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Annual Report
2014-15

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ICAR

ICAR-Indian Institute of Horticultural Research

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Hesaraghatta Lake Post, Bengaluru- 560 089

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2014 - 2015

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Bengaluru 560 089, India
ISO 9001:2008 Certified

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Preface

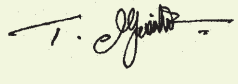
India is the second largest producer of fruits and vegetables in the world after China with a combined production of 251.86 million metric tons (88.97 million metric tons of fruits and 162.89 million metric tons of vegetables) during 2013-14. Horticulture production (268.9 mt) surpassed foodgrain output (257 mt) for the first time in 2012-13. The trend has sustained even in the bumper crop year of 2013-14, with horticulture production (277.4 mt) surpassing foodgrain output (265 mt). Current estimates of horticulture production 280.4 million tonnes in 2014-15 showed that the trend is likely to continue. During 2014-15, India exported fruits and vegetables worth Rs. 7474.14 crores which comprised of fruits Rs. 2771.32 crores and vegetables Rs. 4702.78 crores.

Horticultural crops together contribute around 29% to agricultural GDP from nearly 13% of the total cropped area and support nearly 20% of the agricultural labour force. The days ahead are the days of horticulture technology revolution for food, nutrition and livelihood security. The ICAR-Indian Institute of Horticultural Research, Bengaluru, a premier research institute in horticultural crops, has been contributing significantly in the development of horticultural sector by conducting research, education and extension activities in fruits, vegetables, flowers, medicinal aromatic crops and mushrooms.

I am very much delighted and pleased to present the Annual Report 2014-15 of the ICAR-Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru which has been playing a vital role in accelerating the pace of horticulture growth in the country by developing several high yielding varieties and hybrids, resistance/tolerance to various biotic and abiotic stresses in fruit, vegetable, ornamental, medicinal aromatic crops and mushroom apart from developing many sustainable farmer friendly technologies in crop production, crop protection, post-harvest technologies, value addition and farm mechanization. A brief account of the achievements made in research, education, extension activities, physical and financial progress made during 2014-15 and initiatives taken by the institute in achieving excellence in research and development in horticulture is presented here.

I am thankful to the Institute Management Committee and Research Advisory Committee for their valued suggestions for the development and better performance of the Institute in the field of research, education and transfer of technologies. I profusely thank, appreciate and compliment the Publication Committee Chairman, Dr. C.K. Narayana and members, Dr. S. Shivashankar, Dr. B.Narayanaswamy, Dr. T.R.Usharani, Mr. A.K. Jagadeesan, and co-opted members Dr. B.L.Manjunath, Dr. E. Srinivas Rao, Dr. Anil Kumar Nair, Dr. H.B.Raghupathy, Dr. C. Aswath, Dr. Rajiv Kumar, Dr. S.Sriram, Dr. P.Venkat Rami Reddy, Dr.R. Venkattkumar, Dr. T.M.Gajanana, Dr. G. Senthil Kumaran, and Member Secretary & Editor, Shri P.B.Gaddagimath for their sincere efforts in bringing out this quality annual report well in time.

I am grateful to Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR and Dr. N.K. Krishna Kumar, Deputy Director General (HS) for their continued support and guidance.



T. Manjunatha Rao
DIRECTOR (A)

Bengaluru
June 20, 2015

1. Executive Summary

Introduction

Research work at the Institute is being carried out in 151 sub-projects under 39 in-house projects which include 133 sub-projects from the main station at Hesaraghatta, eight sub-projects from CHES, Chettalli and 10 sub-projects from CHES, Bhubaneswar. Apart from this there are 85 externally funded projects, one international aided project, one national fellow project and seven All India Coordinated Research Projects under operation at the Institute. Recently three Flagship Programs, three New Initiative Programs, one Center of Excellence, six 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 started offering 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 many 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 Institutes were conducted apart from participating in many regional, national and international exhibitions/fairs/ Kisan Melas *etc.* and showcased 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 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 'Quality Management System ISO 9001:2008' during the year.

Summary of the research achievement in various projects under operation is given in the following paragraphs.

Management of Plant Genetic Resources

IIHR has been identified as the nodal centre for management of horticulture plant genetic resources in the country in association with all the other horticultural crop institutes under the Council. In keeping with the fresh mandate, the Institute has added several germplasm accessions with novel features during the year and involved in further exploration, collection, introduction, domestication, evaluation, characterization, conservation and documentation of horticulture plant genetic resources. Presently the total germplasm collection of the Institute, including regional stations stands at 10216 which includes fruit crops (2483), vegetable crops (5971), ornamental crops (1206), medicinal crops (462) and mushrooms (94).

Twenty seven accessions of Jamun were collected from exploration to Srisailam and surrounding areas in AP. Joint explorations with NBPGR Hyderabad and NRCB Trichy resulted in collection of 105 accessions Amaranth and 20 banana collections. In mango, eight indigenous seedling types from north-eastern region and 49 indigenous pickling types from Uttara Kannada were collected. In guava, one exotic collection (Farlong) and one indigenous collection (VNR) were added to the fruit gene bank. In pomegranate, eight accessions with unique traits were collected from Solan – Shimla region and total of 132 accessions were introduced from USDA. In sapota, 13 accessions were collected from Kovur, Tamil Nadu and Arabhavai, Karnataka. Five accessions of strawberry from Shillong and two accessions of passionfruit from Kerala were collected. Surveys were conducted in Dakshin Kannada, Kodagu district of Karnataka and Waynad districts of Kerala by CHES, Chettalli and more than 40 new accessions of 12 fruit crops were collected. One accession of bottle gourd, two of Roselle and two accessions of Pallaku were also collected.

Fifteen tomato germplasm lines and 56 capsicum germplasm lines were collected. Thirteen new accessions of *Abelmoschus esculentus* were collected from secondary sources. Five accessions of *A. caillie* (AF1-175-6, AF1-175-11, AF1-175-13, AF1-175-14 and AF1-175-18) were collected from NBPGR, Thrissur, Kerala. Sixteen wild accessions comprising of *A. moschatus* (4), *A. manihot* (2), *A. angulosus* var. grandiflorus (2*), Hibiscus sabdarifa* (4), *H. acutatus* (2), *A. caillei* (2) were collected. In cucumber, three new wild accessions *viz.*, *Cucumis hystrix, C. muriculatus* and *C. metliferous* were collected from NBPGR Regional Station, Thrissur. In ornamental crops, 15 genotypes in carnation and 50 germplasm in crossandra were collected. In medicinal crops, 13 germplasm lines from different regions *viz.,* Karnataka (7) Maharashtra (2), Madhya Pradesh (2), Meghalaya (1) and released cultivar Vallabh Medha (DMAPR, Anand) in *Centella asiatica* and two colchicine induced polyploids were collected. Two germplasm lines in kalmegh and eight land races of betelvine were collected from Tumukuru and Chikmagaluru district of Karnataka, respectively. Seven wild species of edible mushrooms were collected from Manipur. At CHES, Bhubaneswar, a total of 153 new germplasm accessions were collected in different vegetable crops (minor cucurbits, moringa and leafy vegetables). Hotspot areas of Horticultural gene pool distribution & database developed and mapped in biodiversity rich areas in Eastern Ghats. Generated satellite based Vegetation Type maps, Disturbance Index and Fragmentation. Optimized germplasm domestication strategies for introducing new species of horticultural importance by achieving clonal multiplication by air layering in *Flacourtia montana, Psidium guineense, P. littoralle* and *Baccaurea courtallensis*. Direct and reciprocal crosses have been made between *P.guinense* and cultivated guava with moderate success. Aroma profiles in *P. gueneense* were analyzed using SPME followed by GCMS. Developed protocols for ready to use juice concentrate in *P. guineense*. More than two decades cryopreserved pollen of tomato (Pusa Ruby) and brinjal (Arka Shirish*)* were *in vitro* germinated and used for pollination resulted in efficient fruit & seed set. MS media supplemented with BA and NAA recorded emergence of good sprouting in *Aegle marmelos*. Garlic, *Alpinia calcarata, Embelia ribes* and *Northopodytes pneumoniana* vitro plants were conserved under SCC for various periods. Genotyping of Vellaikolumban and Nekkare morphotypes was carried out by SSR analysis. The seedling morphotypes were screened for zygotic or nucellar origin at molecular level by comparing the allelic profiles of mother tree and the seedlings. The genetic relationships among the chrysanthemum accessions were assessed by a cluster analysis using similarity matrix.

