops with socio-economic studies. Extension bulletins and development of ICT tools are contemplated for the beneficiaries with appropriate illustrations.
- The recommendation is noted for compliance and action will be taken immediately for implementation at the earliest.

Advisory points

- Studies may be initiated on remunerative and sustainable cropping sequences in vegetables maximising productivity in off-season vegetable production.
- Major emphasis be given on standardizing and popularizing grafting in brinjal, tomato and capsicum on bacterial wilt resistant root stocks.
- There is a need to take up the work on sustainable cultivation of vegetables under protected/polyhouse/ net-house.
- Scope of seedling selection in important fruit crops may be explored looking into the heterozygosity of the crops/varieties.
- Pollinators and pollinizers study in mango and some other fruit crops should be studied.
- Case study analysis of used flowers from temples in town or city for production of value added products like pot purri, natural colors be conducted so that the technology will be useful to upcoming entrepreneurs.
- Dry flower technology developed at ICAR-IIHR may be popularised through training of entrepreneurs through training programmes.
- Integrated and sustainable weed management is to be intensified.
- Considering the needs of urban population work on dwarfs shrubs, potted plants be given more importance.
- Southern blot of all the events in transgenic work for confirmation of gene integration is a pre-requisite for further studies. Multidisciplinary approach is required for reliable and early results.
- Solar drying/zero energy technologies, small machineries needs to be given priority for research and dissemination to stake holders.
- In view of the frequent occurrence of severe epidemics of chilli leaf curl virus diseases experienced in several states, priority to be

accorded for identification of resistance sources to virus and/or whitefly, breeding for virus resistance and virus and vector management in chill needs attention.

- A network project be initiated on identification, synthesis and evaluation/standardisation of pheromones (sex, aggregation and alarming) and other semio-chemicals/kairomones for field bio-efficacy for designing appropriate IPM programmes/modules for important insect pests giving priority to mango and guava fruit borer caterpillars, pomegranate butterfly and borer, pumpkin beetles, cabbage leaf webber etc.
- Work on pesticide residue although satisfactory, research on pesticide resistance management with ongoing and new molecules for pest management should be intensified and the team has to concentrate on crop wise recommendation and take steps to popularise among various departments and farmers.
- The status of processing of horticultural crops in India may be worked out jointly by PHT, Extension and Economics divisions by approaching the industries in organised as well as un-organised sector.
- Women empowerment and tribal development work requires encouragement and strengthening. Further, collaboration with industries to be strengthened.
- Institute may expand and maintain a technology demonstration plots.

12.2 Institute Research Committee (IRC) Meeting

Chairman: Director

Members: All scientists of the main Institute and its regional stations.

Member Secretary: Dr. M.R. Hegde

The 85th IRC Meeting was held from 05 May to 26th June, 2015, under the Chairmanship of Director, ICAR-IIHR, Bengaluru. All the ongoing research projects of the Institute 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

- Passport data for the exotic mango collection which is found to be tolerant to fruit fly (EC 95862) to be obtained from NBPGR, New Delhi.
- The selected two passion fruit hybrids and one strawberry hybrid should be field planted.

2. Enhancement of productivity in fruit crops

- The HDP trial on Alphanso mango by Reju M. Kurian is concluded as per the recommendations of 84th IRC after last harvest season. A technical bulletin on the research findings may be brought out.
- Dr. Sampath Kumar will take over the experiment on organic production of Sapota following superannuation of Dr. V. V. Sulladmath which can be merged with the sub project 011(4) as it forms part of integrated nutrient management.

3. Breeding tropical vegetable crops for resistance to biotic and abiotic stresses with high yield and quality attributes through marker-assisted selection (MAS)

- Base material for breeding tomato hybrids suitable for polyhouse cultivation should have nematode resistance.
- Observations on fruit color retention of chilli powder and whole dry fruit may be taken in comparison with a reference commercial variety.
- Screening should be initiated for jassids resistance/tolerance in okra.
- Quality seed production under protected condition with insect pollinators needs to be compared with seed production under natural pollination of open conditions.

4. Developing production technology for tropical vegetables

- Work on cherry tomato may be initiated.
- Impact of organic treatments on the soil physical conditions like bulk density, infiltration rate etc, may be recorded in organic farming trials.

5. Genetic improvement of Ornamental Crops

- Small flowered varieties may be developed for garland purpose.
- Mite resistant and powdery mildew lines may be registered.

- Incidence of *Fusarium* wilt, infestation of mites and thrips in open field condition should be recorded.

6. Enhancing quality and production of ornamental crops through cultural practices

- Shade net colour should be correlated with incidence of insect-pests and diseases.
- Collected material to be maintained by the curator Dr. H.P. Sumangala.

7. Development of post-harvest technologies for loss reduction and utilization of perishable horticultural crops

- The demonstration of technology on scientific handling practices may be intensified by organizing awareness programmes for farmers and small traders in collaboration with the Division of Extension and Training.
- As the design of package for sapota has been standardized and tested the same may be validated through AICRP-Fruits Centres. Dr. Bhuvaneswari may provide the same to end users through PC (Fruits).

8. Development of disease diagnostics and molecular characterization of plant pathogens infecting horticultural crops

- Per cent virus infection on seed coat in relation to systemic infection may be documented in tomato and bottle gourd.
- The genome of the resistance breaking strain of the ToMV may be analyzed in detail to understand the difference with normal strain.

9. Development of forecasting systems for effective management of diseases of fruits and vegetables

- The occurrence of new population of yellow rust of grapes may be confirmed.
- Moisture stress and virus interaction may be examined taking using chilli veinal mottle virus/ cucumber mosaic virus in chilli.

10. Development of integrated disease management strategies in horticultural crops

- Effect of sudden weather changes (e.g., unexpected rains) during the fruit set stage on the anthracnose incidence and post-harvest damage in mango and capsicum may be studied.
- The efficacy of vegetable oils against pomegranate blight may be evaluated.
- The bio efficacy of selected bio-agents needs to be tested under AICRP on vegetables.

11. Collection, improvement and utilization of mushrooms

- Modalities for export of mushroom germplasm need to be facilitated and provided by the Head, Division of PGR, ICAR-IIHR.

12. Pest management in vegetable crops

- For trapping thrips using blue colour traps, standard colour code should be specified.

13. Bio-intensive management of major pests of horticultural crops

- Objectives completed as per the RPF I, hence the sub-project may be closed and RPP-III & IV may be submitted.

14. Management of nematodes in horticultural crops

- Popular articles in local languages should be published in collaboration with Division of Extension & Training.
- Wherever possible, the quality of biopesticide samples may be checked randomly in the industries licensed to produce biopesticides using IIHR technology to ensure quality.

15. Investigations on tolerance to biotic and abiotic stresses for sustainable productivity in horticultural crops

- Dr. M.R. Dinesh, Head, Division of Fruit Crops may be consulted in studies on sex expression pattern in papaya under salinity.
- The threshold temperature for pollen germination may also be studied.

16. Investigations on physiological factors limiting productivity and quality of horticultural crops

- Possibility of commercializing mango seed kernel based antioxidants may be explored.

17. Biochemical basis of fruit disorders

- Soil properties of the region, optimum fruit-maturity, relative humidity and stage of harvest may be included for studies on causes of jelly seed formation in mango.

- The formulation developed by Dr. V. Ravindra, Division of Plant Physiology & Biochemistry, for prevention of spongy tissue in Alphonso mango may be tested for prevention of jelly seed in the next fruiting season.

18. Dynamics of soil and plant nutrients and their management in horticultural crops for yield and quality

- Micronutrient formulations may not be promoted in NE region as the entire NE is declared as organic farming states.
- Work on nutrient dynamics in soil with respect to water soluble fertilizer and normal fertilizer may be given emphasis.

19. Soil health, food and environmental safety in horticultural cropping systems

- Streptomycin residue study in pomegranate to be under taken.
- Waiting period for different chemicals on different crops has to be made available on ICAR-IIHR website.

20. Impact assessment and transfer of technology in horticulture

- Training impact has to be studies in a case study mode.
- Demonstrations of technologies with the participation of small and marginal farmers at cluster level may be organized.
- A new project may be submitted targeting impact of innovative ICT methods.

21. Exploration, collection, domestication and conservation of genetic resources in horticulture crops

- Mapping data to be shared with concerned crop curators for exploration activity.
- Validate the taxonomic identity of the target species through expert taxonomist to be done.
- With respect to RET species in IIHR FGB, for floral biology studies, details pertaining to prevailing climatic factors like temperature, RH to be recorded, owing to frequent shifts in climate patterns.

22. Evaluation, characterization, quarantine, exchange and documentation of germplasm

- In polyembryonic results of mango, a preponderance of zygotic seedlings over nucellar types obtained to be checked.
- *J. grandliflorum* for high concrete, besides Mysore mallige and Udupi mallige, for which GI tag is assigned may be included in collection programs, identity of Hiriyur mallige may be traced *(J. auriculatum* - Hadagali mallige) from Huvina Hadagali to be collected.
- In place of Dr. P.C. Tripathi, who is transferred to ICAR-IIHR, Bengaluru, Dr. R. Senthil Kumar is identified from CHES Chethalli.

23. Development of molecular markers for application in horticultural crops

- Since capsicum is susceptible to wilt, RGAs from capsicum may not be good source. *S.torvum* (sold by KAU) and Pusa Jwala are resistant to Bacterial wilt. These lines should be used for developing RGAs. Basic knowledge of the pathogen is very important as the pathogen/bacteria is very variable.

24. Gene cloning, regeneration systems and transgenic development for important horticultural traits

- The shortlisted events should be put through rigorous selection at NRC Pomegranate. Resistant ones may be put through biosafety evaluation.
- Ascertain for presence of *Xa21* gene or its analogue in pomegranate, check for the methylation status of its promoter and then go for de-methylation.

25. Endophytic and molecular microbiology

- Tissue culture can be used for multiplication of Arka Prabath.
- Tissue culture protocols should be developed to multiply various inter-generic hybrids of papaya developed at the Institute under the flagship program for PRSV resistance in papaya.

26. Seed multiplication and quality assurance of seed propagated horticultural crops

- Seed set need to be recorded in all the plants which show resistance to shoot and fruit borer.
- Commercial application of ultra-drying in addition to germplasm conservation may be explored.

27. Mechanization of production and processing of horticultural crops

- Prioritization of crops for mechanization needs to be made by the section after discussing with the crop division scientists.
- The exhaust fans of tunnel type solar drier may be integrated with photovoltaic module.

28. Economic research, statistical modelling and computer applications in horticulture

- NRC on Grapes protocol may be followed for developing an effective DSS useful to farmers.
- Technical bulletins reflecting research findings w.r.t. PHL, economics of production, cost of cultivation and other economic and statistical aspects may be released.

29. Collection & evaluation of under-utilized fruits for humid tropics and purification of papaya

- Promising under-utilized fruits may be registered with NBPGR.
- A project may be initiated on standardization of production technologies of important underutilized fruit crops.
- The purification of papaya may be continued.

30. Demonstration and impact of CHES technologies

- The number of farmers surveyed should be increased by another 25 farmers. The data of survey of 5 farmers can not reflect the real situation and the interpretation made is misleading information.

31. Development, refinement and popularization of cropping system models for improving productivity of horticultural crops in high altitude regions of Western Ghats of India

- The survey of the humid areas such as Bhagmandala, Sulia etc. may be done for collection of indigenous vegetables.

32. Plant genetic resource management and improvement in horticultural crops

- Collection of fruit crops should be made considering the traits of interest like earliness, colour, fruit quality, etc.
- Back cross progeny may be advanced through backcross with spine gourd i.e. BC_3F_1.
- Rust resistance trait may be taken into consideration in Amaranthus screening.

33. Management of biotic stress in horticultural crops for Eastern India

- Mango varieties come to flowering at different time hence incidence of powdery mildew should be recorded at different stage like pea, mustard and flowering, so that impact of powdery mildew in different stage on the fruit bearing can be worked out.

12.3 Institute Management Committee

During the period 01.04.2015 to 31.03.2016, the 83rd and 84th IMC meetings were held on 28.10.2015 and 23.04.2016 respectively.

12.3.1. 83rd Institute Management Committee Meeting

Chairman: **Dr. M. Anandaraj**
Director, ICAR-IIHR, Bengaluru

Members: **Dr. D.P. Kumar**
Director of Education, 1st Floor, Naik Bhavan, UAS, GKVK, Bengaluru-560 065

Dr. P.C.Tripathi,
Principal Scientist, Division of Plant Genetic Resources, ICAR-IIHR, Bengaluru

Shri. K.M. Parashiva Murthy
Addl. Director of Horticulture (Fruits), Govt. of Karnataka, Dept. of Horticulture, Lalbagh, Bengaluru

Shri. Satyabrata Sahoo
Commissioner of Horticulture and Plantation Crops, Govt. of Tamil Nadu, Chennai (Represented by Shri.S.V.K.Rajendran, Joint Director of Horticulture and Plantation Crops)

Shri. D.D. Verma
Comptroller, ICAR-NAARM, Rajendranagar, Hyderabad-500 030.

Shri. Bhagawan Asaram Dongare
At P.O., Sawargaon (Hadaq), Tq. Dist., Jalna-431 203, Maharashtra

Shri. A. Shivanna
Kukkur Doddi, Marchanahalli Post, Mallur Hobli, Channapatna Taluk, Ramanagar District, Karnataka

Member-Secretary:
Shri. Charles Ekka,
Senior Administrative Officer, ICAR-IIHR, Bengaluru

Special Invitees from IIHR, Bengaluru:

Dr. M. R. Hegde,
Chairman, RPMEC

Dr. A.T. Sadashiva
Head, Division of Vegetable Crops
ICAR-IIHR, Bengaluru.

Dr. Sudha Mysore
Chairperson, Institute Technology Management & Consultancy Processing Committee, ICAR-IIHR, Bengaluru.

Dr. R.Venkattakumar
Head, Division of Extension and Training, ICAR-IIHR, Bengaluru.

Dr. H. Ravishankar
Chairman, Farm Management Committee, ICAR-IIHR, Bengaluru.

Dr. A.N. Ganeshamurthy
Chairman (Works), ICAR-IIHR, Bengaluru.

Dr. R. Venugopalan
Chairman, P.G. Education Committee, ICAR-IIHR, Bengaluru.

Shri. J.N.L. Das
Senior Administrative Officer (SP), ICAR-IIHR, Bengaluru

Shri. A. Srinivasa Murthy
Finance & Accounts Officer, ICAR-IIHR, Bengaluru.

Major Recommendations

1. Post Graduate Education

- It was suggested to construct the hostel building before the next academic session to house Ph.D students.
- In order to facilitate students for ease of accessibility to city, allotment of a vehicle exclusively for PG students is recommended.
- In order to facilitate teaching of courses in four major disciplines and minor courses, creation of 5 class rooms with modern facilities like smart board, podium, computer, tables with foldable chairs may be created.
- Recommended to establish PG admin cell ("PGSI and PGSII") along similar lines as that at IARI for dealing with fellowship, contingency, comprehensive exams, online management of courses and hostel related matters.
- Play ground facility for students may be created.
- Identification of land for PG administration and class room buildings.

2. Setting up of waste water recycling plant at ICAR-IIHR, Bangaluru at a cost of Rs.25 lakhs.
3. Building for setting up of of a multi-commodity horticultural crop processing centre for training/ demonstration/skill upgradation and custom hiring at a cost of Rs.75 lakhs.

12.3.2. 84th Institute Management Committee Meeting

Chairman: **Dr. M.R. Dinesh**
Director, ICAR-IIHR, Bengaluru

Members: **Dr. Sreenath Dixit**
Director, ATARI,
Zone-VIII, Hebbal, Bengaluru

Dr. A.K. Singh
Managing Director, National Horticulture Board, Ministry of Agriculture & Farmers Welfare, Government of India, 85, Institutional Area, Sector-18, Gurgaon – 122 015, Haryana.

Dr. Anita Karun
Principal Scientist, ICAR-CPCRI, Kasaragod-671 124, Kerala.

Dr. P.C.Tripathi
Principal Scientist, Division of Plant Genetic Resources, ICAR-IIHR, Bengaluru.

Shri. D.D. Verma
Comptroller, ICAR-NAARM, Rajendranagar, Hyderabad-500 030.

Member Secretary:
Shri. G.G. Harakangi
Chief Administrative Officer, ICAR-IIHR, Bengaluru.

Special Invitees from IIHR, Bengaluru

Dr. C.K. Narayana
Chairman, Project Monitoring & Evaluation Cell, ICAR-IIHR, Bengaluru.

Dr. H. Ravishankar
Chairman,
Farm Management Committee,
ICAR-IIHR, Bengaluru.

Dr. B.N.S. Murthy
Head, Division of Fruit Crops,
ICAR-IIHR, Bengaluru

Dr. R. Venugopalan
Chairman, P.G. Education &
Training Committee, ICAR-IIHR,
Bengaluru.

Dr. R. Venkattakumar
Head, Division of Extension and
Training, ICAR-IIHR, Bengaluru.

Dr. V. Ravindra
Assistant Finance & Accounts Officer
Incharge, ICAR-IIHR, Bengaluru.

Shri. J.N.L. Das
Senior Administrative Officer,
ICAR-IIHR, Bengaluru

Major Recommendations

1. The IMC suggested to replace the vehicles (2 Tata Sumos), and one Tempo Traveller of IIHR and a Sumo of CHES, Bhubaneshwar, for which recommendation of the IMC was already taken in 82nd/83rd IMC meeting, as these vehicles have out-lived their lives and their condition is very bad. The committee also insisted to make concerted efforts to get funds for replacement of these vehicles, as the proposal has been lingering on since 82nd IMC meeting held on 25th February, 2015.
2. Regarding the activities of the consultancy processing cell, the committee suggested to commercialize as many technologies as possible on non-exclusive basis to generate more revenue.
3. Dr. Sreenath Dixit, Director, Agricultural Technology Application Research Institute, suggested to conduct training programmes on regular basis for the Subject Matter Specialists (Hort.) of the KVKs of all zones to refresh the SMSs on latest developments in horticultural technology, production systems, protection measures etc.
4. The IMC ratified the action of the then Director to accord administrative approval/sanction for Rs.150 lakhs towards the construction of extension to farmers/trainees hostel and scientists home along with furniture. The IMC appreciated the action of the then Director for according administrative approval and expenditure sanction for the extant work and depositing the amount of Rs.150 lakhs to CPWD, otherwise no action would have been initiated by the CPWD till the deposit was made by the Institute with the recommendation/approval of the IMC and work would not have been started.