Crop Improvement

During the current year a total of six varieties/hybrids, two in fruit crops, one in vegetable crops and three in ornamental crops were identified for release at the Institute level.

In fruit crops, a semi-vigorous F_1 hybrid mango, H-12 (Arka Udaya) from the parentage Amrapali x Arka Anmol and guava hybrid 3-29 (Arka Rashmi) were identified for release. Seven intergeneric papaya progenies tolerant to papaya ring spot virus (PRSV) were developed. Twenty eight pomegranate lines with superior characteristics were selected from a population exposed to mutagenic treatments. Cryo-preservation of pollen in five pomegranate accessions were studied and hybridization was made between blight tolerant accessions and Bhagwa. Twenty two pummelo accessions were characterized for 17 traits. Half sib progenies of custard apple cv. Balanagar (135 nos.) were evaluated for commercial cultivation. Inter-specific hybridization was carried out between *Annona atemoya* and *Annona squamosa* varieties. One hybrid progeny of strawberry H-10/4 was identified for crispness, big sized fruits and high TSS. Rose apple (*Syzygium jambos*) CHRA-1 with promising traits was identified. Tamarind germplasm, CHTM-3 has been found promising in terms of yield (18.5 kg/plant), pod length (10.8cm), pod weight (18.5g), TSS (35.3 Brix), pulp content (50.47%), TSS acid ratio (3.8) and the number of seeds/pod (8.3). A catalogue on 47 'Appemidi' mango pickling varieties was brought out.

In vegetable crops, Hybrid-369 with triple disease resistance (ToLCV+BW+EB) and Hybrid-371 with combined resistance to ToLCV and early blight have been evaluated. Eleven varieties were screened for triple disease resistance to ToLCV+BW+EB. In chilli, among the 45 hybrids evaluated under drought stress, two F_1's, showed significant positive better parent heterosis for Instantaneous Water Use Efficiency. Two pedigree selections of brinjal *viz.,* IIHR438-2 x IIHR-571-5-3-1-2-7 (2.45 kg/plant), IIHR438-2 x IIHR-571-5-3-1-4-3 (2.00 kg/plant) were found promising for yield and quality. Two pedigree selections viz; 2BMG-1 x IIHR571-2-3-7-6-9 (2.10kg/plant) and 2BMG-1 x IIHR571-2-3-4-6-8 (1.85 kg/plant) were found promising for bacterial wilt resistance. The fertility of F_1 inter-specific hybrid between *Solanum macrocarpon* and *Solanum melongena* was restored with production of BC_1, BC_2 and BC_2F_1 seeds. *Solanum macrocarpon* and BC_1 were found to be resistant to brinjal shoot and fruit borer under artificial challenging. Two lines of okra, IIHR-11-1-50 and IIHR-299-1 for high yield and combined resistance to YVMV + powdery mildew were identified. F_1 hybrid of okra Hyb-7 followed by Hyb-5 and Hyb -3 were found promising.

The top three hybrids viz., Hyb -7, Hyb-5 and Hyb-3 showed resistance to YVMV. GMS hybrid GMSH-7 recorded highest yield followed by GMSH-5. In studies on identification of stable sources of resistance to YVMV of okra, seven accessions of *A. caillei* and 12 accessions of *A. angulosus* var. *grandiflorus* recorded 0% incidence of YVMV, while the susceptible check ACC-1685 recorded 100% incidence of YVMV under natural field conditions. Three advanced lines of onion *viz.,* UKM 210-10, N-2-4-471-12-1 and PBRBC-480-10 were found to possess combined resistance to purple blotch, basal rot and white rot diseases under field conditions. The advanced line MST 690-58-1 was found resilient to soil moisture stress with high bulb yield and qualities. In breeding carrots for high carotene content, three advanced lines *viz.,*HC-12 (17.91 mg), HC-15 (17.06 mg) & HC-229 (16.55 mg) were found to have high carotene content with good quality. In muskmelon, six lines belonging to Canary yellow (39, 42 and 47), Galia (68) and Western shipper (57 and 71) backgrounds were selected for yield and quality. The selections 39 (Brown yellow rind, 11.5 °Brix), 47 (Yellow green tinge rind, 12.0 °Brix) and 24 (Shiny yellow rind, 11.7 °Brix) in Canary yellow background were found promising and are being proposed for identification and release. In breeding ridgegourd for downy mildew resistance, two advanced inbred lines, *viz.,* IIHR-7-5-1 and IIHR-17-2-1 were found to be mildew resistant. DUS testing of a total of 84 entries in tomato, 89 entries in brinjal and 49 entries in okra has been carried out.

In ornamental crops, tuberose hybrid 1 x 6(1) and an open pollinated seedling of cv. Shringar were found tolerant to nematodes (*Meloidogyne incognita*). In gladiolus, two new hybrid selections *i.e.* Arka Aayush for flower quality and resistance to *Fusarium* wilt and hybrid selection Arka Manorama for its attractive flower quality, have been identified for release. In China aster, four purelines *viz.,* IIHRCAH13A (INGR14048), IIHR CAJ17 (INGR14049), IIHR-35 (INGR14050) and IIHR-42 (INGR14051) have been registered with NBPGR, New Delhi for their novel traits. In marigold, three hybrid selections *viz.,* Arka Bangara, Arka Agni and Arka Alankara for loose flower have been identified for release.

Biotechnological approaches

Transgenic papaya expressing dsRNA to counter silencing suppressor gene has been developed. Field screening of transgenic banana cv. Rasthali under containment showed moderate resistance to *Fusarium* wilt disease. Plant ferrodoxin like protein (pflp) gene imparts resistance to pomegranate bacterial blight disease. T_1 transgenic pomegranate lines of Xa21showed resistance to *Xanthomonas axonopodis* pv. *punicae*. A total of 406 M13 tailed SSR were employed for screening tomato genotypes and over expression of a novel gene PjVP1 enhanced drought and salinity tolerance in tomato. Fungal resistance can be effectively achieved by multiple gene stacking with chitinase, PGIP and NPR1. A polymorphic RGAP marker with ChiVMV resistance was identified. Bt brinjal line, 2HA1-1 resists infection to brinjal fruit and shoot borer. China aster varieties Arka Aadya and Arka Archana were DNA fingerprinted using SRAP markers.

Crop Production

High density planting of 'Alphonso' mango on 'Olour' rootstock with paclobutrazol application gave more than five-fold increase in the productivity. Manipulation of plant architecture with four primary and three secondary branches was found to be the best treatment in Arka Neelachal Kesari to enhance yield. In Alphonso mango, a significant finding was that the reduced synthesis of fats in seeds during fruit growth was found to lead to an inhibition of synthesis of very long chain fatty acids (VLCFAs) leading to premature germination followed by induction of spongy tissue. In sapota cv. Cricket ball, corky tissue disorder was higher during summer due to increased rate of reverse flow from fruit to shoot. A method for the isolation of kernel antioxidants from defatted mango kernels exhibiting antibacterial activity was standardized. Production practices for cultivation of tomato under shade net, nylon net and rain shelter were standardized to achieve off-season production. Bell pepper grafted on BW tolerant chilli rootstocks was found to improve the yield. In okra, a 25% saving in fertilizer was achieved by following fertigation. In pole bean, yields under organic farming practice and conventional farming did not differ significantly. Ultra drying of seeds of papaya, onion and China aster with moisture content of 4.0, 2.8 and 3.0% respectively, maintained seed viability and vigour even after 48 months of storage under ambient conditions. Proteome wide characterization of viable and non-viable cucumber seeds showed that isocitratelyase gene expression played a significant role in seed germination. Foliar application of micronutrients improved the seed yield of China aster significantly. In Leather leaf fern, application of NPK @ 100:30:60 kg /ha/year(full P as basal application and 50% N and K to substrate in 2 equal splits during June and January + remaining 50% as foliar spray at fortnightly intervals) recorded maximum number of cut foliage/plant/month (9.21) and total number of cut foliage/plant/year (110.56). Leather leaf fern grown under red shade net recorded

the maximum production of leaves/plant/month (10.58), length of lamina (22.52 cm), length (17.29 cm) and diameter (1.82 mm) of stipe in comparison to white and black shade nets. Production practices for coleus and ashwagandha and organic production practices for kalmegh were standardized. Fortification of substrate with ferrous sulphate resulted in iron-enrichment of *Hypsizygus ulmarius* (Elm oyster mushroom).

The extent of deficiency of micronutrients in solanaceous vegetable crops and potential area for obtaining response to applied micronutrients were identified based on crop boundary and micronutrient delineation maps. New grades of micronutrient mixtures for vegetable crops were prepared with improved performance. Nutrient diagnostic norms for pomegranate with higher sensitivity were developed. An actinobacterial consortium with high ability to mobilize nutrients, plant growth promotion attributes and disease suppression was developed. Technology for rapid production of nematode and disease free arbuscular mycorrhizal fungal inoculant using cocopeat was developed. Compost teas produced utilizing horticultural wastes was found to act as efficient phytostimulator. MRLs and Safe waiting periods for azoxystrobin and trifloxystrob in mango and carbendazim, metalaxyl and propargite on pomegranate were worked out. A multi-residue protocol for analysis of 52 pesticides was standardized by LC-MS/MS.

Crop Protection

Effort is continued to record and study the occurrence of new invasive and emerging pests. A new invasive pest *Tuta absoluta* commonly referred to as South African tomato leaf miner or tomato moth was recorded and identification was confirmed using molecular tools. It has spread to larger extent in southern Karnataka.

The management of pests and diseases of fruit crops has been the priority of the Institute. Fruit borer diversity in mango involving *Bactocera rufomaculata, Glena multigulata* and *Coptopsa edificatory* was studied. Integrated management practices including biological inputs were developed for pomegranate nodal blight (*Xanthomonas axonopodis* pv punicae) and wilt (*Ceratocystis fimbriata*), papaya ring spot virus and grapes rust (in the var. Bangalore Blue). Foliar diseases of vegetable crops *viz.*, early and late leaf blight of tomato, *Phytophthora* blight and anthracnose in capsicum and chilli, purple blotch of onion and downy mildews of cucurbits were addressed and eco-friendly management practices were developed. Molecular characterization of begamoviruses with associated beta satellites affecting tomato was carried out. Bacterial wilt of brinjal could be managed with bacterial antagonists at both Hesaraghatta and Bhubaneswar center. Formulations of *Bacillus thuringiensis* with genes Cry11, Cry3A, CM, MD and AU were developed and tested against brinjal ash weevil *Myllocerus subfasciatus.*

For the foliar diseases of ornamental crops like black spot and powdery mildew of rose, Phoma blight of tuberose, suitable fungicide schedules were developed. Use of the bio-agent *Encarsia transvena* for the whitefly management in gerbera was demonstrated. Biological management of nematodes was demonstrated in chillies, tomato, capsicum, banana and gerbera using bio-agents viz. *Trichoderma harzianum, Paecillomyces lilacinus, Bacillus subtilis* and *Pseudomonas fluorescens* that were developed at IIHR.

Using DNA barcoding 151 species of thrips were identified that provides the feasibility to host of independent integrated taxonomy library for thrips to serve as thrips identification system. Attempt to silence the genes *viz.,* OBP2, vATPase and JHBP resulted in mortality of aphids (80%) indicating future possibilities of utilizing the RNAi technology for pest management.

Crop Utilization and Postharvest Management and, Farm Mechanization

Standardized and validated processes for box shrink wrapping of capsicum, edible coating and MAP for minimally processed vegetables such as radish and carrot. Work on osmotic dehydration of mango slices with low sweetness beetroot and muskmelon slices, fortified tomato beverages (soup & juice) with lycopene obtained from tomato peels was also initiated. Among the six future fruits and vegetables examined, karonda and avocado were found to be rich in phenols, flavanoids and anthocyanin. Hurdle technology for preservation of ripe guava fruits has been standardized. Customized CFB boxes of size 450x300x150mm, 5 ply rate thickness, 20 kg/cm^2 bursting strength with in-built cushioning were found suitable for packaging and storage of papaya at low and ambient temperatures. Vase solution composed of 250 ppm patchouli essential oil and 1.5% sucrose significantly extended the vase life of rose var. Carvette. A recipe for 'Mushroom fortified chutney powder' was standardized to enhance the nutritional quality of the daily diet.