13. Papers Presented In Seminar/Symposium/Conference etc.

1. **Workshop on Regional Horticultural Research and Extension Advisory and Project Formulation of UHS, Bagalkot, COH Mysuru, April 16-17, 2015.**

❖ Aghora, T. S. - French bean variety, Arka Arjun, for on farm trials.

2. **National Seminar on Harmonizing Biodiversity and Climate Change: Challenges & Opportunity (NSBC-2015), ICAR-Central Island Agricultural Research Institute, Port Blair, April 17-19, 2015.**

❖ Shamina Azeez, Pooja Bohra, Shivaramu, K. and Anuradha Sane - Evaluation of jamun (*Syzygium cumini* L.) germplasm for major biochemical constituents.

❖ Shivaramu, K., Pooja Bohra, Anuradha Sane and Ganesh, N. Khadke - Assessing the variability amongst seedling population of jamun (*Syzygium cumini* L.) for morphometric parameters.

3. **International Conference on Low Temperature Science and Biotechnological Advances, NASC Complex, New Delhi, April 27-30, 2015.**

❖ Ganeshan, S. – Cryogene banking in horticulture - current status and future perspectives.

❖ Rajasekharan, P. E. and Ganeshan, S. - Preservation of threatened species pollen cryopreservation in RET medicinal plants of Indian origin.

4. **6th International Conference on Emerging Technologies in Food and Nutrition for Health Management (International Institute of Food and Nutritional Sciences), NDRI (SRS) Adugudi, Bengaluru, May 14-15, 2015.**

❖ Bhuvaneswari, S., Senthil Kumaran, G. and Raghupathy, H. B. - Effect of high humidity storage on freshness and nutritional quality of coriander leaves.

❖ Ranjitha, K., Sudhakar Rao, D. V., Shivashankara, K. S. and Roy, T. K. - Effect of pre-treatments and modified atmosphere packaging on the shelf life and quality of fresh cut carrots.

❖ Shamina Azeez, Tripathi, P. C., Karunakaran, G., Shivashankara, K. S. and Roy, T. K. -Antioxidant potential of the under-utilized fruit karonda in relation to its phenolics.

5. **National Seminar on Jackfruit Fest, Aranmula, Kerala, May 15-16, 2015.**

❖ Linta Vincent, Shivaraj, Anushma, P. L., Rajasekharan, P. E. and Ganeshan, S. - Conservation of jack fruit genetic diversity.

6. **XXXIII Annual Group Meeting of All India Coordinated Research Project on Vegetable Crops, ICAR-IIVR, Varanasi, May 21-23, 2015.**

❖ Madhavi Reddy, K. - Ten AICRP (VC) trials on chilli, bell pepper and paprika.

❖ Sadashiva, A.T. - Tomato seed requirement & gap.

7. **Brain Storming Session on Avocado, CHES Chettalli, May 27, 2015.**

❖ Karunakaran, G., Tripathi, P. C., Sakthivel, T., Sankar, V. and Senthil Kumar, R. - Commercial potential of avocado fruits - with promising future.

❖ Priti Sonavane, Tripathi, P. C., Senthil Kumar, R., Sankar, V. and Jayanthi Mala, B. R. - Incidence and severity of anthracnose disease in avocado germplasm.

❖ Priti Sonavane, Tripathi, P. C., Senthil Kumar, R., Sankar, V. and Jayanthi Mala, B. R. - Etiology and management of anthracnose disease in avocado.

❖ Reddy, T. M., Sankar, V. and Senthil Kumar, R.. - Analysis of avocado marketing in Kodagu.

❖ Sankar, V., Tripathi, P. C., Senthil Kumar, R. and Karunakaran, G. - Nutritional benefits of avocado - A review.

❖ Saxena, A. K., Preeti Sonawane and Tripathi, P. C. - Disease management in avocado.

❖ Tripathi, P. C., Karunakaran, G., Sakthivel, T., Sankar, V., Senthil Kumar, R., Jayanthi Mala, B. R., Priti Sonavane, Ravisankar, H. and Chithraichelvan, R. - Avocado research at CHES Chettalli.

❖ Tripathi, P. C., Karunakaran, G., Sankar, V. and Senthil Kumar, R. - Propagation studies in avocado.

- Tripathi, P. C., Senthil Kumar, R., Sankar, V., Karunakaran, G. and Sakthivel, T. - Selection of promising lines of avocado.

8. National Conference on Dynamics of Smart Horticulture for Livelihood and Rural Development, organized by LASMF, CHAI & JISL, Jalgaon at MGCGV, Chitrakoot, Madhya Pradesh, May 28-31, 2015.

- Narayana, C. K. - Postharvest management of horticultural crops for sustainable livelihood and rural development.
- Sumangala, H. P. - Floriculture for livelihood and rural development.

9. Awareness Raising Meeting on International Year of Soils, MANAGE, Hyderabad, June 05, 2015.

- Kalaivanan, D. - National soil policy towards food and nutritional security.

10. 1st International Conference on Agriculture and Horticulture Sciences, New Delhi, June 06-07, 2015.

- Carolin Rathinakumari, A. - Physical and mechanical properties of garlic bulbs and cloves.

11. 1st National Conference on Agricultural Scientific Tamil, Chennai, June 13-14, 2015.

- Senthil Kumaran, G., Carolin Rathinakumari, A. and Veere Gowda, R. - *Vengaya vidhai vidhakkum Eyandhiram* (Tamil).
- Senthil Kumaran, G., Carolin Rathinakumari, A and Channabassamma. - *Poondupal vidhaiporul thayarika poodu udaikum Eyandhiram* (Tamil).

12. One Day Seminar on Biological Indication of Kuttiattoor Mango, organized by Kerala Agriculture Department, SHM, KVK, Kannur, IIHR, Bengaluru, Gram Panchayat, Kuttiattoor, June 15, 2015.

- Gajanana, T. M. - Marketing of indigenous mangoes.

13. 1st Task Force Meeting, organized by PPV&FRA, New Delhi for finalization of the DUS Test guidelines of Amaranth, Palak and Ridge gourd, UHS, Bagalkot, June 16, 2015.

- Varalakshmi, B. - DUS Test guidelines of Amaranth.
- Varalakshmi, B. - DUS Test guidelines of palak.
- Varalakshmi, B. - DUS Test guidelines of ridge gourd.

14. Jackfruit Diversity Fair- 2015, IIHR-CHES, Hirehalli, Tumakuru. June 27, 2015.

- Patil, P. and Naduthodi, N. - Jackfruit production technology.
- Karunakaran, G. and Loganandhan, N. - Custodians of jackfruit diversity: An overview.

15. National Conference on Emerging Issues in Environment Occupational Health and Safety - National Scenario and Regional Needs, ROHC(S)-NIOH-ICMR, Complex Bengaluru, July 22-24, 2015.

- Lekha, S., Mohapatra, S., Gourishankar, S. and Radhika, B. - Residue dynamics of spiromesifen in cabbage, tomato and soil.
- Radhika, B. Mohapatra, S., Lekha, S. and Gourishankar, S. - Persistence of flubendiamide residues in sandy loam soil.
- Gourishankar, S., Mohapatra, S., Lekha, S. and Radhika, B. - Residual behavior of fluopicolide on cabbage and cauliflower under semi arid climatic conditions.
- Jyothi, V. Divakara and Debi Sharma - Persistence of common pesticides in leafy vegetables.
- Debi Sharma, Jyothi, V. Divakara, Nischitha, Y., Prathiroopa and Vasugi. - Persistence and uptake of oxadiargyl residues in onion greens and cabbage.

16. ITMC Meeting of NRC on Pomegranate, Sholapur, July 28, 2015.

- Sudha Mysore -Technology commercialization, problems and prospects.

17. State Varietal Evaluation Committee (SVEC) Meeting, UHS, Bagalkot, July 29, 2015.

- Varalakshmi, B. - Release proposal of Amaranth varieties Arka Samraksha and Arka Varna.

18. Workshop on *Garcinia* Species, CHES, Chettalli, July 30, 2015.

- Jayanthi Mala, B. R., Sunanda Sanganal, Priti Sonavane, Sankar, V., Senthil Kumar, R. and Venkataravanappa, V. - Flea beetle, *Podontia congregate* (*Coleoptera*: *Chrysomilidae*): a pest on *Garcinia gummigutta*.
- Kishor Kumar, M., Senthil Kumar, R., Venkataravanappa, V., Sankar, V. and Priti Sonavane - Global conservation status of *Garcinia.*
- Sankar, V., Senthil Kumar, R., Karunakaran, G., Tripathi, P. C., Priti Sonavane, Venkataravanappa,

V., Kishor Kumar, M. and Shabarish Rai, P. - Health benefits of kokum (*Garcinia indica* Choisy).

- Senthil Kumar, R.., Tripathi, P. C., Sankar, V., Karunakaran, G., Sakthivel, T., Kishor Kumar, M., Venkataravanappa, V., Priti Sonavane, Ravisankar, H. and Chithraichelvan, R. - Characterization of mangosteen (*Garcinia mangostana* L.) accessions at Kodagu region of Karnataka.
- Senthil Kumar, R., Tripathi, P. C., Sankar, V., Karunakaran, G., Sakthivel, T., Kishor Kumar, M., Venkataravanappa, V., Priti Sonavane, Ravisankar, H. and Chithraichelvan, R. - Characterization of 'gamboge' (*Garcinia morella*) accessions at Kodagu region of Karnataka.
- Senthil Kumar, R., Tripathi, P. C., Sankar, V., Karunakaran, G., Sakthivel, T., Kishor Kumar, M., Venkataravanappa, V., Priti Sonavane, Ravisankar, H. and Chithraichelvan, R. - Evaluation of 'Yellow Mangosteen' (*Garcinia xanthochymus* Hook.) accessions at Kodagu region of Karnataka.
- Tripathi, P. C., Senthil Kumar, R., Sankar, V., Karunakaran, G., Sakthivel, T., Kishor Kumar, M., Venkataravanappa, V., Priti Sonavane, Ravisankar, H. and Chithraichelvan, R. - Evaluation of Malabar tamarind (*Garcinia gummigutta*.) accessions at Kodagu region of Karnataka.
- Tripathi, P. C., Senthil Kumar, R., Sankar, V., Karunakaran, G., Sakthivel, T., Kishor Kumar, M., Venkataravanappa, V., Priti Sonavane, Ravisankar, H. and Chithraichelvan, R. - Evaluation of kokum (*Garcinia indica* Choisy.) accessions at Kodagu region of Karnataka.
- Venkataravanappa, V., Priti Sonavane, Sankar, V., Senthil kumar, R., Kishor Kumar, M., Sunanda Sanganal and Prasanth Kumar, G. M. - Screening of *Garcinia* germplasm against anthracnose and scab.

19. Summer School at ICAR-CIAE, Bhopal, August 01, 2015.

- Oberoi, H. S. - Bioethanol production from lignocellulosic and starchy materials - problems and prospects.
- Oberoi, H. S. - Enzyme production from agricultural wastes and by-product.

20. Third International Symposium on Underutilized Plant Species-Exploration and Conservation for Future Generation, Madurai, Tamil Nadu, August 05-08, 2015.

- Linta Vincent, Anushma, P. L., Ganeshan, S. and Rajasekharan, P. E. - Diversity, distribution, collection and conservation of Amaranth germplasm from Andhra Pradesh.
- Murthy, B. N. S. - Breeding passion fruit (*Passiflora edulis*) for direct consumption.
- Ravishankar, H., Sakthivel, T. and Karunakaran, G. - Prospects of avocado (*Persea americana* mill.) cultivation in some parts of India - need for augmentation of genetic resources and their improvement.
- Ravishankar, H., Sakthivel, T., Murthy, B. N. S. and Anuradha Sane. - What ails passion fruit (*Passiflora edulis* Sims.) industry of the world? Way forward.
- Sakthivel, T., Ravishankar, H., Chelvan, R. C., Tripathi, P. C., Karunakaran, G., Senthil Kumar, R. and Sankar, V. - Rambutan (*Nephelium lappaceum* L.), a potential fruit crop of the humid subtropical India: Some suggestions for future.
- Sankaran, M., Abirami, K., Vivekananda Singh, Dam Roy, S. and Murugan, C. -*Triphasia trifolia*: an underutilized citrus family fruit in Nicobar Islands of India.
- Sankaran, M., Dinesh, M. R., Prakash Patil and Reddy, B. M. C. - Evaluation of promising genotypes of Pommelo for yield and other attributes.
- Sumangala, H. P. - Adaptability and utilization of native ornamentals of Western Ghats of India.

21. Symposium on Germplasm to Genes: Harnessing Biotechnology for Food Security and Health, NASC, New Delhi, August 09-11, 2015.

- Smita, R. Maske, Anuradha Upadhyay and Satisha, J. - RNA sequence analysis to understand response to GA_3 application in grapes (*Vitis vinifera* L) cv. Thompson seedless.

22. Integrated Crop Management in Vegetable Crops for Foreign Delegates from Kenya, Malawi and Liberia, August 10, 2015.

- Singh, T. H. - Advances in seed production techniques in eggplant.

22. Fourth US-India-Africa Triangular International Training Programme, organized by MANAGE, Hyderabad, August, 10-13, 2015.

- Sudha, M. - Technology commercialization and business process development at IIHR.

23. International Certificate Course on Requisites of Seed Production, Processing Quality Assurance, ICAR-IIHR, 10-14, August, 2015.

- Bhanuprakash, K. - Advances in seed quality testing in vegetable crops.
- Padmini, K. - Advances in seed production and seed standards of vegetable crops.
- Singh, T. H. - Advance in seed production methodology in brinjal.
- Varalakshmi, B. - Advances in seed production methodology in gourds and leafy vegetables.

24. International Training Programme for African Nationals, August 11, 2015.

- Aswath - Panel discussion on flower production.

25. Workshop on Onion, Department of Horticulture, Telangana, Hyderabad, August 14, 2015.

- Sreenivasa Rao, E. - Promotion of onion area expansion.

26. Workshop on *Garcinia* Speices, CHES, Chettalli, Kodagu, August 20, 2015.

- Vasantha Kumar, T., Tripathi, P. C., Lokesha, A. N. and Rohini, M. R. - Medicinal properties of *Garcinia.*
- Tripathi, P. C., Karunakaran, G., Sankar, V. and Senthil Kumar, R. - *Garcinia* in India. –
- Senthil Kumar, R., Tripathi, P. C., Sankar, V., Karunakaran, G., Sakthivel, T., Kishor Kumar, M., Venkataravanappa, V., Priti Sonavane, Ravisankar, H. and Chithraichelvan, R. - Fifteen year of research on *Garcinia* at CHES Chettalli.
- George, S. and Padmavathy, M. K. - Value addition training programmes in Kokum.

27. National Seminar on Biological Products from Crop, Animal and Human Health: Problems and Prospects, organized by the National Academy of Biological Sciences and the University of Mysore, August 21-22, 2015.

- Pious Thomas - Disturbance of field microbial community by introduced putative biocontrol bacterium and its survival in soil: A case study with *Pseudomonas aeruginosa*

28. Special Training Course on Advances in Production Technology of Horticultural Crops, organized at ICAR-IIHR, August 25-28, 2015.

- Madhavi Reddy - Advances in production technology of selected horticultural crops-chilli and capsicum.

29. One Day Panel Discussion on Medicinal and Aromatic Plants Research: A Way Forward, organized by MAPAI, DMAPR, Anand, September 01, 2015.

- Ganeshan, S. - Concepts understood & misunderstood.

30. 3rd International Symposium on Phytophthora: Taxonomy, Genomics, Pathogenicity, Resistance and Disease Management, organized at IIHR, September 09-12, 2015.

- Sriram, S. - *Phytophthora* diseases in ornamental crops in India.
- Sonavane, P. S., Saxena, A. K., Venkataravanappa, V., Krishnareddy, M. and Jayanthi Mala, B. R. - Status and management of *Phytophthora* diseases in Coorg Mandarin.
- Saxena, A. K., Rathnamma, K. and Thilaka Rani, R. - Influence of weather factors on black banded disease in mango in view of climate change.
- Sridhar, V., Vinesh, L. S., Mohan Kumar, S. P., Chowdappa, P. and Saxena, A. K. - Global potential distribution of *Phytophthora infestans* under current and climate change situations.

31. XXIII AICRP MAP & BV Group Meeting, DMAPR, Anand, September 27-30, 2015.

- Vasantha Kumar, T. - Work done under centre of excellence on betelvine.
- Suryanarayana, M. A. - Work done under AICRP MAP & betelvine of IIHR.
- Hima Bindu, K. - DUS guidelines of betelvine.

32. National Consultation Meeting on Sapota, organized by Navsari Agricultural University and AICRP (Fruits), IIHR at Navsari, September 29, 2015.

- Patil, P., Naduthodi, N. and Singh, P. - Status of sapota cultivation in India.

33. National Conference on Science and Technology for Indigenous Development in India Bioblooms, M.S. Ramaiah College of

Arts, Science and Commerce, Bengaluru, October 05-07, 2015.

- Gopalakrishnan, C. - Evaluation of talc based formulations of *Pseudomonas fluorescens* and *Bacillus subtilis* against bacterial wilt of tomato caused by *Ralstonia solanacearum* E.F. Smith (Yabuuchi*et al.*).
- Usharani, T. R., Sowmya, H. D., Sowmya, S., Sunisha, C. and Dhamodhar, P. - Sonication assisted *Agrobacterium* transformation of banana cv. Neypoovan shoot tips with GUS reporter gene.

34. Special Training Course on Advances in Production Technology of Horticultural Crops-for Horticultural field officers of Karnataka, organised by KVK Gonikoppal and ICAR-IIHR, October 05-08, 2015.