In farm mechanization, the animal drawn onion seed drill and manual drawn onion seeder were improvised and modified to make them more efficient. A tractor drawn bed former-cum-onion seeder, motorized garlic

bulb breaker for garlic planting material production and an evaporative cooling type outdoor growing unit for small scale mushroom growers were designed and fabricated. An integrated system developed for cleaning, conveying and storage of grains for mushroom production has been tested and modified to save time and manpower by 50%. Apart from this, an efficient and cost effective power tiller mounted prototype for fertilizer application in fruit crops to ensure timeliness in fertilizer application and a mechanical peeling process of the tender jackfruits and its post-harvest treatment for longer shelf life and colour retention have also been developed. The existing model of mango harvester has been improvised with an aim to reduce drudgery, avoiding injuries to the fruits and increasing the harvesting efficiency in terms of number of fruits harvested per unit time.

Economics, statistical modeling and computer applications

The cultivation of 'Prajwal' in Meerut is considered important crop in small area of around an acre for obtaining a daily ready cash of around Rs 1000 for meeting the household expenses. Though hardly 15 % of the average farm area is allotted towards tuberose in Meerut, the crop accounts for 34% costs and contributes to more than 51% of the average annual farm income thereby signifying its preference for the farmers. All the major mango pulp importing countries registered positive and significant growth. Saudi Arabia continues to be the major importer of mango pulp from India. The share of Netherlands, UK, Yemen, and Canada increased during TE 2012-13 while that of USA and Kuwait decreased. Gherkin from India is exported in three forms viz. Fresh/chilled, Provisionally preserved and Prepared/preserved by vinegar/acetic acid. The export of gherkin (total) from 1987-88 to 2012-13 increased at a compound growth rate of 40.69% in quantity and 44.34% in value. Bootstrapping is a resampling procedure wherein samples of different sizes were generated to arrive at the optimum sample size required for crop yield estimation. Original sample (size of n=100) corresponding to various crop specific traits were utilized to generate samples of various sizes starting from n=50 till n=500 (increment of 10). Every time, using the sample size generated models were fitted and mean square errors were computed. Finally, a model having minimum MSE (hence high R^2) and the corresponding sample size were identified as optimum. Accordingly, a sample of size 150 for Banana and 200 for Papaya would be the optimum for developing biometrical models with least error in prediction. Decision support systems for tomato and mango have been developed with different modules.

Extension and Transfer of Technology

The research and extension gaps for varieties and technologies developed in "Protected cultivation of vegetables with bio-intensive management of pests and diseases" were identified through participatory rural appraisal (PRA) and incorporated into the research system for further refinement and modifications. Impact analysis of capacity building of trainees on the adoption of the technologies developed by the Institute including identification of future training needs were identified. Field demonstrations of the techonolgies developed by the Institute were organized under real farm situations and the productivity potentials and profitability of technologies under real farm situation were worked out. Group approach as an innovative extension, information and communication method to spread the technologies horizontally, Farmers Interest Group (FIG) were formed and demonstrations of the technologies were taken up. The climate resilient technologies (CATs) developed by the Institute in onion, pest and diseases and integrated crop management practices in protected cultivation of vegetable and flower crops were demonstrated in the farmers' fields. Apart from this many off campus training programs on the advanced production technologies developed in various crops/ aspects were conducted and inputs were distributed to the farmers to popularize the technologies. On the transfer of technology front, many training programs for different stakeholders of horticulture including interested farmers groups on the advanced technologies developed by the Institute were conducted. On campus and off campus FLDs' were taken up for the benefit of the farmers. The institute participated in various TV programs and radio talks on various topics were given by the scientists of the Institute for the accelerated dissemination of information. The Institute also participated in many exhibitions, agriculture fairs and Kisan Melas and showcased the achievements and technologies developed by the Institute. The Institute published many popular technologies in newspapers and popular magazines apart from publishing popular extension and technical literature for the benefit of the end users.

Women Empowerment

Systematic study on mainstreaming gender in agriculture was taken up under which the time utilization and decision making pattern of horticulture farmers were studied. In order to bring women into the mainstream of agriculture and rural development, women interest groups were formed and on-campus

trainings and demonstrations were organized on product development from dried mushroom and incorporation of mushrooms in daily diet, use of dried flower technology for income generation, establishment of kitchen garden, use of drudgery reducing implements, grafting technique in propagation of fruit crops *etc*. to technically empower women. Based on the research and development experience on mushroom production technology, a model has been developed by which the agricultural wastes generated at the village level can be recycled through mushroom cultivation which aims to create self-employment among unemployed youth, women in the village, address environmental pollution and help enhance nutrition among the village population. Apart from this many women friendly farm equipments/tools and machineries were developed and popularized among the farm women to reduce the drudgery. Many skill development training programs were also conducted exclusively for farm women.

Tribal sub-plan and NEH program

Under tribal sub-plan two programs *viz.*, Promotion of horticulture for tribal livelihood at IIHR, Regional Station, Bhubaneswar and Skill up-gradation and input distribution program for tribal farmers at IIHR, Regional Station, Chettalli were taken up. At Bhubaneswar, 24 villages were covered from eight tribal dominated gram panchayats for whom a total of five training-cum-demonstration programs were conducted and distributed critical inputs like fertilizers, micronutrients, farm tools, tree pruner, sprayers, portable fruit analysis equipment, *etc.* to disseminate the suitable technologies and to make the cultivation more profitable. At CHES, Chettalli five off campus trainings and one on-farm training-cum-demonstration on various aspects of horticulture were organized and inputs were distributed to the farmers benefitting 142 tribal families.

Fifteen training programs were also organized on various aspects such as fruit production, vegetable cultivation, vegetable nursery production, poultry production, pig rearing, coffee nursery production, black pepper nursery production *etc.* benefiting more than 1000 tribal farmers.

Under the NEH program on horticulture many sustainable technologies suitable to the NEH region were demonstrated. Training programs were also conducted for the benefit of the farmers of the region and technological products and varieties/ hybrids developed by the Institute were distributed to the farmers.

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 Karnataka at Hesaraghatta in Bengaluru 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 Gonikopal. Over the years, the experimental stations at Lucknow, Nagpur, Ranchi, and Godhra have grown in size and have attained the status of independent institutes. As of today, the IIHR, Bengaluru has three Central Horticultural Experiment Stations at 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 upgradation 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 IIHR, Bengaluru has been carrying out research on fruits, vegetables ornamentals, 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 & 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 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 on 263 ha land. Recently the Institute has also taken over 24 acres of land of IVRI at Yelahanka, Bengaluru and also about two 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 crop 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 equipment like electron microscope, ultra-centrifuge, LC-MS,HPLC, GLC, LScounter *etc.,* and infrastructures like a series of poly houses and net houses, growth chambers, mist chambers, cold storage, gene bank, local area network with video conferencing facilities, seed processing and nursery units *etc.* The temperature gradient chambers and phenomics facility is the first of its kind, 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 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 all other 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 Citrus Experiment Sub-station at Gonikoppal. The mandate 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. 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 sub station were shifted to Chettalli with effect from 1.1.1992. The station occupies an area of 92 ha.

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 the IIHR, Bengaluru on February 01, 2004 and renamed as Central Horticultural Experiment Station, Hirehalli. Presently the Station has a total area of 68 acres, involved in breeder seed and foundation seed production of IIHR released vegetable varieties and research work on fruit crops, particularly maintenance of germplasm, breeding work on betelvine and a few flower crops in collaboration with IIHR, Hesaraghatta,

Bengaluru. During 2013 the Station acquired additional 26 acres of adjoining area for research purpose.