- Karunakaran, G. - Potential of future fruit crops and their adoption.

35. XXIV National Conference-VIROCON 2015: Transboundary Viral Diseases Under one Health: Perspectives and Challenges. NEIGRIHMS, Shillong, Meghalaya, October 08-10, 2015.

- Krishna Reddy, M., Hemachandra Reddy, P., Jalali, S., Samuel, D. K. and Aksatha, G. - Phylogeography, genetic diversity and molecular evolution of zucchini yellow mosaic virus (ZYMV).

36. ICAR Winter School on Advanced Breeding Strategies for Biotic and Abiotic Stress Tolerance in Vegetable Crops, IIHR, Bengaluru, October 08-28, 2015.

- Aghora, T. S. - Advance breeding strategies for biotic and abiotic stress tolerance in French bean and cowpea.
- Madhavi Reddy, K. - Advanced breeding strategies for biotic and abiotic stress tolerance in chilli and bell peppers (*Capsicum annuum* L.).
- Sadashiva, A. T., Krishna Reddy, M., Ravishankar, K.V., Singh, T. H., Bhatt, R. M., Dominic Prakash D'mello and Punith Kumar, R. - Advanced breeding strategies for biotic and abiotic stress tolerance in tomato (*Solanum lycopersicum* L.).
- Singh, T. H. - Advance breeding strategies for biotic and abiotic stress tolerance in brinjal (*Solanum melogena* L.).
- Rao, E. S., Thontadarya, N. and Nagesh, G. C. - Breeding muskmelon and watermelon for resistance to biotic and abiotic resistance.
- Ravishankar, K. V. - Application of molecular markers in biotic stress tolerance in vegetable crops.
- Varalakshmi, B. - Advanced breeding strategies for biotic and abiotic stress tolerance in gourds and leafy vegetables.
- Veere Gowda, R. - Advanced breeding strategies for biotic and abiotic stress tolerance in onion and carrot.
- Nair, A. K. - Integrated crop management practices to overcome biotic stresses in open cultivation of vegetable crops.
- Hebbar, S. S., Nair, A. K. and Prabhakar, M. - Protected cultivation of vegetable crops for overcoming biotic and abiotic stresses.

37. Seminar cum Field Day on Rambutan, CHES, Chettalli, October 10, 2015.

- Jayanthi Mala, B. R., Karunakaran, G., Tripathi, P. C., Rangnath, H R., Senthil Kumar, R., Sankar, V., Venkataravanappa, V., Priti Sonavane and Kishore Kumar, M. - Insect pests and their management in Rambutan (*Nephalium lappaceum*) under humid tropics.
- Jayanthi Mala, B. R., Shabarish Rai, P., Sunanda Sanganal, Priti Sonavane and Senthil Kumar, R. - *Apis florea* (Apidae: Hymenoptera) a predominant bee species in Rambutan *(Nephelium lappaceum* L.).
- Karunakaran, G., Tripathi, P. C., Ravishankar, H., Sankar, V., Sakthivel, T. and Senthil Kumar, R. - Scope and potential of Rambutan cultivation in Western Ghats – Success story of farmers.
- Kishor Kumar, M., Senthil Kumar, R., Sankar, V., Venkataravanappa, V., Jayanthi Mala, B. R. and Priti Sonavane. - Physical and biochemical changes in commercial quality of 'CHES-28' accession of rambutan during modified atmospheric packaging storage.
- Kishor Kumar, M., Senthil Kumar, R., Venkataravanappa, V., Sankar, V., Priti Sonavane and Jayanthi Mala, B. R. - Rambutan (*Nephelium lappaceum* L.) - Physiological and nutritional disorders and their management.

- Ravishankar, H., Sakthivel, T. and Karunakaran, G. - Rambutan - a potential fruit crop of the humid tropical regions of Southern India - approaches to commercial exploitation.
- Sankar, V., Senthil Kumar, R., Karunakaran, G., Priti Sonavane, Venkataravanappa, V., Kishor Kumar, M., Jayanthi Mala, B. R. and Shabarish Rai, P. - Health benefits of rambutan.
- Senthil Kumar, R., Kishor Kumar, M., Sankar, V., Sakthivel, T., Karunakaran, G., Tripathi, P. C., Chithiraichelvan, R. and Ravishankar, H. - Current status and conservation of rambutan (*Nephelium lappaceum* L.) germplasm at CHES. Chettalli.
- Senthil Kumar, R., Kishor Kumar, M., Sankar, V., Tripathi, P. C., Karunakaran, G., Sakthivel, T. and Ravishankar, H. - Evaluation of rambutan (*Nephelium lappaceum* L.) accessions for free stone character.
- Sudhakar Rao, D. V. - Post harvest management practices and value addition of rambutan.
- Tripathi, P. C., Karunakaran, G., Sankar, V. and Senthil Kumar, R. - Improved production technologies of rambutan.
- Venkataravanappa, V., Priti Sonavane, Senthil Kumar, R., Kishor Kumar, M., Sankar, V. and Jayanthi Mala, B. R. - rambutan diseases and their management.

38. Winter School on Precision Citriculture for Sustainable Production and Post-Harvest Management, organized at ICAR-CCRI, Nagpur, October 15-November 04, 2015.

- Lakshmana Reddy, D. C. - Biotechnological tools for crop improvement.

39. Training Programme on Ways to Enhance Tomato Production in Bhutan, organized by AVRDC, The World Vegetable Centre and IIHR at UAS, Bengaluru, October 25-November 06, 2015.

- Padmini, K. - Seed production of open pollinated varieties at farmer's field.

40. International Conference on Vertical Farming, Bengaluru, November 02-03, 2015.

- Manjunath, B. L., Singh, N. P., Desai, A. R., Sunetra Talaulikar, Gaonkar, V. Y. and Raj Narayan. - Homestead farming-the future agricultural asset for prosperity.
- Murthy, B. N. S. - Strawberry - A candidate fruit crop for growing under soilless vertical culture system.
- Raimani Hembrom and Manjunatha Rao, T. - Skyscraping gardening-revolution on rise.
- Hemlata, Manjunatha Rao,T., Ishan Yadav and Pratiksha Kumari. - Vertical farming prospects and challenges in India.
- Carolin Rathinakumari, A., Senthil Kumaran, G., Dayananda, P. and Pushpalatha, V. - Protray step seeder for vertical farming.
- Meera Pandey, Senthil Kumaran, G., Satisha, G. C. and Shamina Azeez. - Vertical mushroom gardening – A synthesis of nutrition and aesthetics.
- Gaddagimath, P. B. and Aswath, C. - Vertical farming towards resilient food system in India: a potential component of urban and peri-urban horticulture.

41. International Symposium on Next Generation Approaches for Sustainable Development of Hill and Upland Horticulture, organized by Department of Horticulture, Sikkim University, Gangtok, November 05-07, 2015.

- Das, R., Veere Gowda, R , Chowdappa, P. and Halesh, G. K. - Evaluation of onion (*Allium cepa* L.) genotypes for resistance to purple blotch disease (*Alternaria porri* (Ellis) Ciferri).
- Meera Pandey and Senthil Kumaran. – Mushroom - an appropriate crop to enhance nutrition and livelihood opportunities in Sikkim.
- Shivananda, T. N., Hegde, M. R., Ravishankar, H., Narayanaswamy, B. and Nita Khandekar. - Role of Agricultural Technology Information Centre (ATIC) of IIHR in dissemination of horticultural technologies.

42. International Conference on Frontiers of Plant Sciences and Developing Technologies, Institute of Agricultural Sciences, Benaras Hindu University, Varanasi, November 07-28, 2015.

- Singh, R. P., Dey, S. K., Satisha, G. C., Singh, R. S. and Jacob, J. - Growth and yield performance of seven popular *Hevea* clones and soil properties in sub-tropical areas of Mizoram.

43. Seminar on Achieving Double Digit Growth in Horticulture Sector Andhra Pradesh, ICRISAT Hyderabad, November 13, 2015.

- Aswath, C. - IIHR technologies for higher growth in horticulture.

44. Brain Storming Session on Citrus Industry at Sikkim University, Gangtok, November 15, 2015.

❖ Tripathi, P. C. - Citrus research at IIHR.

45. Training Material for Precision Farming Practices (Micro irrigation, mulching, fertigation, IPM etc) Fruit, Vegetable and Flower Crops suitable for Kerala, November 16-21, 2015.

❖ Padmini, K., Singh, T. H. and Veere Gowda, R. - Precision farming techniques in hybrid seed production of vegetable crops.

46. Winter School on Recent Advances in Development of Automatic Systems/Machines for Secondary Agriculture, CIPHET, Ludhiana, November 18 - December 08, 2015.

❖ Oberoi, H. S. and Ranjitha, K. - Bioethanol production from agricultural by-products.

❖ Oberoi, H. S. and Ranjitha, K. - Enzyme production from agricultural waste and by- products.

❖ Bhuvaneswari, S. - Smart/intelligent packaging of food materials.

47. National Seminar on Recent Advances in Research & Development in Medicinal & Aromatic Plants- A Country Scenario, organized by State Forest Research Institute, Jabalpur, November 27-28, 2015.

❖ Ganeshan, S. - Genetic resource management in medicinal and aromatic plants: A country scenario.

48. National Symposium on Sustainable *Citrus* Production: Way Forward, ICAR-Central Citrus Research Institute, Nagpur, November 27-29, 2015.

❖ Ravishankar, H., Sakthivel, T., Karunakaran, G., Raghupathi, H. B., Shivananda, T. N. and Samuel, D. K. - History and present status of Coorg mandarin cultivation and strategies for its revival in Kodagu region of Karnataka.

❖ Tripathi, P. C. - *Citrus* germplasm of south India-utilization in crop improvement and production.

❖ Senthil Kumar, R., Kishor Kumar, M. and Sankar, V. - Proximate analysis of twenty high yielding clones of Coorg mandarin (*Citrus reticulata* Blanco).

❖ Senthil Kumar, R., Sankar, V., Karunakaran, G., Tripathi, P. C. and Kishor Kumar, M. - Refinement of technologies to improve productivity of Coorg mandarin under multitier cropping system.

❖ Sudha, M., Gajanana, T. M. and Sreenivasa Murthy, D. - *Citrus* production marketing and commercialization: prospects and opportunities.

49. National Seminar on Citrus Improvement, CICR, Nagpur, December 02, 2015.

❖ Aswath, C. - Use of molecular markers in *Citrus* improvement.

50. Symposium on Challenges in Plant Virology and Our Preparedness, Division of Plant Pathology, IARI, New Delhi, December 05, 2015.

❖ Samuel, D. K., Krishna Reddy, M., Jalali, S., Gad, A. and Reddy, H. C. - Deployment framework for no cost Linux, free and open-source software (FOSS) for viral bioinformatics with easy access from Windows Operating System.

51. National Seminar on Developments in Soil Science- 2015 and 80th Annual Convention of Indian Society of Soil Science, UAS, GKVK, Bengaluru, December 05-08, 2015.

❖ Kalaivanan, D., Panneerselvam, P., Ganeshamurthy, A. N. and Revathi, V. - Alleviation of salt stress in tomato var. Arka Rakshak by intervention of halotolerant bacteria.

❖ Rupa, T. R., Kalaivanan, D., Vijay Singh and Srividya, B. R. - Optimizing nutrient management for drip irrigated mature cashew plantations.

❖ Raghupathi, H. B. and Shilphashree, V. M. - Compositional nutrient diagnosis (CND) technique for assessment of nutrient imbalance in pomegranate.

❖ Satisha, G. C., Bharathi, K., Shruthi, T. S., Mazhar Jamil and Ganeshamurthy, A. N. - Effect of foliar application of micronutrients on growth and yield of okra (*Abelmoschas esculentus* L. moench).

52. Workshop on Papaya Farming: Production, Marketing, Value Addition and Opportunities, Directorate of Extension, UHS, Bagalkot, December 08, 2015.

❖ Vasugi, C. - Advanced technologies and varieties in papaya.

53. Awareness Programme on Off-Season Litchi Cultivation in South India, CHES, Chettalli, December 10, 2015.

- Narayana, C. K. and Oberoi, H. S. - Postharvest management and value addition in litchi.
- Tripathi, P. C., Karunakaran, G., Sankar, V., Sakthivel, T. and Senthil Kumar, R. - Scope and potential of off season litchi cultivation in western ghats.
- Senthil Kumar, R., Kishore Kumar, M., Sankar, V., Karunakaran, G., Tripathi, P. C., Sakthivel, T. and Ravisankar, H. - Performance of litchi cultivars under high altitude and high rainfall areas of western ghats.
- Sankar, V., Senthil Kumar, R., Venkataravanappa, V., Priti Sonavane, Kishor Kumar, M., Shabarish, P. Rai and Karanakaran, G. - Nutritional and health benefits of litchi.
- Venkataravanappa, V., Priti Sonavane, Kishor Kumar, M., Sankar, V., Senthil Kumar, R. and Prasanth Kumar, G.M. - Management of emerging diseases of litchi.

54. International Symposium on Biodiversity, Agriculture, Environment and Forestry Fortune, Resort Sullivan Court, Selbourne Road, Ooty, Tamil Nadu, December 11-12, 2015.

- Anuradha Sane, Madhuri Ghatke, Archana Gadre and Tejaswini - Cross amplification of microsatellite *loci* in marigold (*Tagetes erecta*) for genetic diversity analysis.

55. 3rd International Plant Physiology Congress, Challenges and Strategies in Plant Biology Research, New Delhi, December 11-14, 2015.

- Shivashankara, K. S. - Anther dehiscence, pollen viability, stigma receptivity and pre, post-pollination biochemical changes in three varieties of mango.
- Laxman, R. H. - An approach for high throughput phenotyping of tomato genotypes using plant phenomics platform.

56. Symposium on Spices and Aromatic Crops (SYSMAC VIII) Towards 2050-Strategies for Sustainable Spices Production, Tamil Nadu Agricultural University, Coimbatore, December 15-18, 2015.

- Kishor Kumar, M., Senthil Kumar, R. and Sankar, V. - Modelling individual fruit volume of Malabar tamarind (*Garcinia gummiguutta*) based on fruit length and diameter measurements.
- Hima Bindu, K., Ramakrishnan, R., Suryanarayana, M A., Shivasankara, K. S., Roy, T. K. and Vasantha Kumar, T. - Essential oil composition of betelvine hybrid and parents Sirugamani 1 and Swarna Kapoori.

57. National Symposium on Prospects and potentials in Medicinal and Aromatic Plants, Govt. Colleges (PG & UG), Ananthapur, Andhra Pradesh, December 19, 2015.

- Vasantha Kumar, T. - Medicinal and aromatic plants- health perspective.

58. DBT Review Meeting, CGO Complex, New Delhi, December 22, 2015.

- Sadashiva, A. T. - Progress on begomovirus resistance in tomato.

59. IP&TM Interactive Workshop, New Delhi, December 23, 2015.

- Sudha, M. - Activities and role of ZTMU and agri-business incubation facility at IIHR.

60. Training Programme for Innovative Farmers on Profitable Rambutan Cultivation, KVK, Pattanamthitta, Kerala, January 11, 2016.

- Karunakaran, G. - Introduction to commercial varieties and propagation methods of rambutan.

61. Advanced Production Technologies in Flower Crops, organized by College of Horticulture, Mysore, January 12, 2016.

- Dhananjaya, M. V. - Tuberose cultivation.

62. 103rd Indian Science Congress-2016, University of Mysore, Mysuru, January 03-07, 2016.

- Satisha, G. C., Bharathi, K., Shruthi, T. S. Mazhar Jamil and Ganeshamurthy, A. N. - Response of cauliflower (*Brassica oleracea* L. ssp. *botrytis* to soil applied sulphur in typic haplustepts of transition zone of Karnataka.
- Nandeesha, P., Bharat, V., Mahadevaswamy, H., Ashokan, R. and Rao, M. S. - Towards cloning of nematicidal *cry* genes from indigenous isolates of *Bacillus thuringiensis* from India.
- Satisha, G. C., Bharathi, K., Shruthi, T. S., Mazhar Jamil and Ganeshamurthy, A. N. - Effect of foliar application of $ZnSO_4$ and ZnO nanoparticules on growth, biomass production and uptake of cole crops.
- Usharani, T. R., Sunisha and Sowmya - *In vitro* selection of Neypoovan (*Elakki bale*) for *fusarium* wilt resistance by induced mutation of embryogenic cell suspension.

63. National Symposium on Recent Trends in Plant Pathological Research and Education, IPS South Zone, UAS, Raichur, January 05-06, 2016.

- Ashwathappa, K. V., Krishna Reddy, M., Madhavi Reddy, M. and Jalali, S. – Biological characterization of cucumber mosaic virus (CMV) infecting chilli (*Capsicum annum* L.).
- Ashwathappa, K. V., Krishna Reddy, M., Lakshiminarayana Reddy, D. C. and Hemachandra Reddy, P. - Molecular identification of cucumber mosaic virus infecting chilli (*Capsicum annum* L.).
- Ashwathappa, K. V., Krishna Reddy, M., Hemachandra Reddy, P. and Jalali, S. - Survey for the incidence of cucumber mosaic virus infecting hot and bell peppers (*Capsicum annuum* L.).
- Krishna Reddy, M., Madhavi Reddy, K. and Sadashiva, A. T. - Mechanism of natural resistance to plant viruses: status and prospects for virus disease management.

64. 8th GCRA International Conference on Innovative Applications for Sustainable Development, UAS, Bengaluru, January 05-07, 2016.

- George, S. and Veerendra Kumar, K. V. - Changing communication preferences of pepper and coffee farmers in Kodagu.
- Atheequlla, G. A., Venkattakumar, R., Balakrishna, B., Nita Khandekhar, Naryanaswamy, B., Achala Paripurna and Jagadish, K. N. - E-horticulture-an initiative to solve real farm situations.
- Balakrishna, B., Atheequlla, G. A., Hebbar, S. S. and Ayisha - Business meet as a strategy to promote protected cultivation in India.
- Jagadish, K. N., Harish, B. S. and Loganandan, N. - WhatsApp group "Horticulture Solutions": A smart phone based innovative extension approach.

65. National seminar on Chilli and Turmeric: Challenges and Opportunities, University of Horticultural Sciences, Bagalkot, January 08-09, 2016.

- Singh, T. H., Pandiyaraj, P. and Rajeev Kumar Yadav - Doubled haploid in chili.
- Madhavi Reddy, K. - Chilli crop improvement.

66. 1st KVK Symposium Zone VIII on Technology Delivery Mechanisms of KVKs for Higher Productivity and Profitability in Agriculture, Organized by ICAR- Agricultural Technology Application Research Institute, Bengaluru and Directorate of Extension, UAS, Dharwad, January 21-22, 2016.

- Veerendra Kumar, K. V., George, S. and Prabhakar, B. - Survey of incidence of foot rot disease of black pepper (*Piper nigrum* L.) in Kodagu.
- Veerendra Kumar, K. V., George, S. and Prabhakar, B. - Outcome of demonstration on rice blast disease managmetn in Kodagu.
- Saju George and Hegde, M. R. - Horticulture solutions: WhatsApp group with smart mobile – smart farmers.
- Hanumanthegowda, B., Prasanth, J. M., Shashidhara, K. N., Ramesh, P. R., Jagadish, K. N. and Loganandhan, N. - Integrated management of bacterial blight on pomegranate caused by *Xanthomonas axonopodis pv.punicae*,

67. National Meet on Distant Hybridization in Horticultural Crop Improvement, IIHR, Bengaluru, January 22-23, 2016.

- Pitchaimuthu, M., Dutta, O. P., Sadashiva, A. T. and Madhavi Reddy, K. - Wild species utilization in vegetable crop improvement – challenges and way forward.

68. A Perspective International Symposium on Medicinal Plants and Herbal Drugs in Human and Livestock - A Global Perspective Chennai, January 29-31, 2016.

- Vasantha Kumar, T. - Past, present and future - a perspective.

69. International Conference on Biodiversity and Bio active Natural Products for Human Welfare, Karur, Tamil Nadu, February 10-12, 2016.

- Kusuma, D. K., Sudhakar Rao, D. V., Bhuvaneswari, S., Vasantha Kumar, T., Hima Bindu, K. and Suryanarayana, M. A. - Effect of storage temperature, packaging on the shelf life of betel leaves.
- Kusuma, D. K., Ranjitha, K. Sudhakar Rao, D. V., Vasantha Kumar, T., Hima Bindu, K. and Suryanarayana, M. A. - Occurrence of enteric pathogens and their survival in betelvine leaves (*Piper betle* L.).
- Ranjitha, K., Kusuma, D. K., Sudhakar Rao, Vasantha Kumar, T., Hima Bindu, K., and Suryanarayana, M. A. - Prevalence and survival of gastro enteric pathogens in betel leaves.

- Hima Bindu, K., Ramakrishnan, R., Upreti, K. K., Vasantha Kumar, T., Suryanarayana, M. A. and Kusuma, D. K. - Screening for Phyto-chemicals in different cultivars of *Piper betle* L. (Piperaceae).

70. National Seminar on Horticultural Diversity for Prosperity, OUAT, Bhubaneswar, Odisha, February, 10-12, 2016.

- Anuradha Sane and Rajiv Kumar - Morpho-molecular characterization and diversity of China aster (*Callistephus chinensis Nees.L*) varieties.
- Singh, H. S. and Sangeetha, G. Pest and disease management options in horticultural crops.

71. International Conference on Climate Change and Food Security: Ethical Perspective, Hyderabad, February, 11-13, 2016.

- Selvakumar, G., Hema Bindu, G., Bhatt, R. M. and Upreti, K. K. - Microbial mediated alleviation of deficit irrigation stress in tomato.

72. National Symposium on Vegetable Legumes for Soil and Human Health, IIVR, Varanasi, February12-14, 2016.

- Aghora, T. S., Mohan, N., Kamala Venkateswaran and Susmita, C. - Development of high yielding yard long bean variety, Arka Mangala under technical session underutilized and underexploited legume vegetables.
- Aghora, T. S., Mohan, N., Ravishankar, K. V., Krishna Reddy, M., Samuel, D. K. and Susmita, C. - Evolving French bean variety for resistance to mungbean yellow mosaic virus (MYMV).
- Paresh Chaukhande, Geeta Biradar, Aghora, T. S. and Laxman, R. H. - Temperature induction response studies in french bean.
- Mohan, N., Susmita, C., Aghora, T. S., Srinivasa Rao, N. K. and Bhatt, R. M. - Evolving garden pea varieties tolerant to high temperature.
- Susmita, C., Mohan, N., Aghora, T. S. and Girija Ganeshan. - Developing early garden pea varieties for resistance to powdery mildew.
- Mohan, N., Susmita, C. and Aghora, T. S. - Developing pole type vegetable dolichos for round the year production.
- Mohan, N., Susmita, C. and Aghora, T. S. - Prospects of vegetable soybean in India to overcome chronic malnutrition.

73. Workshop on Recent Trends in Cellular Mechanisms and Gene Expression, Department of Botany, St. Joseph's College, Bengaluru, February 13, 2016.

- Nandeesha, P. - Hetrogenous gene expression in crop plants.

74. 29th National Convention of Agriculture Engineers on Agro Tech Industries: Status, Scope and Strategies for Food Security, Anand Agricultural University, Gujarat, February 20-21, 2016.

- Meera Pandey and Senthil Kumaran, G. - Mushroom production – building an agro-industry from waste.
- Senthil Kumaran, G., Carolin Rathinakumari, A., Yogheesha, H. S. and Dayanand, P. - Storage studies on germination qualities of onion seeds extracted by ICAR-IIHR onion seed extractor.

75. Task Force Committee Meeting on DUS Betelvine, UAS, Dharwad, February 22, 2016.

- Hima Bindu, K. - DUS guidelines of betelvine.

76. 6th International Conference Plant, Pathogens and People Challenges in Plant Pathology to benefit Humankind, New Delhi, February 23-27, 2016.

- Gopalakrishnan, C., Rashmi B. Artal. and Anuradha Sane - Occurrence of bacterial wilt caused by *Ralstonia solanacearum* on bird of paradise, *Stelitzia reginae* in India.
- Anandaraj, M., Dinesh Singh, Eapen, S. J., Gopalakrishnan, C., Krishna Reddy, M., Prameela, T. P., Ramesh, R., Rosana, O. B., Singh, B. P., Vinay Sagar, Suseela Bhai, R., Patil, V. V. and Vivek Srivastava - Comparative genomics of *Ralstonia solanacearum* strains from India reveals their phyletic profiles and diverse effectomes.
- Krishna Reddy, M. - Molecular diagnosis and distribution of vector borne fastidious vascular colonizing prokaryotes in horticultural crops.
- Gopalakrishnan, C. - Evaluation of zanthonil against bacterial blight of pomegranate.
- Rekha, D., Krishna Reddy, M., Chowdappa, P. and Mohan Kumar, S. P. - Development of integrated disease management (IDM) for the management of early blight of tomato (*Lycopersicum esculentum* Mill) caused by *Alternaria solani*.

- Priti Sonavane - Phylogenetic analysis and selection of candidate DNA barcode for *Bipolaris* sp.
- Gupta, N., Prabha, K., Kadam, G. B., Sriram, S. and Chandran, N. K. - Yellows and corm rot in gladiolus: Incidence, identification and characterization of *Fusarium oxysproum* f. sp. *gladioli*.
- Srinivas, N., Sriram, S. and Shivashankara, K. S. - Metabolomics approach to study the bioefficacy of *Trichoderma asperellum* isolates in India.

77. Satellite Workshop on PGPRs for Sustainable Crop Productivity by the Asian PGPR Society, NASC, New Delhi, February 25, 2015.

- Pious Thomas - Endophytic bacteria: their roles in plant health and biocontrol.

78. International Conference on Greenhouse Technologies for Sustainable Ecosystems and Trade Show, Bengaluru, February 26-27, 2016.

- Carolin Rathinakumari, A., Senthil Kumaran, G., Priyanka, U., Tiwari, R. B. and Dayananda, P. - Development of greenhouse type solar dryer for dehydration of amla.
- Aswath, C. - Vertical farming for sustainable food security.
- Radhika, B., Mohapatra, S., Gourishankar, M. and Lekha, S. - Effect of temperature and moisture on the persistence of flubendiamide on soil.
- Lekha, S., Mohapatra, S., Gourishankar, M and Radhika, B. (2015). Effect of temperature on the degradation of spiromesifen in different soils.

79. 10th DUS Review Meeting conducted at MPKV, Rahuri by PPV&FRA, February 26-27, 2016.

- Singh, T. H. - Analysis of DUS testing in tomato, brinjal and okra.

80. International Conference of Floriculture - Perspective of Challenges Options, Hindustan Antibiotic Exhibition Ground, Pimpri, Mumbai, February 27, 2016.

- Sumangala, H. P. - Opportunities in landscape gardening for lifestyle and eco-friendly environment.

81. Argus FMB Technical fertilizer Conference and Exhibition- NPK Fertilizers India-2016 Balanced Fertilization-Cultivating a New Future, New Delhi, March 09-10, 2016.

- Ganeshamurthy, A. N., Kalaivanan, D. and Manjunath, B. L. - Fertilizer systems of key horticultural crops in India.

82. International Symposium on Sustainable Horticulture-2016, Mizoram University, Aizol, March 14-16, 2016.

- Lenka, J. and Tiwari, R. B. - Osmotic dehydration of mango varieties Alphonso and Totapuri.
- Aswath, C. - New dynamics in horticulture breeding.

83. Second World Noni Congress SRM University, Chennai, March 18-21, 2016.

- Vasantha Kumar, T. - Bio prospecting of medicinal plants.
- Pious Thomas - Endophytic microorganisms: their significance in noni and other medicinal plants.

84. Advance Techniques of Rose Onion Cultivation using Improved Varieties, Organized by Department of Horticulture, Chikkaballapur collaboration with CII-FACE, APEDA at PRS Farm Nandhi Cross, March 19, 2016.

- Veere Gowda, R. - Rose onion.

14. Symposia / Seminars / Other Events

During the year, several conferences/seminars/ workshops/meetings and other important events were organized by the main institute, its regional stations and Krishi Vigyan Kendras, the details of which are given below:

14.1 Conference / Seminars/ Symposia / Meetings

First South Horticulture ZTMC Annual Review Meeting 'HortIP-2016'

ICAR-IIHR organized this meeting on 8th February 2016 at its main campus in Bengaluru, wherein 28 participants from 11 member and host institutes participated. Dr. M. Anandaraj, Director, ICAR-IIHR presided over the event and Dr. R Kalpana Sastry, Joint Director, ICAR-NAARM was the Guest of Honour.

Inaugural session of the ZTMC annual review meeting

Interactive Meet of Karnataka Pomegranate Growers and Technical Experts

To address various production issues, a one-day interactive meet of Karnataka pomegranate growers with technical experts was organized on Saturday, 19th March, 2016 at Chitradurga by the Division of Fruit Crops, ICAR-IIHR, Bengaluru. About 500 farmers from different parts of Karnataka, staff of KVK's at Hirehalli and Babbur, staff of NGO's from Chitradurga and neighboring districts participated in the meet. Technical resource persons were drawn from ICAR-IIHR, Bengaluru; NRC on Pomegranate, Solapur; University of Horticultural Sciences, Bagalkot, University of Agricultural Sciences, Dharward, University of Agricultural and Horticultural Sciences, Shivamogga; M/s. Jain Irrigation Systems Limited, Mysuru; M/s. Netafim Irrigation India Pvt. Ltd, Benagluru and M/s. Reliance Retail Ltd, Bengaluru. Dr. M.R. Dinesh, Director, ICAR-IIHR presided over the meet and Shri C.S.Patil, State Marketing Manager, IFFCO, Bengaluru was the chief guest. Various topics including selection of site with suitable agro-climatic conditions, varietal selection, establishment of new orchards, training-pruning, canopy management, irrigation, fertigation, abiotic and biotic stress management including bacterial blight/wilt management strategies and grading/marketing of fruits were covered. A technical bulletin on pomegranate cultivation and a mobile application developed by ICAR-IIHR were released during the meet for exchange of ideas among various stakeholders.

Brain Storming Session and Exhibition on Avocado

A one day brain storming session and exhibition on avocado was organized at CHES, Chettalli on 27th May, 2015 to discuss issues related to the avocado industry in India and to create a platform for exchange of ideas and thoughts among various stake holders associated with avocado cultivation, promotion, marketing etc. More than 150 scientists, processors,

Glimpses of the brain storming meet on Avocado

planters and industrialists from Kerala, Karnataka, Tamil Nadu, Maharashtra and North Eastern states participated. An exhibition of 100 promising selections of avocado maintained in CHES, Chettalli, more than 50 collections from farmers and processed products of avocado were displayed. Papers were presented on genetic resources, production technologies, processing, marketing and other aspects of avocado. A souvenir on avocado was released and several planters shared their experiences in avocado cultivation.

Workshop on *Garcinia* Species

A one day workshop on *Garcinia* species was organized at CHES, Chettalli on 20th August 2015 to discuss issues related to *Garcinia* production in India and to create a platform for exchange of ideas among various stake holders associated with *Garcinia* cultivation, processing and marketing. The workshop was attended by over 250 participants. Papers on various aspects of *Garcinia* cultivation were presented by experts. Shri. Ammatanda Rathu Belliyappa (Hakathur Village, Madikeri district), Smt. Vasanthi Ponnappa (Horoor, Madikeri), Shri.Anil Balanja Naravi (Belthangadi, Dakshina Kannada) and Shri.Vidheesha L. Bhat (Kotematha, Siddpaur, Uttara Kannada) were felicitated for their contributions in collection, conservation and processing of *Garcinia*.

Seminar-cum-Field Day on Rambutan

A one day seminar-cum-field day on rambutan was organized at CHES, Chettalli on 10th October, 2015 for displaying the rambutan germplasm available at CHES, Chettalli and to discuss the prospects of rambutan cultivation in Karnataka and Kerala. About 200 participants including 130 planters from Kodagu district of Karnataka participated. The rambutan selections of CHES, Chettalli were displayed on the occasion.

Participants in the field day on Rambutan

Awareness Programme on Off-season Litchi Cultivation in South India

An awareness programme on off-season litchi cultivation in South India was organized at CHES, Chettalli on 10th December, 2015. Nearly 225 participants including scientists and planters of Kodagu district of Karnataka participated. A souvenir on litchi was released on the occasion.

Inaugural session of the awareness programme on off season cultivation of litchi

Jackfruit Diversity Fair cum Exhibition -2015

A jackfruit diversity fair cum exhibition was organized by Central Horticultural Experiment Station and Krishi Vigyan Kendra (KVK), Hirehalli, Tumakuru, in collaboration with AICRP, Fruits and DBT Project on Jack Fruit, UAS, GKVK, Bengaluru, on 27th June 2015. The fair was inaugurated by Dr. S.V. Hittalamani, former Additional Director (Fruits), Department of Horticulture, Govt. of Karnataka. About 500 farmers and 70 officials from different organizations participated in the event.

Inaugural session of the jackfruit diversity fair

Plant Varieties Protection and Farmers Right Act (PPV&FRA) Awareness Programme

An awareness-cum-training programme on PPV& FRA was organized at Cherambane village, Madikeri Taluk on 11th March, 2016, by KVK, Gonikoppal in association with Division of Extension & Training, IIHR, Bengaluru. The programme was inaugurated by

Shri Rajeev, a progressive farmer and attended by 120 farmers. Participants were sensitized on DUS testing guidelines in cardamom, black pepper, turmeric and ginger; role and importance of the PPV&FR Act. A compendium on PPV&FRA in Kannada was released on the occasion.

National Consultation Meeting on Sapota at NAU, Navsari

The National consultation meeting on sapota was jointly organized by ICAR-AICRP on fruits and Navsari Agricultural University at Navsari, Gujarat, on 29th September, 2015 to address the major issues of sapota cultivation in Gujarat. One hundred delegates from SAU's and ICAR centres of ICAR-AICRP, researchers, progressive farmers, SHGs and presidents of growers associations participated. An exhibition of sapota varieties and products was organized on the occasion.

Dr. Janakiram, ADG (Hort.) adressing the participants during the national consultation on sapota

Group Discussion of ICAR-AICRP on Fruits

The third group discussion of the ICAR-AICRP on Fruits was organized at Punjab Agricultural University, Ludhiana from 3rd to 6th March, 2016. One Hundred and sixty five delegates from 28 SAU's, 13 ICAR institutes, 1 CAU and 1 private center, participated in the four-day event. Dr. N.K. Krishna Kumar, Deputy Director General (HS), ICAR, inaugurated the group discussion. The research achievements during 2014-15 in crop improvement, crop production and crop protection were reviewed and the research programme for 2016-17 was finalized.

Participants of the group discussion of ICAR- AICRP on fruits

Five technologies suitable for different regions of the country were recommended. Four publications *viz.*, "Insect and Mite Pests of Citrus in India," "Integrated Pest Management of Banana and Plantain" (in 5 regional languages)" "*Neembu Vargeeya Falon Ke Vibhinn Keet Evam Unka Prabandhan" and Kinnow Panchang"*, were released and 18 progressive farmers were honoured on the occasion.

Kharif Awareness Programme

Kharif awareness programme was organized by KVK, Hirehalli on 7thAugust, 2015.Around 900 farmers and 70 officials from different organizations participated. Smt. B. Jayashree, Hon'ble Member of Parliament (Rajya Sabha), inaugurated the event. Three publications of the KVK namely, "Implementation of Technology Demonstration Component of NICRA - A Case Study from D. Nagenahalli Village of Tumakuru District, Karnataka", "KVK, Hirehalli, Tumakuru-Activities and Achievements (2010–15)" and "*Tengu - Kalpavriksha*" (Kannada) were released. An exhibition of 20 stalls was set up for the benefit of farmers.

Kharif awareness programme was also organized by Krishi Vigyan Kendra, Gonikoppal, on 15th September 2015. A total of 476 officials from different departments, SKDRDP, SHGs, progressive farmers/ farm women and special invitees participated. It was inaugurated by Sri. K. G. Bopaiah, Honorable Member of Legislative Assembly, Virajpet and presided over by Dr. M. Anandaraj, Director, ICAR-IIHR. The technical experts interacted with the farmers on production, protection and introduction of new crops in Kodagu district.