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

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

Central Horticultural Experiment Station and Krishi Vigyan Kendra, Hirehalli, Tumkur, Karnataka

The Regional station of Central Plantation Crops Research Institute, Kasargod at Hirehalli, Tumkur District, Karnataka was transferred to the IIHR, Bengaluru on February 1, 2002 and renamed as Central Horticultural Experiment Station, Hirehalli. The Station was sanctioned with a Krishi Vigyan Kendra in the year 2009. Apart from the activities of Krishi Vigyan Kendra, it has taken up popularization of IIHR developed technologies and production and distribution of seeds and planting material and technological products developed by IIHR, Hesaraghatta, Bengaluru

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, 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.

Research Prioritization, Monitoring and Evaluation Cell (RPMEU)

The Research Prioritization, Monitoring and Evaluation Cell (RPMEU) 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 RPMEC 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 Cell

The IIHR has set up an Institute Technology Management Unit and Consultancy and Processing Cell through which the technologies developed by the Institute are being commercialized. 'ARKA', the trade mark for the varieties/hybrids and technologies developed by the Institute has also been registered. All the varieties /hybrids and technologies recommended by the Institute Variety and Technologies Identification Committee are also handled by the ITMU for commercialization. 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 also 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.

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 center.

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 as per the circular of ICAR F. No. 1(3)2015 - Vig.- 1 dated 25th February 2015. The Vigilance Cell under the Vigilance Officer and the Vigilance Team constituted 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 would assist and guide Heads 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 Center by more than 17Agricultural/ Horticultural and other universities in which the students can register for doctoral studies with the concerned university (including master's degree studies in horticultural sciences with UAS, Bengaluru and UHS, Bagalkot) and continue their research work at IIHR, Bengaluru under the guidance of the scientists of the Institute.

The Institute also offers short term training in selected disciplines to the needy clients. Apart from this, the Division of Extension and Training conducts regular training programs to farmers and development personnel on various advanced technologies in horticultural sector.

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

Library

Due to technological developments, the availability and access of information has changed the complexion of information seekers. Hence the trend is moving towards the e-contents than the browsing of physical documents. The Library has a total collection of 31110 documents: 11413 books, 15552 back volumes, 112 theses, 1552 reports, 1948 bulletins and 533 other documents & proceedings, which includes 358 books added this year. 341 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 & 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 43 Foreign Journals and 156 Indian Journals for its Main station, Regional Stations and KVK libraries. Apart from this, 10 Indian Journals and 11 Foreign Journals are received on gratis to supplement the information needs. 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: 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'. CeRA has got many facilities in it for information searching and accessing including full-text, 'browsing Table of Content', E-Mail alert for the journals chosen-subject selected under 'My Journals, User- profiles, Journal configuration'- head and Document delivery.

Linkages

The Institute has established linkages with many national and international organizations in the field of research and training. Collaborative research programs 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 Chief 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 advise 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; once in 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, center for entrepreneurship development for lower middle level technical personnel, a center 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 more than 220 varieties and hybrids and development of a good 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 10216 germplasm in various horticultural crops. The main station at Hessaraghatta, Bengaluru holds 8277 germplasm in its fold comprising of 1242 in fruits, 5611 in vegetables, 868 in ornamentals and 462 in medicinal plants apart from 94 in mushroom and betel vine. The CHES, Chettalli and CHES, Bhubaneswar have a collection of 1431 and 508 germplasm in fruits and vegetables respectively. The Institute has the largest *ex situ* field gene bank of mango comprising of more than 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 fruit, 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 more than 220 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 31 varieties; three in papaya, six in mango, four in guava,11 in grapes, one each in annona, ber, litchi, lime and passion fruit and two in pomegranate. Recently released high yielding pink fleshed Arka Prabhat papaya hybrid, Arka Kiran, a red fleshed hybrid guava and Arka Sahan, a hybrid of annona with large globules and less seeds hold excellent promise and are gaining popularity within the country and abroad.

In vegetable crops, the Institute so far has developed and released 85 high yielding open pollinated varieties and 17 F_1 hybrids resistant to pests and diseases for commercial cultivation in 31 vegetable crops *viz.,* tomato, brinjal, chilli, capsicum, watermelon, muskmelon, longmelon, roundmelon, cucumber, pumpkin, bush squash, bottle gourd, bitter gourd, ridge gourd, pointed gourd, spine gourd, Ivey gourd, teasel gourd, okra, French bean, cowpea, cluster bean, dolichos bean, garden pea, radish, carrot, onion, amaranth, palak, cauliflower, coriander *etc.* 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 76 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, Vilet cushion and Shashank, tuberose cultivars - Shringar, Suvasini, Prajwal and Vibhav and crossandra varieties -Arka Kanaka 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 jasmine, having higher percentage of essential oil. 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 orchard, 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 micro nutrients *viz.,* mango special, banana special, citrus special and vegetable special for higher and quality yields.
- Technology of distal end nutrient feeding of banana bunch to increase yield and enhance quality of banana.
- Causative factor for the development of spongy tissue, a major physiological disorder in Alphonso mango has been found and an eco-friendly formulation developed for its prevention.
- Developed bio- fertilizers like PSB, azospirillum, VAM *etc.*
- Technology for production of tomato, colored capsicum, cucumbers and melons under protected conditions.
- Refined the technology for production nursery seedlings using protrays.
- Microbial Consortium for improving soil health for production of healthy seedlings.

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 the feeding insects like *Helicoverpa* or epidemic of disease 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 fruit, vegetable 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 fruit, vegetable 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;

- Technology of pest management using trap crops like, African marigold for control of tomato fruit borer, and mustard as trap crop for control of DBM in Cole crops.
- Biological control of aquatic weeds and parthenium.
- Use of botanicals and plant products like, neem soap and pongamia soap for control of major pests.
- Use of Microbial Bio-control Agents (MBA) and microorganisms like *Trichoderma harzianum, Pseudomonas fluorescence, 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.
- Integrated disease management protocols and diagnostic kits for viruses have also been developed.
- Sealer and healer for management of stem borer.

Post-harvest management and value addition to horticultural crop produce attains highest priority because of the high perishable nature of the horticultural commodities. 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, Gel documentation unit, Thermal cycler, Ultra centrifuge, Micro-propagation facilities, Isolation chambers, *etc*. are available to carry out research in frontier areas of biotechnology like, genetic engineering, DNA finger printing, genomics, development of molecular markers, marker assisted selection studies, development of micro propagation protocols, regeneration protocol, development of transgenics *etc.*

The Institute has developed and standardized protocols for micro propagation of banana, grape root stocks, pomegranate, pointed gourd, triploid seedless watermelon, bougainvillea, carnation, orchids, anthurium, rose, day lily, chrysanthemum *etc. In vitro* shoot tip grafting technique for citrus for true to type virus free planting material has been developed. Hybrid embryo cultures have been developed from mango and grape. In the field of genetic engineering, double constructs for replicase gene of tomato leaf curl virus (TLCV) 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 from 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, ideo type 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 and, 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.*

The Institute is involved in first line transfer 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 30 subject matter workshop cum seminars for officers of different states, organized more than 470 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 60field days on IIHR developed technologies and varieties have been organized both at the Institute and on farmers' fields. About 300 radio and TV programs on various technologies and aspects have been given by the scientists 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 research and development worldwide, playing a greater role in the economy. Identifying IPR 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 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 for patenting in India. Potential technologies, parental materials of verities/hybrids, potential breeding lines of vegetables, ornamental and fruits crops are commercialized by sale of these severally to entrepreneurs, private companies, KVKs, NGOs, *etc.* as a part of revenue generation for the Institute and more so mainly for wider spread of these technologies. More than 370 clients have been successful in dissemination of these technologies through commercialization across the country by marketing the products.

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 2014-15 including regional stations under plan and non-plan was Rs. 349.50 and Rs.24.96 lakh 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 CHESs including the KVKs was Rs.145, 89,819.

Staff Position

Category	SANCTIONED	FILLED	VACANT
SCIENTIFIC	152+1*	143+1*	9
TECHNICAL	226	174	52
ADMINISTRATION	83	73+1	10
SSS	145	73	72
Total	**607**	**464**	**143**

* Includes Director

STATION-WISE BUDGET ALLOCATION 2014-15

PLAN

Sl. No.	Heads	IIHR B'lore	CHES Chethalli	CHES B'war	CHES Hirehalli	TOTAL
A 1.	Capital	100.00	0	0	0	**100.00**
	Total –Plan Capital	**100.00**	**0**	**0**	**0**	**100.00**
B	Revenue					
I	i. Establishment Charges	0				
	ii. Wages	0				
	iii. Overtime Allowance	0				
II	Travelling Expenses	22.00	1.00	2.00	0.00	**25.00**
III	Research & Operational	86.43	8.00	8.00	5.00	**107.43**
IV	Administrative Expenses	97.21	2.00	1.00	1.00	**101.21**
V	Miscellaneous(HRD)	12.86	1.50	1.50	0.00	**15.86**
VI	Pension & Retirement	0	0.00	0	0	**0**
	Total Plan Revenue	218.5**0**	12.5**0**	12.5**0**	6.**00**	249.5**0**
	Total Plan (Capital+Revenue)	**318.50**	**12.50**	**12.50**	**6.00**	**349.50**

STATION-WISE EXPENDITURE INCURRED 2014-15

PLAN

Sl. No.	Heads	IIHR B'lore	CHES Chethalli	CHES B'war	CHES Hirehalli	TOTAL
A 1.	Capital	100.00	0	0	0	**100.00**
	Total –Plan Capital	**100.00**	**0**	**0**	**0**	**100.00**
B	Revenue					
I	i. Establishment Charges	0				
	ii. Wages	0				
	iii. Overtime Allowance	0				
II	Travelling Expenses	22.00	1.00	2.00	0.00	**25.00**
III	Research & Operational	86.43	8.00	7.94	5.00	**107.43**
IV	Administrative Expenses	97.21	1.98	1.00	1.00	**101.21**
V	Miscellaneous(HRD)	12.86	1.43	1.50	0	**15.86**
VI	Pension & Retirement	0	0.00	0	0	**0**
	Total Plan Revenue	218.5**0**	12.41	12.44	6.**00**	249.5**0**
	Total Plan (Capital+Revenue)	**318.50**	**12.41**	**12.34**	**6.00**	**349.50**

STATION-WISE BUDGET ALLOCATION 2014-15

NON-PLAN

Sl. No.	Heads	IIHR B'lore	CHES Chethalli	CHES B'war	CHES Hirehalli	TOTAL
A 1.	Capital	53.03	2.57	1.40	0.00	**57.00**
	Total – Non-Plan Capital	**53.03**	**2.57**	**1.40**	**0.00**	**57.00**
B	Revenue					
I	i. Establishment Charges	3820.00	174.00	230.00	76.00	**4300.00**
	ii. Wages	175.00	45.00	0	0	**220.00**
	iii. Overtime Allowance	0.95	0.05	0	0	**1.00**
II	Travelling Expenses	25.25	3.00	6.00	0.75	**35.00**
III	Research & Operational	235.00	40.00	8.00	17.00	**300.00**
IV	Administrative Expenses	430.00	35.00	40.00	15.00	**520.00**
V	Miscellaneous	22.55	1.20	1.00	0.50	**25.25**
VI	Pension & Retirement	1664	36.00	0	0	**1700.00**
	Total Non-Plan Revenue	6372.75	334.25	285.**00**	109.25	7101.25
	Total Non-Plan (Capital+Revenue)	**6425.78**	**336.82**	**286.40**	**109.25**	**7158.25**
VII	Loans & Advances	25.00	0	0	0	**25.00**

STATION-WISE EXPENDITURE INCURRED 2014-15

NON-PLAN

Sl. No.	Heads	IIHR B'lore	CHES Chethalli	CHES B'war	CHES Hirehalli	TOTAL
A 1.	Capital	27.84	2.57	1.40	0.00	**31.81**
	Total – Non-Plan Capital	**27.84**	**2.57**	**1.40**	**0.00**	**31.81**
B	Revenue					
I	i. Establishment Charges	3633.00	173.89	229.75	76.12	**4112.76**
	ii. Wages	173.79	45.00	0	0	**218.79**
	iii. Overtime Allowance	0.25	0.01	0	0	**0.26**
II	Travelling Expenses	25.32	3.00	5.95	0.73	**35.00**
III	Research & Operational	234.99	40.00	7.94	17.07	**300.00**
IV	Administrative Expenses	430.88	34.71	39.66	14.75	**520.00**
V	Miscellaneous	22.49	1.21	0.99	0.56	**25.25**
VI	Pension & Retirement	1664.44	35.56	0	0	**1700.00**
	Total Non-Plan Revenue	**6185.16**	333.38	284.29	109.23	6912.06
	Total Non-Plan (Capital + Revenue)	**6213.00**	**335.95**	**285.69**	**109.23**	6943.87
VII	Loans & Advances	24.96	0	0	0	**24.96**

STATION-WISE REVENUE REALISED

NON-PLAN

Sl. No.	Heads	IIHR B'lore	CHES Chethalli	CHES B'war	CHES Hirehalli	TOTAL
1	Sale of Farm Produce	2001019	1830409	1186524	543349	**5561301**
2	Sale of Publication	284604	0	0	0	**284604**
3	Licence Fee/Guest House	986159	356066	0	0	**1342225**
4	Interest Earned on Loans & Advances	1838899	5980	0	0	**1844879**
5	Leave Salary & Pension Contribution	394224	0	0	0	**394224**
6	Analytical Testing Fee	897041	7544	0	0	**904585**
7	Application Fee From Candidate	600	0	0	0	**600**
8	Receipts from Service Rendered	298450	0	0	0	**0**
	a. Fee/Subscription		0	0	0	**298450**
9	a. Consultancy Service	254000	0	0	0	**254000**
10	Misc. Receipts	3581693	61720	61538	0	**3704951**
	Total	**4134143**	**2261719**	**1248062**	**543349**	**14589819**

3. Research Achievements

3.1. Crop Genetic Resources

3.1.1. Germplasm Exploration and Collection

Collection, evaluation, characterization, conservation, domestication and utilization of horticultural germplasm are among the important objectives of IIHR, Bengaluru. Research is under way at the Institute in various aspects of genetic resources management of mandated horticultural crops on which the institute is conducting research. The Institute holds an immense wealth of horticultural germplasm and current germplasm holding of different horticulture crops at the Institute is presented in the Table below.