Rabi Awareness Programme

The *Rabi* Sammelan was conducted at KVK Gonikoppal in partnership with agriculture and horticulture departments of Kodagu District on 20th January, 2016. Around 250 farmers, farm women and youth attended. Shri Cheppudira Subhash Muthanna, progressive planter from Kodagu was the chief guest and Dr. A. N. Ganeshamurthy, Principal Scientist, ICAR-IIHR, Bengaluru presided over the function. Technical experts interacted with participants on soil health management and importance of microorganisms in soil and plant health management, prospects of vegetable cultivation in Kodagu District and improved technologies and management practices for pepper.

A technical bulletin on the calendar of operations for coffee, arecanut, and black pepper was released. An exhibition of promising IIHR technologies was also arranged on the occasion.

KVK Hirehalli in association with CHES, Hirehalli organized the *Rabi* Awareness Programme on 23rd January, 2016. More than 500 farmers and 60 officials from different organizations participated. Dr. B.R. Mamatha, CEO, Zilla Panchayat Tumakuru inaugurated the event. Ten publications on aspects such as micronutrient formulations for banana, mango, citrus, mango fruit fly traps, sealer cum healer, bunch feeding of banana, drought tolerant finger millet variety ML-365 and fermented cocopeat production were released on the occasion.

Scientific Advisory Committee Meeting

KVK, Gonikoppal organized the Scientific Advisory Committee meeting on 28th Jan 2016, which was attended by the department officials and scientists of ICAR-IIHR and ICAR-IISR, who reviewed the progress and offered valuable suggestions for the ensuing season.

The 6th Scientific Advisory Committee meeting of KVK, Hirehalli was organized on 2nd February 2016. Invitees from state departments, NGOs and farmers representatives shared their ideas.

14.2 Other Events

ICAR Foundation Day Celebration

On the 86th foundation day of ICAR, ICAR-IIHR organised an 'Open Day' with the laboratories and experimental farm remaining open for the public to get acquainted with the activities and achievements of the institute and to share the interesting and fascinating milestones of ICAR. A meeting was held on the occasion. Padmashri Dr. Manmohan Attavar, Chairman, Indo-American Hybrid Seeds, Bengaluru was the Chief Guest. Mr. Syed Ghani Khan, Mandya, Karnataka, Sri. Manish Babaria, Raipur, Chattishgarh and Sri. Durga Prasad, Kadiyaculanka, East Godavari, AP, who adopted and disseminated IIHR technologies were honored on the occasion. Exhibits showcasing the latest varieties and technologies and demonstration plots of ornamental and vegetable crops were arranged for the visitors. Students from five schools and farmers visited the institute on the day and a farmer- scientist interaction meeting was held.

Padmashri Dr. Manmohan Attavar, Chairman, Indo- American Hybrid Seeds, Bengaluru being felicitated by Dr. Manjunatha Rao, Acting Director, ICAR- IIHR

Students visiting the institute on ICAR foundation day

49th Institute Foundation Day

ICAR-IIHR celebrated its 49th Institute Foundation Day on 5th September, 2015. Prof. K.N. Ganeshaiah, School of Ecology and Conservation, UAS, GKVK, Bengaluru, was the Chief Guest of the celebrations and delivered the 2nd Dr. G. S. Randhawa Memorial Foundation Day Lecture. Mr. S. Thimmaiah, Virajpet, Kodagu, Mr. P. Madappa, Ayirahalli, Mysuru and Mr. P.J. Abraham, Murugeshapalaya, Bengaluru, who adopted and disseminated ICAR-IIHR technologies and products were honoured. The ICAR-IIHR Awards of Excellence for the year 2014-15 were conferred on Dr. M.S. Rao, Principal Scientist, Division of

Entomology & Nematology, in the scientific category, Mr. Anjanappa, Technical Officer, Division of Vegetable Crops and Mazhar Jamil, Technical Officer, Division of Soil Science & Agricultural Chemistry in technical category, Mrs. Shylaja Prasad, Assistant in administrative category and Mr. Ramanjani, Farm Management in skilled supporting staff category. Retired staff of the institute *viz.*, Dr. B.S. Prabhakar, Dr. K.S. Krishna Prasad, Mr. R. Govinde Gowda, Mr. Puttanna, Mr. V. Chandrappa, Mr. K. Hanumanthaiah, Mr. N. Rangaswamy and Mr. Chikkabylappa were felicitated for their contributions to the institute. Prizes were distributed to the winners of the foundation day sports events followed by a cultural programme by the staff.

Prof. K.N. Ganeshaiah delivering the 2nd Dr. G. S. Randhawa memorial lecture on ICAR-IIHR foundation day.

Sansad Adarsh Gram Yojana

A programme on '*Sansad Adarsh Gram Yojana*' was organized at Gulur village on 24th November, 2015 by KVK, Hirehalli in collaboration with Division of Fruit Crops, IIHR, Bengaluru. Padamashri Smt. B. Jayashree, Hon'ble MP (RS), graced the occasion as the chief guest. IIHR varieties like Mango-Arka Uday, Papaya-Arka Prabahth and Guava-Arka Rashmi were distributed and planted in the farmers' fields.

Smt. B. Jayashree, Hon'ble MP (RS) inaugurating the Sansad adarsh gram yojana

World Food Day

KVK Hirehalli observed the World Food Day programme along with the NGO AWARE, Tumakuru at Science College, Tumakuru on 16th October, 2015 to highlight the importance of food production and role of every citizen in the process. Dr. Rajasab, Vice-Chancellor of Tumakuru University was the chief guest and around 200 participants took part.

Jai Kisan Jai Vigyan Diwas

ICAR-IIHR, CHES and KVK, Hirehalli jointly organized the "*Jai Kisan Jai Vigyan*" programme to commemorate the birth anniversary of former Prime Ministers Atal Bihari Vajpayee and Late Chaudhary Charan Singh on 29th December 2015 at Hirehalli campus. About 170 farmers and farm women from Tumakuru district, staff of CHES and KVK, Hirehalli participated in the programme. Dr. M. Anandaraj, Director, ICAR-IIHR Bengaluru, in his presidential address emphasized the importance of *Jai Kisan Jai Vigyan Diwas* in showcasing and disseminating new technologies for enhancing agriculture productivity and profitability. Four progressive farmers, Sri Mahesh, N.M., Sri Prabhakar, Smt Mangalagowramma and Smt. Gowramma who successfully adopted the latest technologies and contributed for the wide-scale adoption were honored. A farmers-scientists interaction meet was also conducted on the occasion.

Dr. M. Anandaraj, Director, ICAR-IIHR Bengaluru addressing the participants during Jai Kisan Jai Vigyan Diwas

World Soil Day

World soil day was celebrated on 5th December 2015 at Zilla Panchayat office, Tumakuru, with the support from KVK, Hirehalli. Smt.Mamatha, IAS, CEO, ZP, Tumakuru inaugurated the event, and emphasized the need for conserving soil health by proper monitoring of fertility status and developing soil health cards for the farmers' fields. Dr. Roopa, JDA presided over the function. There was meaningful interaction among

Distribution of soil health card and demonstration of soil sampling technique

farmers and experts on ways and means of conserving soil health by proper utilization of manures and following conservation methodologies, followed by distribution of health cards to 250 farmers. A programme was organized at Gowraganahaalli, Koratagere, Tumakuru district by KVK Hirehalli in collaboration with Department of Agriculture, GoK, wherin the soil sampling methodology and use of GPS tools for the documentation of soil sampling were demonstrated.

Awareness Programme on Nutritional Gardening

An awareness cum training programme on 'Nutritional Gardening' was organized on 4th March 2016 at Siddaganga Mutt exhibition hall in collaboration with Departments of Agriculture and Women and Child Development, Tumakuru to address nutritional security through nutritional gardening. About 200 women participated in the programme.

Participation of ICAR-IIHR in ICAR Inter Institutional Sports Meet

The institute participated in the ICAR inter institutional sports meet (South Zone) organized by Central Institute of Fisheries Technology, Kochi from 25th to 29th of May 2015 and emerged as the overall runners up in the South zone. Smt. Meenakshi, Smt. Venkatalakshmamma and Smt. Bhagyalakshmi

The ICAR- IIHR contingent receiving the overall runners up trophy from Olympian Shri T. C. Yohannan and Dr. Ravishankar, Director ICAR-CIFT, Kochi

secured the gold medals in 100 m, 200 m, high jump, javelin throw, discuss throw respectively. The men's athletic team comprising of Shri. R. Sridhar, Shri. A, Rajanna, Shri. H.R.Venkatesh and Shri. B. Mallesh secured gold in 400m and 4×100m relay events. The institute kabbadi team once again established its supremacy in South zone. The above athletes along with Shri N. Naveen Kumar (cycling) further participated in the ICAR inter-zone sports meet at ICAR- Central Arid Zone Research Institute, Jodhpur from 8th to 12th February 2016. Smt. Meenakshi and Smt. Venkatalakshmamma continued their supremacy in sprint and throw events respectively in the inter-zonal sports meet by winning gold medals while the relay and kabaddi teams finished second.

Visit of QRT of NRC on Orchids, Pakyang, Sikkim to CHES, Chettalli

Dr. Dhimman, Chairman, QRT of NRC on Orchids, members of the QRT and Director, NRC on Orchids, Dr. .Ramani, visited CHES, Chettalli on 12th June, 2015. The Head of the station welcomed the team and briefed about ongoing activities of the station. During the visit, the team identified 10 acres of land at CHES, Chettalli for establishment of a tropical orchid's repository at Chettalli.

Visit of QRT of NRC on Orchids, Pakyang, Sikkim to CHES, Chettalli

15. Women Empowerment

15.1 Outreach

- One thousand seven hundred and forty eight Ready to Fruit (RTF) bags were sold to rural women to grow mushrooms at home as a kitchen garden activity to enhance the daily dietary nutrition.

Rural women growing mushrooms at home

- IIHR Women's Cell Chairperson, Dr. Leela Sahijram and Member Secretary, Dr. Mandakranta Bhattacharya attended a residential workshop on 'Conduct rules with special emphasis on sexual harassment at workplace' organized by National Academy of Human Resource Development (NAHRD, New Delhi), Pudhucherry from February 02-05, 2016.

15.2 Awareness Programs

15.2.1 Women in Agriculture Day

ICAR-IIHR celebrated 'Women in Agriculture Day' on 19th December 2015 wherein 50 farm women from Rajanakunte Gram Thana and nearby villages participated along with the staff and woman-labourers of IIHR. Suggestions were made on facilitating entrepreneurial opportunities for farm-women for their empowerment. Director, ICAR-IIHR, Dr. M. Anandraj, delivered the presidential address. He stated that efforts should be made for the farm-women to continue in the field of agriculture by making this enterprise attractive and lucrative the invited farm-women shared their experiences in integrated farming, cattle rearing, etc. They expressed joy at being able to participate and felt encouraged in an event where their contribution to their family and to the nation was recognized. The farm-women were also taken around the farm and campus. A kit containing ICAR-IIHR products in the form of vegetable seeds, mushroom-fortified *rasam* powder packets and other mushroom-based products were also distributed to them.

15.2.2 International Women's Day

The ICAR-IIHR celebrated 'International Women's Day' on 8th March 2016. The programme was presided over by Director, ICAR-IIHR, Dr. M.R. Dinesh. As part of the programme, two lectures were delivered, one each by IIHR Women's Cell Chairperson, Dr. Leela Sahijram and Member Secretary, Dr. Mandakranta Bhattacharya, for sensitizing the institute staff on the Prevention, Prohibition and Redressal of Sexual Harassment of Women at Workplace Act (2013). A cultural programme by women members of the institute was also organized.

16. Tribal Sub-Plan

16.1 Promotion of Mango Cultivation in the Tribal Belts of Bhubaneswar

Promotion of mango cultivation among 450 farming families continued in Kashipur. Critical inputs like pesticides, farm tools, sprayers, fertilizers, etc. were being provided them. Trainings and demonstrations were organized for effective dissemination of technologies. On the other hand, the backyard nutritional kitchen gardening intervention was continued in 250 tribal households of seven villages of Mohana block of Gajapati district of Odisha for ensuring minimal nutritional security at household level and to generate supplementary income for the farm women engaged in the kitchen gardening. The households have been provided with IIHR vegetable seed kits and fruit crop seedlings for backyard planting. Interventions on promotion of underutilized cucurbits have been taken up in 50 households Seedlings of cucurbit crops like teasel gourd, ivy gourd and pointed gourd have been provided to the selected farmers. Farmer self-help groups have been trained to produce planting material of these crops at the polyhouse nursery established in the Mohana block. Ten SHGs have been supported for minimal processing of raw jackfruits for preparation of ready to cook product for local and urban marketing. Two on-campus trainings, and one off-campus (one day) exhibition cum training were undertaken to educating the participating farmers on backyard nutritional kitchen gardening, commercial cultivation of underutilized cucurbits, post harvest minimal processing of raw jackfruits, etc.

Beneficiaries of the training programme on nutritional gardening

16.2 Mera Gaon Mera Gaurav

Ten villages were selected in two clusters. Each village cluster comprise of five villages and 565, 550 households respectively. Base line survey, awareness camps, farmer advisory services through mobile service, *Kisan Goshthis* etc. were organized for the benefit of the farming community.

Training programmes conducted under TSP

Training	Date	No. of parti-cipants
Field day on mango	May 19, 2015	100
Pre and post-harvest management of mango	Apr 21- 23, 2015	30
Vermi-compost production technology	May 19, 2015	22
Pre and post-harvest management of fruits	May 26-30, 2015	26
Skill development training programme on nursery management	Aug 20-22, 2015	20
Minimal processing of jackfruit	Nov 30, 2015	22
Integrated pest management in mango	Oct 15-16, 2015	50
Recent advances in horticulture	Nov 20-24, 2015	25
Field days on pomegranate cultivation	Oct 30, 2015	100
Field day on citrus cultivation	Oct 31, 2015	100
Minimal processing of tender jackfruit and its marketing	Mar 21, 2016	20

16.3 Exposure Visits

One hundred ten exposure visits were arranged during the period where in around 3711 farmers, farm women, students, officials etc participated.

Exposure visit of farmers to CHES, Bhubaneswar

16.4 Skill Up-gradation and Input Distribution Programme for Tribal Farmers at CHES, Chettalli

CHES, Chettalli organized an off-campus training programme combined with input distribution at Balegundi and Thyagathur villages of Somwarpet Taluk, Kodagu on 6th July 2015. In this training, coconut and vegetable cultivation aspects were explained to them by Dr. Sankar, Senior Scientist, and Mrs. P.B. Swathy, Technical Officer of CHES, Chettalli. About 90 tribal beneficiaries from both the tribal villages attended. At the end of this programme, 1000 six-months-old coconut seedlings (West Coast Tall) and 100 vegetable seed kits were distributed to them. The CHES, Chettalli team also visited Awaragundha tribal village to monitor the progress of nursery raising activities in pepper, coffee and other fruits crops distributed to them.

CHES, Chettalli scientists and technical officers visited the tribal villages of Balagundi and Thyagathur of Somavarpet Taluk on 20th and 27th July, 2015. The importance of fertilizer management and the quantity to be applied as per the age of the plant were explained to them. Chemical fertilizers like single super phosphate, urea and murate of potash were supplied to the tribal beneficiaries. The CHES, Chettalli team also visited the nurseries at Awaregundha tribal village and noted the progress of poultry birds and piglets which were distributed earlier. This programme was coordinated and attended by Sri. Kishore Kumar Mohanthi Scientist and Mrs P. B. Swathy, Technical Officer.

Distribution of inputs to beneficiaries

17. 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 2015-16.

17.1 Main Station, IIHR, Hesaraghatta, Bengaluru

Meetings of Official Language Implementation Committee

- During the year four meetings of the official language implementation committee were convened on 25.04.2015, 30.07.2015, 07.12.2015 and 09.02.2016.

Hindi Workshops

The Institute organised the following Hindi Workshops during 2015-16:

- A workshop on "How to install Unicode?" was conducted on 26.06.2015 for the staff members of Administration.
- A Hindi workshop on "How to work in Hindi on computer?" was conducted on 29.09.2015 for the staff members of Administration.
- A Hindi workshop on "Noting & Drafting" and "Work in Hindi on Computer" was conducted on 22.01.2016 for the staff members of Establishment and Purchase sections.
- A Hindi workshop on "Noting & Drafting" and "Work in Hindi on Computer" was conducted on 11.02.2016 for the staff members of Cash & Bill and Accounts Sections.

Hindi Week Celebration

The ICAR-IIHR, Bengaluru observed the *Hindi Saptah* during September, 14-22, 2015. Various competitions viz., Hindi Recitation, Hindi reading, Hindi terminology and noting, handwriting, Hindi conversation, Hindi song and pre-written Hindi essay, extempore were organized for the benefit of the staff members of the Institute. Prof. Asha Shirolikar, Head, Dept of Hindi, Mount Carmel College, Bengaluru inaugurated the *Hindi Saptah* on September 15, 2015. The *Hindi Saptah* concluded on September 22, 2015 with Prof. Prabhashankar Premi, Ex-Head, Dept. of Hindi, Bengaluru University, Bengaluru as the Chief Guest and prizes were distributed to winners of various competitions.

Prof. Asha Shirolikar inaugurating Hindi Week by lighting the lamp

Dr. Anil Kumar Nair conducting the Khel-Khel Mein Hindi Programme

Prof. Prabhashankar Premi addressing the gathering during the valedictory function

Prize distribution

Participation in World Hindi Conference

- Jagadeesan A.K., Assistant Director (OL) of the Institute participated in the World Hindi Conference held at Bhopal during 10-12 September 2015 organized by Ministry of External Affairs, Govt. of India.

Participation in National Seminar/Conference/ Workshops/Training Programmes

- Charles Ekka and Jagadeesan, A. K. - Official Language Orientation Programme, Central Power Research Institute, Bengaluru, June 23, 2015.
- Jagadeesan, A. K. - Hindi Day Programme, organized by Dept. of Official Language, Govt. of India, Vigyan Bhawan, New Delhi, September 14, 2015.
- Charles Ekka and Jagadeesan, A. K. - Official Language Seminar on Official Language Implementation in Scientific Institution: Uses and Promotion, NASC Complex, ICAR, New Delhi, September 14, 2015.
- Lokesha, A. N. and Ahmad, S. M. A. -Five days basic training programme for working in Hindi on computer, Central Hindi Training Sub-Institute, Bengaluru, February 08-12, 2016.
- Jagadeesan A.K. - Regional Official Language Conference, organized by Dept. of Official Language, Govt. of India at Kerala, February 19, 2016.

Hindi Publications

- Official Language Magazine "*Bagwani*" Vol. VI
- IIHR Annual Report 2014-15 (Hindi)
- Extension Folders – 'Cultivation of China Aster' and 'Protected Cultivation of Gerbera'
- Pocket diaries on 'Arka Microbial Consortium', 'Production Technology of Capsicum', Production Technology of Chillies', Production Technology of French Bean' and Production Technology of Melons'.

Hindi Incentive Scheme

- The Hindi incentive scheme was implemented at the Institute during the year. Prizes and certificates for the participants were distributed during the valedictory function of *Hindi Saptah*.

Award

- Mr. Jagadeesan A.K., Assistant Director (OL), received "*Rajbhasha Gourav Award*" of Department of Official Language, Govt. of India from Shri Pranab Mukherjee, Hon'ble President of India for his article entitled "*Khadya Evam Poshan Suraksha Mein Soybean Ki Bhumika*". The award was given on 14th September 2015 during the Hindi Day celebrations organized at Vigyan Bhawan, New Delhi.

Mr. Jagadeesan receiving the Rajbhasha Gourav Award from Hon'ble President of India, Shri. Pranab Mukherjee

17.2 CHES, Chettalli

Quarterly Meeting of Official Language Implementation Committee

- Four meetings of the official language implementation committee of the centre were convened on 25.06.2015, 10.08.2015, 29.12.2015 and 29.03.2016.

Hindi Week Celebration

Hindi week was celebrated at CHES, Chettalli during September 14-21, 2015. Dr. R. Senthil Kumar, Principal Scientist and Head of the station inaugurated the Hindi Week programme and addressed the staff with comprehensive information about the importance, necessity and scope of Hindi language in day-to-day life. Dr. V. Shankar, Sr. Scientist (Horticulture) and Chairman, Organizing Committee briefed about the activities being carried out during the Hindi Week. During Hindi week, various competitions viz., dictation of Hindi, identification of things, Hindi meanings, copy writing, poem writing and description of an object in Hindi were organized for the staff.

The valedictory function was held on 21 September 2015. Mrs. Neha Sharma, Principal, Sunshine Valley School and Mr. Manoj, Hindi Teacher, Govt. High School, Chettalli were the guests for the function. The guests, in their address, highlighted the importance of Hindi week and the constitutional obligation of working in Hindi. Prizes and certificates were distributed to the winners of different competitions by the guests and Head of the Station.

Valedictory function of hindi week

Prize distribution

Participation in Training Programme

- Suma Srinivas - Five days basic training programme for working in Hindi on computer, Central Hindi Training Sub-Institute, Bengaluru, February 08-12, 2016.

17.3 CHES, Bhubaneswar

Quarterly Meeting of Official Language Implementation Committee

- Four meetings of the official language implementation committee of the centre were convened on 18.06.2015, 30.09.2015, 26.12.2015 and 30.03.2016.

Hindi Week Celebration

Central Horticultural Experiment Station, Bhubaneswar observed "*Hindi Week*" during September, 07-14, 2015. It was inaugurated by Shri Bani Singh, Dy. Director, National Horticulture Board, Bhubaneswar. Dr. H.S. Singh, Head, CHES, Bhubaneswar presided over the function. Dr. Bani Singh, in his address, highlighted the importance of Hindi language. Dr. Deepa Samant, Scientist and Chairperson, Hindi Cell briefed about the activities being carried out during the Hindi week. Various competitions *viz.*, Dictation, Hindi reading, essay, debate and Hindi song were organized. The valedictory function of Hindi Week was organized on September 14, 2015. Dr. G. Naik, Ex. Principal Scientist, CHES, Bhubaneswar was the Chief Guest of the function. He expressed his happiness over the commendable participation in different competitions organized during Hindi Week. Dr. P.C. Ram, Ex. Prof. and Head, Division of Plant Physiology, Narendra Dev University of Agriculture and Technology, Faizabad was Guest of Honour. Dr. Deepa Samant, Incharge, Hindi Cell coordinated all the activities. Smt. Rina Patnaik, Member, Hindi Cell proposed vote of thanks.

Inauguration of Hindi Week

Prize distribution

18. Distinguished Visitors

18.1 ICAR-IIHR, Hesaraghatta, Bengaluru

- Chairman and members of RAC (09.04.2015).
- Mrs. G. Kasturi Rangan and Mr. K. Sriram (14.07.2015).
- Director, Defence Food Research Laboratory, Mysore (01.09.2015).
- Mr. S.K. Singh, Additional Secretary & Financial Advisor, DARE (02.10.2015).
- Dr. N.C. Patel, Vice-Chancellor, Anand Agricultural University, Anand, Gujarat (30.11.2015)
- Mr. C. Vasudevappa, Vice Chancellor, UAHS, Shivamogga (30.11.2015).
- Prof. Dinesh K. Beubi, ICAR National Professor, PAU, Ludhiana (07.12.2015).
- Dr. K. Alagasundaram, Hon'ble Deputy Director General (Engg.) (08.02.2016).
- Dr. Kheya Bhattacharya Addl. Secy., Faculty on Deputation with Ministry of Defence, GoI - along with a delegation of 17 members (16.03.2016).

18.2 CHES, Chettalli

- Dr. P.G. Chengappa, Former Vice Chancellor, University of Agricultural Sciences, Bengaluru (27.05.2015).
- Air Vice Marshall O.P. Tiwari, VSM, Air Force Station, Mysore (27.05.2015).
- Dr. H.V. Batra, Director, DFRL, Mysore (27.05.2015).
- Dr. Dhimman, Chairman, QRT of ICAR-NRC on Orchids (12.06.2015).
- Dr. D. R. Singh, Director, ICAR-NRC on Orchids (12.06.2015).
- Dr. S. B. Dandin, Former Vice Chancellor, University of Horticultural Sciences, Bagalkot & Liason officer, Bioversity International, Bengaluru (20.08.2015).
- Dr. C. Vasudevappa, Vice Chancellor, University of Agricultural and Horticultural Sciences, Shimoga (20.08.2015).
- Dr. Vishal Nath, Director, NRC on Litchi, Muzaffarpur, Bihar (20.08.2015).
- Dr. K.V.Peter, Ex-Director, IISR, Ex-Vice-Chancellor, KAU (02.03.2016).
- Dr. Hanchinal, Chairman, PPV& FRA, New Delhi (25.03.2016).

18.3 CHES, Bhubaneswar

- Mr. V. Pradeep K. Dev, Former MP, Lok Sabha, Parvathipuram, Andhra Pradesh (25.06.2015).
- Prof. P. L. Saroj, Director, ICAR-Directorate of Cashew Research, Puttur, Karnataka (15.01.2016).
- Mr. Balabhadra Majhi, Member of Parliament (Loksabha), Nabarangpur, Odisha (03.02.2016).
- Dr. N K Krishna Kumar, DDG (Hort. Science), ICAR, New Delhi (10.02.2016).
- Prof. S. K. Mitra, Former Dean BCKV, West Bengal (11.02.2016).

18.4 KVK, Gonikoppal

- Mr. K. G. Bopaiah, Hon'ble MLA, Virajpet, Kodagu (15.09.2015).
- Mrs. Sherin Subbaiah, President, Zilla Panchayat, Kodagu (15.09.2015).

18.5 CHES, Hirehalli

- Dr. P. Chowdappa, Director, ICAR-CPCRI, Kasargod (03.06.2015).
- Mr. C.P. Mudalagiriyappa, Ex. M.P., Chithradurga, Karnataka (01.07.2015).
- Dr. N. K. Krishna Kumar, DDG (Hort. Science), ICAR, New Delhi (12.09.2015).

18.6 KVK, Hirehalli

- Padmashri Mrs. Jayashree, Hon'ble MP (Rajya Sabha) (07.08.2015 and 24.11.2015).
- Dr. Mamatha, CEO, ZP, Tumakuru (23.01.2016).
- Dr. Sreenath Dixit, Director, ATARI, Bengaluru (02.02.2016).

19. Personnel

DIRECTOR

Dinesh, M. R. Ph.D.
w.e.f 10.02.2016

Anandaraj, M. Ph.D.
(Additional Charge) 04.09.2015 to 09.02.2016

Manjunatha Rao, T. Ph.D.
(Acting) up to 04.09.2015

SCIENTIFIC STAFF

IIHR, Hesaraghatta, Bengaluru

Division of Fruit Crops

Dinesh, M.R. Ph.D.
Principal Scientist (Horticulture) &
Head up to 09.02.2016

Srinivas Murthy, B.N. Ph.D.
Principal Scientist (Horticulture) i/c Head

Sulladmath, V.V. Ph.D.
Principal Scientist (Horticulture) up to 30.04.2015

Karibasappa, G.S. Ph.D.
Principal Scientist (Horticulture) Up to 31.07.2015

Reju M. Kurian, Ph.D.
Principal Scientist (Horticulture)

Sampath Kumar Pamu, Ph.D.
Principal Scientist (Horticulture)

Rekha, A. Ph.D.
Principal Scientist (Genetics & Cytogenetics)

Sakthivel, T. Ph.D.
Principal Scientist (Horticulture)

Manjunath, B.L. Ph.D.
Principal Scientist (Agronomy)

Satisha, J. Ph.D.
Principal Scientist (Horticulture)

Vasugi, C. Ph.D.
Senior Scientist (Horticulture)

Sankaran, M. Ph.D.
Senior Scientist (Horticulture)

Awachare Chandrakant Madhav, M.Sc.
Scientist (Fruit Science)

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)

Singh, T.H. Ph.D.
Principal Scientist (Horticulture)

Mohan, N. Ph.D.
Principal Scientist (Genetics & Cytogenetics)
Up to 30.09.2015

Varalakshmi, B. Ph.D.
Principal Scientist (Horticulture)

Shankar Hebbar, S. Ph.D.
Principal Scientist (Agronomy)

Anil Kumar Nair, Ph.D.
Principal Scientist (Agronomy)

Sreenivasa Rao, E. Ph.D.
Senior Scientist (Horticulture)

Bharathi, L.K. Ph.D.
Senior Scientist (Hort) w.e.f 03.02.2016

Susmitha Cherukuri. M.Sc. (Ag)
Scientist (Genetics & Plant Breeding)

Ramya, P. Ph.D.
Scientist (Plant Breeding) w.e.f 28.04.2015

Senthil Kumkar, M. Ph.D.
Scientist (Vegetable Science) w.e.f 04.02.2016

Division of Ornamental Crops

Aswath, C. Ph.D.
Principal Scientist (Horticulture)
i/c Head w.e.f. 07.09.2015

Manjunatha Rao, T. Ph.D.
Principal Scientist (Horticulture) &
Head Up to 27.08.2015

Meenakshi Srinivas. Ph.D.
Principal Scientist (Genetics & Cytogenetics)
Up to 31.05.2015

Tejaswini. Ph.D.
Principal Scientist (Plant Breeding)

Sujatha A. Nair, Ph.D.
Principal Scientist (Horticulture)

Dhananjaya, M.V. Ph.D.
Principal Scientist (Plant Breeding)

Rajiv Kumar, Ph.D.
Senior Scientist (Horticulture)

Sumangala, H.P. Ph.D.
Scientist (Horticulture)

Usha Bharathi, T. Ph.D.
Scientist (Floriculture)

Division of Post Harvest Technology

Harinder Singh Oberoi, Ph.D.
Principal Scientist & Head

Doreyappa Gowda, I.N. Ph.D.
Principal Scientist (Horticulture)

Narayana, C.K. Ph.D.
Principal Scientist (Horticulture)

Sudhakara Rao, D.V. Ph.D.
Principal Scientist (Horticulture)

Tiwari, R.B. Ph.D.
Principal Scientist (Horticulture)

Sangama, Ph.D.
Principal Scientist (Horticulture)

Shamina Azeez, Ph.D.
Principal Scientist (Plant Biochemistry)

Bhuvaneshwari, S. Ph.D.
Senior Scientist (AS&PE)

Ranjitha, K. Ph.D.
Scientist (Agricultural Microbiology)

Pushpa Chethan Kumar. M.Sc. (Ag)
Scientist (Food & Nutrition) w.e.f 25.05.2015

Division of Plant Pathology

Krishna Reddy, M. Ph.D.
Principal Scientist (Plant Pathology) & Head

Ramesh, C.R. Ph.D
Principal Scientist (Plant Pathology)
Up to 31.12.2015

Girija Ganeshan. Ph.D.
Principal Scientist (Plant Pathology)
Up to 29.02.2016

Meera Pandey. Ph.D.
Principal Scientist (Plant Pathology)

Gopalakrishnan, C. 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.
Senior Scientist (Plant Pathology)

Rangaswamy, E. M.Sc. (Ag)
Scientist (Plant Pathology) w.e.f. 15.06.2015

Sandeep Kumar, G.M. M.Sc. (Ag)
Scientist (Plant Pathology) w.e.f. 11.09.2015

Dr. Mahesha, B. Ph.D.
Scientist (Plant Pathology) w.e.f. 23.12.2015

Division of Entomology and Nematology

Chakravarthy, A.K. Ph.D.
Principal Scientist (Agricultural Entomology) & Head

Krishnamoorthy, A. Ph.D.
Principal Scientist (Agricultural Entomology)
Up to 31.08.2015

Sreenivas Rao, M. Ph.D.
Principal Scientist (Nematology)

Shivarama Bhat, P. Ph.D
Principal Scientist (Agricultural Entomology)
w.e.f. 01.06.2015

Ranganath, H.R. Ph.D.
Principal Scientist (Agricultural Entomology)

Gopalakrishna Pillai, K. Ph.D.
Principal Scientist (Agricultural Entomology)

Ganga Vishalakshy, P.N. Ph.D.
Principal Scientist (Agricultural Entomology)

Sridhar, V. Ph.D.
Principal Scientist (Agricultural Entomology)

Venkata Rami Reddy, P. Ph.D.
Principal Scientist (Agricultural 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)
w.e.f. 02.05.2015

Jayanthi Mala, B.R. M.Sc. (Ag)
Scientist (Agricultural Entomology) w.e.f. 23.11.2015

Division of Plant Physiology and Biochemistry

Bhatt, R.M. Ph.D.
Principal Scientist (Plant Physiology) & i/c Head

Shivashankar, S. Ph.D.
Principal Scientist (Biochemistry)

Ravindra, V. Ph.D.
Principal Scientist (Plant Physiology)

Upreti, K.K. Ph.D.
Principal Scientist (Organic Chemistry)

Shivashankara, K.S. Ph.D.
Principal Scientist (Plant Physiology)

Laxman, R.H. Ph.D.
Principal Scientist (Plant Physiology)

Keshava Rao, V. Ph.D.
Principal Scientist (Organic Chemistry)

Division of Soil Science and Agricultural Chemistry

Debi Sharma Ph.D.
Principal Scientist (Agricultural Chemistry) &
i/c Head w.e.f. 05.10.2015

Ganeshamurthy, A.N. Ph.D.
Principal Scientist (Soil Science) &
Head up to 29.9.2015

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 Science) w.e.f. 19.02.2016

Soudamini Mahopatra. Ph.D.
Principal Scientist (Organic Chemistry)

Sathisha, G.C. Ph.D.
Principal Scientist (Soil Science)

Varalakshmi, L.R. Ph.D.
Principal Scientist (Soil Science)

Selvakumar, G. Ph.D.
Senior Scientist (Agricultural Microbiology)

Panneer Selvam, P. Ph.D.
Scientist (Agricultural Microbiology)
Up to 23.09.2015

Radha, T.K. Ph.D.
Scientist (Agricultural Microbiology)
w.e.f. 15.12.2015

Kalaivanan, D. Ph.D.
Scientist (Soil Science)

Division of Extension and Training

Venkattakumar, R. Ph.D.
Principal Scientist & Head

Hegde, M.R. Ph.D.
Principal Scientist (Agronomy) up to 31.01.2016

Ravishankar, H. Ph.D.
Principal Scientist (Horticulture) & i/c ATIC

Nita Khandekar, Ph.D.
Principal Scientist (Agricultural Extension)

Balakrishna, B. Ph.D.
Principal Scientist (Agricultural Extension)

Narayanaswamy, B. Ph.D.
Principal Scientist (Agricultural Extension)

Achala Paripurna, Ph.D.
Senior Scientist (Agricultural Entomology)

Reddy, T.M. Ph.D.
Scientist (Agricultural Extension) w.e.f. 22.06.2015

Atheequlla, G.A.
Scientist (Agricultural Extension) w.e.f. 15.06.2015

Division of Plant Genetic Resources

Ganeshan, S. Ph.D.
Principal Scientist (Genetics & Cytogenetics)
& i/c Head

Tripathi, P.C. Ph.D.
Principal Scientist (Horticulture) w.e.f. 16.06.2015

Rajashekharan, P.E. Ph.D.
Principal Scientist (Economic Botany)

Anuradha Sane. Ph.D.
Principal Scientist (Horticulture)

Shivaramu, K. Ph.D.
Senior Scientist (Entomology) up to 31.05.2015

Kanupriya, C. Ph.D.
Scientist (Horticulture) w.e.f. 25.06.2015

Linta Vincent, M.Sc. (Hort.)
Scientist (Fruit Science)

Anushma, P.L. M.Sc. (Hort.)
Scientist (Fruit Science)

Division of Biotechnology

Akella Vani. Ph.D.
Principal Scientist (Genetics & Cytogenetics) & Head

Leela Sahijram. Ph.D.
Principal Scientist (Plant Physiology)