Status of germplasm holding

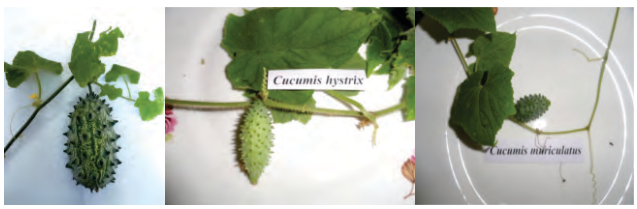
Location	Fruit Crops	Vegetable Crops	Ornamental Crops	Medicinal Crops	Mushrooms	Total
IIHR, Hesaraghatta	1242	5611	868	462	94	8277
CHES, Chettalli	1093	-	338	-	-	1431
CHES, Bhubaneswar	148	360	-	-	-	508
Total	2483	5971	1206	462	94	10216

- Exploration carried out to Srisailam and surrounding areas of AP such as Thummalabailu, Chintala, Diguvametta, Omkaram, Krishanandi, Manikantapuram and Anantapur resulted in collection of 27 accessions of jamun. Twenty accessions of *Musa* wild species and relatives were collected from in and around Arunachal Pradesh from the joint exploration program conducted by NRCB, Trichy.
- In mango, eight indigenous seedling types from northeastern region and 49 indigenous pickling types from Uttara Kannada were collected, bringing the total collection in mango Field Gene Bank (FGB) to 667 accessions.
- In guava, one exotic collection (Farlong) and one indigenous collection (VNR) were added to the FGB taking the collecion to a total 60 accessions including three species.
- In papaya, cryo-preserved seeds of the accessions *viz*., IC 312185, IC 312184, IC 312183, IC 312167, IC 312170, IC 312162 and IC 312176 were obtained from NBPGR and planted for evaluation. A total of 28 accessions were described as per DUS guidelines finalized for papaya.
- Survey taken up in the Solan-Shimla region resulted in the collection of eight pomegranate accessions with unique traits. A total of 132 accessions were introduced from USDA, of which 120 were added to FGB.
- Nine varieties of custard apple, three varieties of Atemoya and four species of Annona *viz*., *Annona reticulata*, *A. cherimola*, *A. glabra* and *A. muricata* are being maintained in Field Gene Bank.
- In sapota, 13 accessions were collected from Kovur, Tamil Nadu and Arabhavi, Karnataka, and total of 46 accessions are maintained in the Field Gene Bank. Five accessions of strawberry from Shillong and two accessions of passion fruit from Kerala were collected. A total of 117 accessions of strawberry and 12 accessions of passion fruit are maintained in the Field Gene Bank.
- Surveys were conducted in Dakshina Kannada, Kodagu district of Karnataka and Wynad districts of Kerala by CHES, Chettalli and more than 40 new accessions of 12 fruit crops were collected.
- Ninety nine accessions of *Amaranthus* comprising of six species of wild and weedy types were collected from parts of Cuddapah, Nellore and Chittoor districts of Andhra Pradesh as joint exploration with NBPGR Regional Station, Hyderabad. The collections

will be deposited at NBPGR Regional station, Hyderabad, NBPGR, New Delhi and IIHR, Bengaluru. One accession of bottle gourd, two of Roselle and two accessions of Pallaku were also collected.

Amaranthus species collections from Cuddapah, Nellore and Chittoor districts of Andhra Pradesh

- In vegetable crops at IIHR, Hesaraghatta, Bengaluru, 15 tomato germplasm lines were collected making the total no. of tomato germplasm at 680. In capsicum, 56 new germplasm lines were collected raising the total viable collection to 1220. Thirteen new accessions of *Abelmoschus esculentus* were collected from secondary sources. Five accessions of *A. caillie* (AF1-175-6, AF1-175-11, AF1-175-13, AF1-175-14 and AF1-175-18) were collected from NBPGR, Thrissur, Kerala. Sixteen wild accessions comprising of *A. moschatus* (4), *A.* manihot (2), *A.angulosus var. grandiflorus* (2), *Hibiscus sabdarifa (4), H. acutatus* (2)*, A. caillei* (2) were collected making the total viable collection at 285. In cucumber, three new wild accessions *viz., Cucumis hystrix*, C. *muriculatus* and *C. metliferous* were collected from NBPGR Regional Station, Thrissur raising the total strength of viable germplasm to 135.



C. metliferous Nematode resistance | *Cucumis hystrix Downy mildew resistance* | *C. muriculatus Powdery mildew resistance*

Wild accessions of cucumber

- Two new germplasm accessions in ridge gourd were collected raising the viable germplasm strength to 100. Thirteen new germplasm accessions were collected from NBPGR, New Delhi raising the viable germplasm strength to 101. In bitter gourd, 21 new germplasm accessions were collected from NBPGR, Thrissur raising the viable germplasm strength to 135.

- At IIHR, Hesaraghatta, Bengaluru, 15 genotypes in carnation and 50 germplasm in crossandra were collected. A total of 82 genotypes in carnation and 58 genotypes in crossandra were maintained at IIHR, Hesaraghatta, Bengaluru.

- In medicinal crops at IIHR, Hesaraghatta, Bengaluru, 13 germplasm lines from different regions *viz.,* Karnataka (7) Maharashtra (2), Madhya Pradesh (2), Meghalaya (1) and released cultivar Vallabh Medha (DMAPR, Anand) in *Centella asiatica* and two colchicine induced polyploids were collected, multiplied and maintained. Two germplasm lines in Kalmegh, one from Tumakuru district under natural distribution in hills of MD colony and one from Chikmagaluru district from home stead garden were collected. Eight land races of betelvine were collected from Chikmagaluru district of Karnataka.

- Seven wild species of edible mushrooms were collected from Manipur. The species were identified as *Schizophyllum commune, Lentinula edodes, Polyporus sulphureus, Polyporus alveolaris, Polyporus auricularis* and one unidentified *Polyporus* species. All these mushrooms were sold in the market and eaten by the locals. Two species *viz. Schizophyllum commune* and *Lentinula edodes* have been cultured, purified and conserved. A total of 83 germplasm (species/strains/mutants) of mushrooms are maintained in the mushroom lab through tissue culture, sub-culture and as spore print.

Wild edible mushrooms in Manipur market

❖ At CHES, Bhubaneswar, a total of 153 new germplasm accessions were collected in different vegetable crops (minor cucurbits, moringa and leafy vegetables) raising the total strength to 420. Five accessions of *Solena amplexicaulis* were collected and evaluated and accession no. 4 recorded highest number of fruits per plant (234.67) and yield per plant (2.72 kg/plant).