Mythili, J. B. Ph.D.
Principal Scientist (Plant Physiology)

Pious Thomas. Ph.D.
Principal Scientist (Horticulture)

Ravishankar, K. V. Ph.D.
Principal Scientist (Plant Physiology)

Ashokan, R. Ph.D.
Principal Scientist (Agricultural Entomology)

Manmohan, M. Ph.D.
Principal Scientist (Plant Physiology)

Vageesh Babu, H.S. Ph.D.
Senior Scientist (Biotechnology)

Lakshmana Reddy, D.C. Ph.D.
Scientist (Biotechnology)

Usha Rani, T.R. Ph.D.
Scientist (Biotechnology)

Nandeesha, P. Ph.D.
Scientist (Biotechnology)

Section of Medicinal & Aromatic Crops

Vasantha Kumar, T. Ph.D.
Principal Scientist (Genetics & Cytogenetics) &
i/c Head

Eugene Sebastian, J.N. Ph.D.
Principal Scientist (Organic Chemistry)
Up to 30.11.2015

Sukanya, D.H. Ph.D.
Principal Scientist (Plant Breeding)

Hima Bindu, K. Ph.D.
Principal Scientist (Plant Breeding)

Suryanarayana, M.A. Ph.D.
Principal Scientist (Horticulture)

Pritee Singh, Ph.D.
Scientist (Biochemistry) w.e.f 10.12.2015

Section of Seed Science & Technology

Naik, L.B. Ph.D.
Principal Scientist (Agronomy) &
Head up to 31.05.2015

Yogeesha, H.S. Ph.D.
Principal Scientist (Seed Technology)
i/c Head w.e.f. 01.06.2015

Bhanu Prakash, K. Ph.D.
Principal Scientist (Plant Physiology)

Padmini, K. Ph.D.
Senior Scientist (Horticulture)

Section of Agricultural Engineering

Senthil Kumaran, G. Ph.D
Principal Scientist (Farm Machinery & Power)
& i/c Head

Carolina Rathina Kumari, Ph.D.
Scientist (Farm Machinery & Power)

Section of Economics & Statistics

Sudha Mysore. Ph.D.
Principal Scientist (Agricultural Economics) &
i/c Head, w.e.f. 12.06.2015

Gajanana, T.M. Ph.D.
Principal Scientist (Agricultural Economics) &
Head up to 11.06.2015

Sreenivasa Murthy, D. Ph.D.
Principal Scientist (Agricultural Economics)

Venugopalan, R. Ph.D.
Principal Scientist (Agricultural Statistics)

Chandra Prakash, M.K. Ph.D.
Senior Scientist (Computer Application)

Radhika, V. M.Sc.
Senior Scientist (Computer Application)

Reena Rosy Thomas MCA.
Scientist (Computer Application)

Project Coordinator's Cell (Tropical fruits)

Prakash Patil. Ph.D.
Principal Scientist (Plant Physiology)

Sujatha, S. Ph.D.
Principal Scientist (Agronomy) w.e.f. 07.12.2015

Nazeeb Naduthodi. M.Sc. (Horti.)
Scientist (Fruit Science)

Central Horticultural Experiment Station, Chettalli

Senthil Kumar, R. Ph.D.
Principal Scientist (Horticulture) &
i/c Head w.e.f. 15.06.2015

Sankar, V. Ph.D.
Senior Scientist (Horticulture)

Venkataravanappa, V. Ph.D.
Scientist (Plant Pathology) w.e.f 26.5.2015

Priti Sonavane. Ph.D.
Scientist (Plant Pathology)

Chandrashekara, C. Ph.D.
Scientist (Plant Pathology) w.e.f. 15.02.2016

Central Horticultural Experiment Station, Bhubaneswar

Hari Shankar Singh, Ph.D.
Principal Scientist (Agricultural Entomology) & Head

Petikam Srinivas, Ph.D.
Senior Scientist (Plant Pathology)

Bharathi, L.K. Ph.D.
Senior Scientist (Horticulture) up to 02.02.2016

Kundan Kishore
Senior Scientist (Horticulture)

Sangeetha, G. Ph.D.
Senior Scientist (Plant Pathology)

Gobinda Chandra Acharya. Ph.D.
Senior Scientist, (Horticulture)

Sudhamoy Mondal. Ph.D.
Senior Scientist (Plant Pathology)

Deepa Samant. Ph.D.
Scientist (Horticulture)

Meenu Kumari. M.Sc.
Scientist (Horticulture)

Ponnam Naresh, Ph.D.
Scientist (Vegetable Science)

Kishor Kumar Mahante. Ph.D.
Scientist (Fruit Science) w.e.f. 01.03.2016

Krishi Vigyan Kendra, Gonikoppal

Saju George. Ph.D.
Senior Scientist and Head

Central Horticultural Experimentation Station (CHES) and Krishi Vigya Kendra, Hirehalli

Karunakaran, G.
Senior Scientist (Horticulture- Fruit Science) & i/c Head, CHES

Loganandhan, N. Ph.D.
Programme Coordinator, KVK

TECHNICAL STAFF

Division of Fruit Crops

Prakash, B. M.Sc. (Organic Chemistry)
CTO (Lab.)

Ravindra Kumar. M.Sc. (Ag)
STO (Lab.)

Division of Vegetable Crops

Kashinath, B.L. M.Sc. (Ag)
CTO (Seed Prod.) up to 05.09.2015

Umashankar, B.E. B.Sc. (Ag)
ACTO (Lab.)

Nage Gowda, N.S. M.Sc. (Ag)
STO (Farm)

Lakshmipathi. Ph.D.
STO (Farm) w.e.f. 10.02.2016

Anjanappa, M.
TO (Field) up to 30.11.2015

Rangaiah, M.
TO (Field)

Sanna Manjunatha. M.Sc. (Ag)
TO (Field)

Division of Ornamental Crops

Lakshmisha, R. M.Sc. (Ag)
STO

Huliyappa, B.
TO (Field) up to 31.07.2015

Idiya, H. K.
TO (Field) w.e.f 18.01.2015

Division of Post Harvest Technology

Reddappa, K. B.Sc., PGD (FT)
ACTO (Lab.)

Dharma Naik
TO (Lab.)

Division of Plant Pathology

Salil Jalali. M.Sc.
CTO (Lab)

Balasubramanian, K. B.Sc.
TO (Lab.)

Division of Entomology and Nematology

Sujatha, A. Ph.D.
CTO (Field)

Subbaiah, N.
TO (Field) up to 31.05.2015

Siddaveeraaradhaya, H. C.
TO (Field)

Lokesh, C.
TO (Field)

Division of Plant Physiology and Biochemistry

Bujji Babu, C.S. M.Sc.
CTO (Lab.)

Tapas Kumar Roy. M.Sc.
CTO (Lab.)

Jayaram, H.L. M.Sc.
CTO (Lab.)

Qazi, S.M. B.Sc.
STO (Lab.)

Lakshmaiah, M.
TO (Lab.) up to 30.04.2015

Division of Soil Science and Agricultural Chemistry

Mazhar Jamil. B.Sc.
STO (Lab)

Jyothi V. Divakar. M.Sc.
STO (Lab.)

Gopala, D.
TO (Field)

Somashekhar, K.
TO (Lab) up to 30.09.2015

Division of Extension and Training

Murugesh, B.J.
TO (Field) up to 30.06.2015

Venkateshwar Rao, R.
TO (Projection)

Annu.
TO (Field)

Division of Plant Genetic Resources

Shetti, D.L. M.Sc. (Ag)
ACTO (Lab.)

Division of Biotechnology

Sreedhara, S.A. M.Sc.
CTO (Lab) up to 30.06.2015

Chandrashekhara, S.C. M.Sc.
ACTO (Lab.)

Madhusudhana Rao, B. M.Sc.
STO (Field)

Venkateshaiah, S.
TO (Field)

Section of Agricultural Engineering

Dayananda, P.
TO (Mechanic)

Economics & Statistics

Dakshinamoorthy, V. M.A., M.Phil.
CTO (Lab.)

Thippeswamy, S. MCA
ACTO (Computer Lab)

Seed Science & Technology

Arun, M.N., M.Sc. (Ag.)
ACTO (Field) up to 10.04.2015

Prioritization, Monitoring and Evaluation Cell

Janmay Jai Deveshwar. M.Sc.
CTO (Field/Farm)

Chandra Kumar Chitrala. M.Sc.
STO (Lab. Tech- Computer)

Publication

Gaddagimath, P.B. M.Sc., M.A.
CTO (Inf. & Pub. Officer) up to 30.09.2015

Aris Cell

Jayasankar, N. MCA
STO (Computer Operator)

Krishananda, S.
TO (Computer Lab)

Library

Shankara Prasad, K.V. M.L.I.Sc.
STO (Library Science)

Photography & Artist Cell

Rajendra Astagi M.F.A.
STO (Artist)

Chandrashekaraiah, K. B.Com.
TO (D.R.A.)

Medical and Paramedical

Mandakrantha Bhattacharya, M.B.B.S., D.L.O.
CTO (Medical)

Farm Management

Pandey, R.N. M.Sc. (Ag)
CTO (Farm)

Nagappa
STO (Lab)

Mahanthesh, P.T.
TO (Mech.)

Works Unit

Bhanu, A. M. Tech., P.G.D.B.A.
CTO (Engg.)

Robert Lewis
STO (Ref.) up to 31.05.2015

Harish, K.M., B.E.
STO (Civil)

Mahishi, V.K.
TO (Elect.)

Lakshmana Kanthan, A.
TO (Turner)

Narendra, S.
TO (Elect.)

Jagadeesh Kumar, D.N.
TO (Elect.)

Manjunath, R.
TO (Welder)

Transport Section

Siddaram G. Kalashetty, B.E. (AE)
STO (Transport)

Nagaraj E. Kodekal
TO (Mech.)

Sunder Raj, G.
TO (Driver)

Security Wing

Siddegowda, C.
TO (Field) up to 30.04.2015

Central Horticultural Experimentation Station (CHES), Chettalli

Patil, C.S., M.Sc., B.Lib.Sci.
ACTO (Lib.) up to 30.06.2015

Swathy, P. B.
TO (Lab.)

Varadarajachary, K.V.
TO (Mech.)

Central Horticultural Experimentation Station (CHES), Bhubaneshwar

Singray Majhi. B.Sc. (Ag), D.C.A.
TO (Lab.)

Central Horticultural Experimentation Station (CHES) and Krishi Vigya Kendra, Hirehalli

Jagadish, K.N., M.Sc. (Ag)
STO (SMS) (Agricultural Extension)

Ramesh, P.R., M.Sc. (Ag)
STO (SMS) (Soil Science)

Prashanth, J.M., M.Sc. (Hort.)
STO (SMS) (Horticulture)

Hanumanthe Gowda, B., M.Sc. (Ag)
STO (SMS) (Plant Protection)

Radha R.Banakar, M.Sc. (Home Science)
STO (SMS) (Home Science)

Somashekhar, Ph.D
STO (SMS) (Plant Breeding)

Parashuram, H.D.
TO

Krishi Vigya Kendra, Gonikoppal

Devaiah, K.A. M.Sc. (Hort.)
ACTO (SMS)

Prabhakara, B. M.Sc. (Ag)(Hort.)
ACTO (SMS)

Veerendra Kumar. M.Sc. (Ag)(Hort.)
STO (SMS)

Suresh, S.C. Ph.D
STO (SMS) (Livestock)

Padmavathy, M.K. M.Sc.
STO (Lab) – Programme Assistant

Vasantha Kumar, C.K. M.Sc.
TO (Field) – Programme Assistant up to 31.05.2015

ADMINISTRATION AND ACCOUNTS

Main Institute, Hesaraghatta, Bengaluru

Administration

Harakangi, G.G.
Chief Administrative Officer w.e.f. 16.11.2015

Charles Ekka
Senior Administrative Officer up to 05.12.2015

Das, J.N.L.
Senior Administrative Officer w.e.f. 05.08.2015

Alok Kumar
Administrative Officer up to15.02.2016

Mohana, G.
Assistant Administrative Officer

Anasuya, N.
Assistant Administrative Officer

Kalai Selvi, N.
Assistant Administrative Officer

Lokanatha, B.
Assistant Administrative Officer

Raghuraman, V.
Assistant Administrative Officer & DDO up to 04.11.2015

Tittu Kumar, K.B.
Assistant Administrative Officer

Official Language Cell

Jagadeesan, A.K.
Assistant Director (Official Language)

Finance and Accounts

Srinivasa Murthy, A.
Finance & Accounts Officer up to31.12.2015

Ramanchandrappa, B.N.
Assistant Finance & Accounts Officer up to 03.09.2015

Rina Pattnayak
Assistant Finance & Accounts Officer w.e.f. 08.10.2015

Central Horticultural Experimentation Station (CHES), Chettalli

Administration

Mohan, C.M.
Assistant Administrative Officer

Central Horticultural Experimentation Station (CHES), Bhubaneswar

Administration

Banshsidhar Mohapatra
Assistant Finance & Accounts Officer up to 31.01.2016

20. Meteorological Data

20.1 ICAR-IIHR, Hesaraghatta, Bengaluru

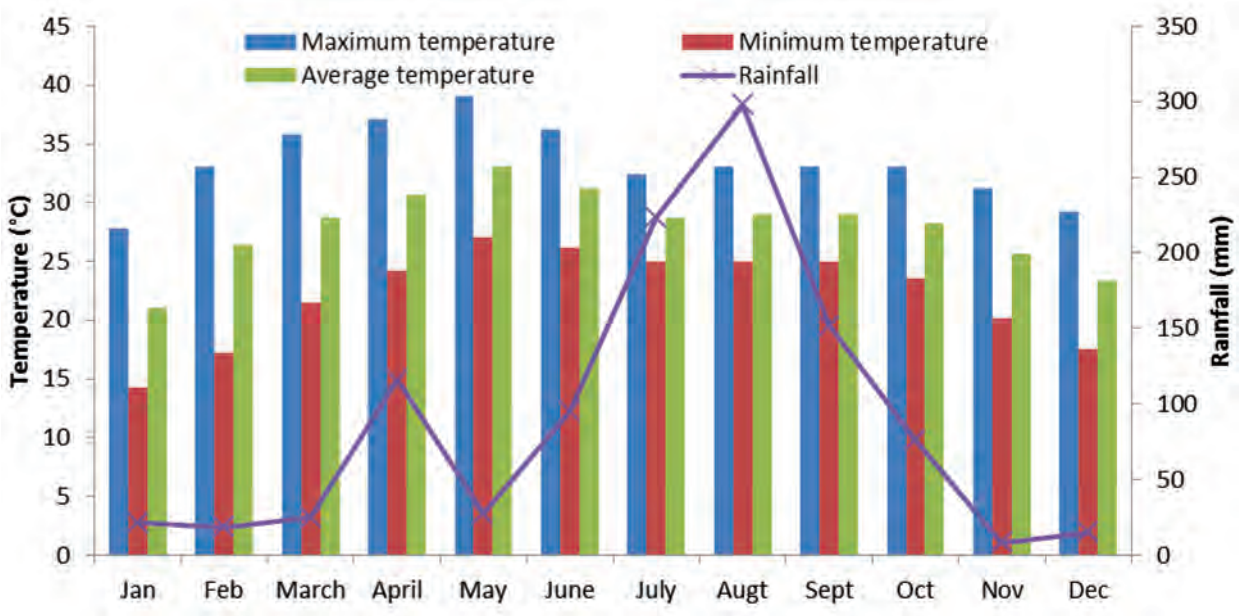
Month	Temperature (°C)		Relative Humidity (%)		U.S.W.B. Class	Mean wind speed (km/h)	Rainfall (mm)
	Max.	Min.	07.30 hrs.	14.00 hrs.			
April 2015	32.3	20.4	73.1	55.2	5.2	4.1	65.8
May 2015	31.9	21.1	79.5	54.5	4.1	3.9	186.2
June 2015	30.9	21.3	78.1	53.8	3.7	6.6	89.0
July 2015	30.3	21.1	77.8	52.1	3.7	5.9	62.2
August 2015	30.0	20.2	79.9	50.3	3.3	5.0	140.4
September 2015	30.2	20.0	80.1	51.6	3.0	3.9	251.2
October 2015	30.4	20.0	78.8	52.6	3.4	2.5	145.5
November 2015	28.2	18.0	84.2	53.1	1.4	2.8	173.0
December 2015	28.0	17.8	79.7	52.8	1.7	2.5	0.5
January 2016	27.8	15.4	77.7	45.6	3.2	2.3	0.0
February 2016	32.3	19.0	75.4	48.3	4.7	3.2	0.0
March 2016	35.5	21.5	69.4	43.3	5.9	3.0	0.0

20.2 CHES, Chettalli

Month	Temperature (°C)		Relative Humidity (%)		U.S.W.B. Class	Mean wind speed (km/h)	Rainfall (mm)
	Max.	Min.	07.30 hrs.	14.00 hrs.			
April 2015	31.9	19.0	86.9	22.8	52.7	3.3	100
May 2015	29.7	19.9	79.8	22.8	45.8	3.4	130
June 2015	24.6	18.6	69.1	40.9	221.9	2.6	90
July 2015	21.3	16.5	64.9	33.6	210.7	2.1	190
August 2015	23.6	18.9	81.4	32.9	324.2	2.9	150
September 2015	28.2	18.3	86.0	26.3	208.6	3.0	100
October 2015	28.6	17.9	53.2	24.0	58.9	3.1	90
November 2015	26.2	18.1	90.7	29.4	113.3	2.4	60
December 2015	27.9	16.4	86.9	23.0	0.0	2.8	0
January 2016	29.0	12.5	89.0	15.1	0.0	2.6	0
February 2016	28.6	21.8	88.0	26.3	3.1	2.5	10
March 2016	30.5	18.1	85.6	21.0	0.0	2.6	0

20.3 CHES, Bhubaneswar

The prevailing climatic condition of CHES, Bhubaneswar is tropical hot and humid. The average maximum, minimum and mean temperature were 33.4, 22.2 and 27.9°C respectively. The average humidity was 69% and annual rainfall was 1071 mm. The year 2015 received less rainfall than previous years.



Weather parameters of CHES, Bhubaneswar during 2015

21. Results-Framework Document (RFD)

ICAR-Indian Institute of Horticultural Research (2015-2016)

Address: Hesaraghatta Lake P.O, Bengaluru- 560 089

Website: www.iihr.res.in

Section-1: Vision, Mission, Objectives and Functions

Vision

- Technology-led, demand-driven and need-based sustainable horticulture for attaining food & nutritional security, better livelihood options and ultimately, economic development.

Mission

- To undertake research, education and extension in horticultural crops for enhancing productivity and sustainability to achieve food, nutritional and livelihood security.

Objectives

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

Functions

- To plan, coordinate, implement, monitor R&D programmes for sustainable production and resource conservation and to serve as knowledge and data repository in horticulture and establish national and international cooperation and visualize research needs as per the changing scenario.

Acronyms

Acronym	Description
IPM	Integrated Pest Management
INM	Integrated Nutrient Management
DAC	Department of Agriculture and Cooperation
ICT	Information and Communication Technologies
R&D	Research and Development
IIHR	Indian Institute of Horticultural Research
PRA	Participatory Rural Appraisal
TV	Television
NHM	National Horticultural Mission
NHB	National Horticultural Board
SAU's	State Agricultural Universities
KVK	Krishi Vigyan Kendra
NAAS	National Academy of Agricultural Sciences
MSC	Mitigating Strategies for reduction of potential risk of Corruption
IAP	Innovative Action Plan

Section-2: *Inter se* priorities among Key Objectives, Success Indicators and Targets

Objectives	Weight	Action	Success indicators	Unit*	Weight	Target/Criteria value				
						Excellent 100%	Very good 90%	Good 80%	Fair 70%	Poor 60%
Enhancing productivity and quality of horticulture crops through sustainable integrated crop production, protection and post harvest management practices	45	Technologies and products to improve productivity of horticulture	Technologies and products developed	No.	15	19	16	13	10	7
		Development of protocols and products for minimizing post harvest loss	Protocols and products developed for reducing post harvest losses	No.	10	11	9	7	5	3
		Production of breeder seed and planting material	Breeders' seed of vegetable and ornamental crops	Q	10	190	160	130	100	70
			Production of vegetative planting material	Lakhs	8	2.6	2.2	2.0	1.8	1.6
			Mushroom spawn	Q	2	290	242	194	146	98
Increasing productivity and quality of horticultural crops through varietal improvement	20	Development and introduction of improved hybrids/varieties	Hybrids/varieties developed	No.	16	12	10	8	6	4
		Collection and conservation of genetic resources for sustainable use	Germplasm accessions added to gene bank	No.	4	290	245	200	155	110
Dissemination, popularization, adoption, refinement and impact assessment of IIHR technologies	15	Use of innovative extension methodologies, including ICT, for dissemination of horticultural technologies	Programmes conducted	No.	8	810	680	550	420	290
		Conduct of trainings to farmers and development department officials	Trainings conducted	No.	7	32	27	22	17	12
Publication/ Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	3	54	45	36	27	18
		Timely publication of the Institute Annual Report (2014-2015)	Annual Report published	Date	2	June 30, 2015	July 02, 2015	July 04, 2015	July 07 2015	July 09 2015

*No. : Number; Q: Quintals

Section-3: Trend Values of the Success Indicators

Objectives	Actions	Success Indicators	Unit	Actual values for 2013-14	Actual values of 2014-15	Projected values for 2015-16	Projected values for 2016-17	Projected values for 2017-18
Enhancing productivity and quality of horticulture crops through sustainable integrated crop production, protection and post harvest management practices	Technologies and products to improve productivity of horticulture	Technologies and products developed	No.	15	18	16	18	20
	Development of protocols and products for minimizing post harvest loss	Protocols and products developed for reducing post harvest losses	No.	9	11	9	10	11
	Production of breeders' seed and planting material	Breeders' seed of vegetable and ornamental crops	Q	221	271.8	160	180	200
		Production of vegetative planting material	Lakhs	2.027	2.505	2.2	2.50	2.80
		Mushroom spawn	Q	201	370.4	242	275	300
Increasing productivity and quality of horticultural crops through varietal improvement	Development and introduction of improved hybrids/varieties	Hybrids/varieties developed	No.	10	13	10	11	12
	Collection and conservation of genetic resources for sustainable use	Germplasm accessions added to gene bank	No.	229	280	245	265	285
Dissemination, popularization, adoption, refinement and impact assessment of IIHR technologies	Use of innovative extension methodologies, including ICT, for dissemination of horticultural technologies	Programmes conducted	No.	608	771	810	820	840
	Conduct of trainings to farmers and development department officials	Trainings conducted	No.	23	41	32	34	36
Publication/ Documentation	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	29	41	54	56	58

*No. : Number; Q: Quintals

Section 4(b): Description and definition of success indicators and proposed measurement methodology

Success Indicator	Description	Definition	Measurement	General comments
Technologies and products developed	The factor productivity is low because of low input-use efficiency and biotic/abiotic stresses The factor productivity can be improved through precision farming technologies including protected cultivation, INM, IPM, mechanisation and organic cultivation	Precision farming refers to optimisation of inputs use to matching need as per growth stage resulting in saving of valuable resources like water, nutrients and chemicals with field specific and crop specific approach. INM refers to the maintenance of soil fertility for sustaining the desired productivity. Water use efficiency refers to yield per unit of water used. IPM refers as use of organic, inorganic and biological components in an integrated manner to control pests. Protected cultivation refers to growing crops under protective structures to shield them from pests and weather.	No. of technologies developed ❖ off-season production ❖ protected cultivation ❖ organic production ❖ reduction in water requirement ❖ customized fertilizers developed ❖ seed priming ❖ machineries for reduced drudgery ❖ IPM & IDM packages ❖ identification of resistance sources for major plant pathogens ❖ disease diagnostics and forecasting systems ❖ markers for pyramiding genes	-
Protocols and products developed for reducing post harvest losses	To reduce high losses during storage, particularly under non-refrigerated conditions To reduce the glut in the market. To utilize crop residues left behind after harvest	Shelf life of the product depends on balanced harvest, pre and post harvest protocols Value addition is defined as adding value to the harvested product with better shelf life and economic returns	Number of protocols for reduction of post harvest loss and value added products developed	-
Breeders' seed of vegetable and ornamental crops	Nucleus seed and breeder seed is the starting point in seed chain for producing quality seeds	Breeder seed is the starting point in seed chain which is multiplied / converted in to foundation /certified seed	Quantity produced (Quintals)	Quantity may vary as per indent from DAC

Success Indicator	Description	Definition	Measurement	General comments
Production of vegetative planting material	Production of planting material of vegetatively propagated horticultural crops	It is a process of vegetative means by which new individuals arise without production of seed or spores	Number of cuttings/grafts/layers/ budded plants (in lakhs)	In a wider sense, planting material arising from vegetative propagation including cuttings, layering, budding, grafting and tissue culture
Mushroom spawn	Mushroom spawn is in-vitro multiplied in the form of mycelium to maintain genetic purity	Spawn is the starter culture in multiplication and production of quality mushrooms which is similar to crop seeds	Quantity produced (Quintals)	Quantity may vary as per indents received
Hybrids/varieties developed	Breeding lines developed are evaluated along with checks and the best performing lines are identified	Best performing entry is identified as a new variety for release	Number of such hybrids/ varieties identified	The identification of varieties depends upon the availability of superior material for yield, biotic and abiotic resistance / tolerance over the existing varieties
Germplasm accessions added to gene bank	Germplasm is the genetic resource of crops and is a source of genetic variability	Germplasm is collection of cultivars, landraces, wild species and stable segregating lines for conservation and utilization	Number of germplasm collected from primary and secondary sources	Germplasm material serves as a base for crop improvement programs for breeding new varieties
Programmes conducted	Trials, demonstrations, field visits, ICT, radio and TV programmes, Farmer-scientist interaction, PRAs, conducted for technology transfer	Frontline demonstration is the demonstration on important technologies conducted on farmers field under the close supervision of scientists. New extension methods like ICT to facilitate transfer of technologies in a better manner	Number of programmes conducted	
Trainings conducted	Development programmes conducted for farmers, rural youth and extension personnel	Training is a process of imparting knowledge and skill to the personnel for improving farm productivity	Number of trainings conducted	Depending upon the sponsoring agencies like DAC, State Governments and Extension agencies.

Section 5: Specific performance requirements from other departments that are critical for delivering agreed results

Location Type	State	Organisation Type	Organisation Name	Relevant Success Indicator	What is your requirement from this organisation	Justification for this requirement	Please quantify your requirement from this organisation	What happens if your requirement is not met?
Central Govt.	State Govt's	Departments	DAC Department of Horticulture	Breeders' seed of vegetable and ornamental crops	Indent for requirement	Crop-wise and variety wise indent for requirement	Quantity of breeders seed produced as per requirement	Less or more quantity of seed produced
Central Govt.	State Govt's	State Governments and Extension agencies	NHM NHB SAU's	Trainings conducted	Indent for requirement of trainings	Aspect-wise trainings	Number of sponsorships	If requests are not made in time, it is difficult to plan and co-ordinate these programmes

Section 6: Outcome / Impact of activities of Department/Ministry

Outcome/ Impact	Jointly responsible for influencing this outcome / impact with the following organization(s)/ department(s) / ministry(ies)	Success Indicator (s)	Unit	2013-14	2014-15	2015-16	2016-17	2017-18
Enhanced vegetable productivity, nutritional security and higher income	State Dept/SAU's KVKs, etc.	Increase in productivity of vegetables due to IIHR intervention	%	0.17	0.2	0.21	0.22	0.23
		Increase in per capita availability of vegetables	%	1.2	1.3	1.5	1.6	1.68
		Impact on socio-economic status and livelihood of farmers due to adoption of IIHR varieties/ technologies	% income increase	20	22	24	26	27.0

Classification of Success Indicators according to its Category

Success Indicator(s)	Input	Activity	Internal Output	External Output	Outcome	Measures Qualitative Aspects
Technologies and products developed	True	True	False	False	True	True
Protocols and products developed for reducing post harvest losses	True	True	False	False	False	False
Breeders' seed of vegetable and ornamental crops	True	True	False	False	True	True
Production of vegetative planting material	True	True	False	False	True	True
Mushroom spawn	True	True	False	False	True	True
Hybrids/varieties developed	True	True	True	True	True	True
Germplasm accessions added to gene bank	True	True	False	False	False	False
Programmes conducted	True	True	False	False	False	False
Trainings conducted	True	True	False	False	False	False

Past Achievements of the Success Indicators

Success Indicators	Past Achievements of the Success Indicators							Mean of the achieve-ments	Additional information
	VII 2008-09	VI 2009-10	V 2010-11	IV 2011-12	III 2012-13	II 2013-14	I 2014-15		
Technologies and products developed	5	12	19	18	21	**15**	18	15.42	A formal procedure for identification of technologies was started in 2010 when several technologies were released.
Protocols and products developed for reducing post harvest losses	4	7	7	4	5	**9**	11	6.71	There was a demand from industry and also Thrust was given to develop protocols in 12th plan.
Breeders' seed of vegetable and ornamental crops	77.4	51.1	77.9	200	80	**221**	271.8	139.88	KVK's were facilitated to produce breeders seeds, besides emphasizing on Village seed concept
Production of vegetative planting material	0.85	2.27	1.82	0.75	1.50	**2.027**	2.505	1.67	RKVY project has given a boost
Mushroom spawn	91.8	127.6	202.5	160	190	**201**	370.4	191.90	Project on empowerment of rural women facilitated enhanced demand.
Hybrids/varieties developed	4	7	19	11	8	**10**	13	10.28	A formal procedure for identification of varieties was started in 2010 when several superior varieties were released.
Germplasm accessions added to gene bank	155	322	268	900	150	**229**	280	329.14	During 2009-12 these accessions were collected specifically for a medicinal crops exploration project
Programmes conducted	367	516	495	400	450	**608**	771	515.28	Drastic increase in number of programs happened from 2009-10 due to NHM and RKVY programs
Trainings conducted	17	16	18	20	15	**23**	41	21.42	More responses were received from farmers after meeting on polyhouse cultivation, innovative farmers meet and KISAN 2015

Format of 'Table for setting the Agreed Performance Targets'

Success indicator (s)	Past Achievements of the Success Indicators							Mean of the Achieve-ments (after rejec-ting too low/ high values)	*110% (1.1 times) of the mean achieve-ments for setting the targets under 90% (Very Good) column of Section 2	Projected value of the success indicator for 2015-2016 as per the approved RFD 2014-15	** Proposed target value by RFD Reporting Officer under 90% (Very Good) column of Section 2 in draft RFD 2015-2016	Deviation (%) in proposed target value under 90% (Very Good) column of Section 2 in draft RFD 2015-2016 compared to the projected target value of the Success Indicator in approved RFD 2014-2015	*** Final target value under 90% (Very Good column) of Section 2 in draft RFD 2015-2016	120% (1.2 times) of proposed target value under 90% (Very Good) column for 100% (Excellent) column of Section 2 in draft RFD 2015-2016	**** Target interval between 100% (Excellent) and 90% (Very Good) columns
	2009-10	-	V 2010-2011	IV 2011-2012	III 2012-2013	II 2013-2014	I 2014-2015								
Technolgies	12	5	12	19	18	21	18	15.8	17.38	16	16	0	16	19	3
PHT Protocols	7	7	4	5	**9**	7	11	7	8	9	9	0	9	11	2
Breeders seed	77.4	51.1	77.9	200	80	**221**	271.8	131.26	144.39	260	160	-38.5*	160	192	32
Planting material	0.85	2.27	1.82	0.75	1.50	**2.027**	2.505	1.69	1.86	2.30	2.2	-4.35	2.2	2.6	0.4
Mushroom spawn	91.8	127.6	202.5	160	190	**201**	370.36	176.2	193.8	230	242	+5.0	242	290	48
Hybrids/ varieties developed	4	7	19	11	8	**10**	13	10	11	10	10	0	10	12	2
Germplasm accessions added to gene bank	188	155	322	268	900	150	280	243	267	260	245	-5.77	245	290	45
Programmes conducted	367	516	495	400	450	**608**	771	494	543	715	680	-5.0	680	810	130
Trainings conducted	18	16	18	20	15	**23**	41	19	21	27	27	0	27	32	5
Research publication	39	53	49	49	72	**29**	41	46	50	-	45	-	45	54	9

*The production of breeders' seed will come down because of discontinuation of RKVY project. Further the demand for OP seeds will come down, while demand go up for hybrids.

Annual (April 1, 2015 to March 31, 2016) performance evaluation report of RSC i.e., Institutions for the year 2015-16

Name of the Division : Horticulture

Name of the Institution : ICAR-IIHR, Bengaluru

RFD Nodal Officer : Dr. C. Aswath

Objectives	Weight	Action	Success indicators	Unit*	Weight	Target/Criteria value					Achieve-ments	Performance			
						Excellent 100%	Very good 90%	Good 80%	Fair 70%	Poor 60%		Raw Score	Weighted Score	% Achieve-ments Against Target value of 90% Col.	Reason for Shortfall or excessive achieve-ments if applicable
Enhancing productivity and quality of horticulture crops through sustainable integrated crop production, protection and post-harvest management practices	45	Technologies and products to improve productivity of horticulture	Technologies and products developed	No.	15	19	16	13	10	7	18	100	15	112.5	
		Development of protocols and products for minimizing post-harvest loss	Protocols and products developed for reducing post-harvest losses	No.	10	11	9	7	5	3	10	100	10	111.11	
		Production of breeder seed and planting material	Breeders' seed of vegetable and ornamental crops	Q	10	190	160	130	100	70	195.99	100	10	122.49	
			Production of vegetative planting material	Lakhs	8	2.6	2.2	2.0	1.8	1.6	2.53	100	8	115	
			Mushroom spawn	Q	2	290	242	194	146	98	344.44	100	2	149.56	Due to excess demand from growers

Objectives	Weight	Action	Success indicators	Unit*	Weight	Target/Criteria value					Achieve-ments	Performance			
						Excellent 100%	Very good 90%	Good 80%	Fair 70%	Poor 60%		Raw Score	Weighted Score	% Achieve-ments Against Target value of 90% Col.	Reason for Shortfall or excessive achieve-ments if applicable
Increasing productivity and quality of horticultural crops through varietal improvement	20	Development and introduction of improved hybrids/ varieties	Hybrids/ varieties developed	No.	16	12	10	8	6	4	11	100	16	110	
		Collection and conservation of genetic resources for sustainable use	Germplasm accessions added to gene bank	No.	4	290	245	200	155	110	292	100	4	119.18	
Dissemination, popularization, adoption, refinement and impact assessment of IIHR technologies	15	Use of innovative extension methodologies, including ICT, for dissemination of horticultural technologies	Programmes conducted	No.	8	810	680	550	420	290	807	100	8	118.67	
		Conduct of trainings to farmers and development department officials	Trainings conducted	No.	7	32	27	22	17	12	62	100	7	229.63	Due to demand from state govt.'s
Publication/ Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	3	54	45	36	27	18	77	100	3	171.0	Due to increase in no. external projects

ICAR- Indian Institute of Horticultural Research
Hesaraghatta Lake Post, Bengaluru - 560 089, India

QUALITY POLICY

We, at ICAR-Indian Institute of Horticultural Research, Bengaluru, are committed to achieving sustainable development in horticulture through research and development, transfer of technology and post-graduate education in fruit, vegetable, ornamental, medicinal crops and mushrooms. We accomplish this with a quality management system, its periodic review and a competent manpower with continued improvement to stakeholders' satisfaction.

Director

Arka

भा कृ अनु प – भारतीय बागवानी अनुसंधान संस्थान
हेसरघट्टा लेक पोस्ट, बेंगलूरु – ५६० ०८९

ICAR-Indian Institute of Horticultural Research
Hesaraghatta Lake Post, Bengaluru - 560 089
Phone : +91-80-28466420-23, +91-80-28446140-43, Fax:+91-80-28466291
E-mail: director@iihr.res.in | Website: http://www.iihr.res.in