Solena amplexicaulis Acc-4

❖ At CHES, Bhubaneswar, hot chilli and leafy vegetables were collected from northeastern states and beans from Vidharbha region.

❖ At CHES, Bhubaneswar total germplasm collection stands at 632 which includes fruits [mango (122), jackfruit (37), bael (11), (11) annona sp., underutilized fruits (31)] and vegetables [ivy gourd (18), pointed gourd (20), spine gourd (40), teasel gourd (80), bitter gourd (48), sweet gourd (01), melothria (07), chilli (106), moringa (10), beans (40), leafy vegetables (50)].

Germplasm of hot chilli, amaranthus and Dolichos lablab

❖ **Mapping hotspot areas of horticultural gene pool distribution & database development:** Plant biodiversity and characterization at landscape level was implemented to identify and map the potential horticultural biodiversity rich areas in Eastern ghats. Generated spatial information on Satellite based Vegetation Type map, Disturbance Index, Fragmentation, Biological Richness. The vegetation and fragmentation maps provided by satellite sensors like Cartosat-1, IMS-1(HYSI), Resourcesat-1 (AWIFS) & Resourcesat-1(LISS-III) were obtained. Land Vegetation images as normalized difference vegetation maps (NDVM) & vegetation fraction maps (NFM) were obtained pertaining to hot spot locations. Among the vegetation types in Eastern ghats of Orissa, AP, TN, Karnataka and east coast of West Bengal, the spectral based species identification in the forest ecosystem is achievable accurately only with Arc GIS software for analyzing data. Preliminary attempts suggested that horticultural species richness in Eastern ghats were distributed in Orissa, AP, TN, Karnataka and east coast of West Bengal. Fragmentations are medium to low in least disturbed ecosystems with respect to species richness of *Mangifera indica, Syzygium* sps*, Garcinia sps, Butea superba* and *Cycas beddomei.*

3.1.2. Germplasm Conservation and Domestication

❖ ***In vitro* Conservation and Cryopreservation**

The cryopreserved *Feronea limonea* successfully established in field and exhibited total survival as compared to controls. The long term cryopreserved pollens of tomato (Pusa Ruby) and brinjal (Arka Shirish), remained intact after 23 and 26 years, respectively. The viability status was tested through *in vitro* germination of pollen and used to pollinate emasculated flowers of Arka Rakshak and Arka Anand resulted in fruit set to an extent of 45 and 96 per cent. A more than optimal recovery of seeds from fruits resulted in germination of 94 and 93 per cent, respectively. This technology was successfully transferred to a private seed company.

Fruit & seed set along with seedling emergence in brinjal & tomato induced with cryostored pollen

- *In vitro* propagation protocol was standardised using MS media supplemented with 1mg/l BA and 0.1mg/l NAA. A bud burst was noticed in accession of *Aegle marmelos (*Nanjangud) using different MS media based treatments. Slow growth studies in garlic resulted in conservation of garlic *in vitro* plants for 12 weeks under SCC and 10^0C. *Alpinia calcarata in vitro* plants were conserved for one year under SCC, *Embelia ribes in vitro* plants for one month at SCC and *Northopodytes pneumoniana in vitro* plants for 3 months at SCC.

- Studies on cryo-preservation of pollen in five pomegranate accessions *viz.*, Bhagwa, Jodhpur Red, P-23, Yercaud, Jodhpur were carried out and five wild accessions; 318736, 318752, IIHR-SH 21/6, IIHR-SH 21/13, Bhagwa OP 20/6, collected from Western Himalayan region.

❖ Identification of Zygotic Seedling in Polyembryonic Varieties of Mango Using Molecular Approaches

- Genotyping of Vellaikolumban and Nekkare morphotypes (single, double and triple seedlings) was carried out with fluorescent SSR primers viz., MISHRS 29, LMMA 10, LMMA 12, IIHR18, IIHR 24, IIHR 23, and IIHR 26 by multiplex PCR reaction. The PCR products were resolved by capillary electrophoresis using Gene scan. The seedlings morphotypes were assessed for zygotic or nucellar origin at molecular level by comparing the allelic profiles of the mother tree and the seedlings.

- In Vellaikolumban, OP seedlings (Single-25, double-14, and triple-9) were analyzed with gene scan using 8 SSR loci (MISHRS 29, LMMA 10, LMMA 12, IIHR18, IIHR 11, IIHR 23, IIHR 24, IIHR 26). Out of 8 SSR, 5 yielded homoallelic profiles and 3 resulted in heteroallelic profiles. Number of zygotic seedlings identified in each morphotype category differed with the SSR loci used. Among 8 fluorescent primers, IIHR 18 and IIHR 11 identified zygotic and nucellar seedlings in single, double and triple seedling morphotypes.

- In Nekkare, OP seedlings (Single-35; double, triple, tetra and hexa-13) were analyzed with gene scan using 5 SSR loci (MISHRS 29, LMMA 10, LMMA 12, IIHR 23, and IIHR 26). Out of 5 SSR, 2 yielded homoallelic profiles and 3 resulted in heteroallelic profiles. Results of Gene scan indicated that MISHRS 29 SSR loci discriminated zygotic from nucellar seedlings in different morphotypes of Nekkare.

- Stomatal index in seedlings of Moreh variety revealed marginally higher density of stomata in the leaf-tip sector irrespective of the tree.

- In order to establish correlation between cluster bearing and polyembryony, hermaphrodite to male flower ratio in panicles were recorded in mono and polyembryonic varieties of mango at three different agro climatic zones such as IIHR, Bengaluru, NBPGR, Thrissur and CIARI, Port Blair.

❖ Optimization of Germplasm Domestication Strategies for Introducing New Species of Horticultural Importance for Crop Diversification

- Clonal multiplication was accomplished in *B. courtallensis, Flacourtia montana, P. guineense* and *P. littoralle* through air layering (>50% rooting observed in hard wood). Four domesticated *A. marmelos* (Nanjangud collection) have fruited in their 6th year of planting and fruits varied in shape and size. A mass propagation method was developed in *A. marmelos* collected from Lohara forest in gunny bags under net house.

- **Phenological studies:** Plant dimorphism in the form of smooth and thorny trunk and

dioceous flowering habit was noticed in the field gene bank of *Flacourtia montana* (Governors plum). Out of 18 plants, 6 plants were male, 7 were female and five plants are yet to flower. Pollen viability studies have been taken up in male flowers using acetocarmine staining method.

➢ **Controlled cross pollination in wild guava:** Crossing have been effected between *P. guineense* and cultivated guava as direct cross and reciprocal cross. In direct cross between *P. guineense* x *P. guajava,* 10.34% fruit set was recorded while in reciprocal crosses, 8.92% fruit set was recorded. In *P. guineense* and *P. littoralle* aroma profiles were analyzed using SPME followed by GCMS during fruit development and ripening stages revealed the presence of 32 volatile compounds in *P. guineense* and 62 in *P.littoralle*.

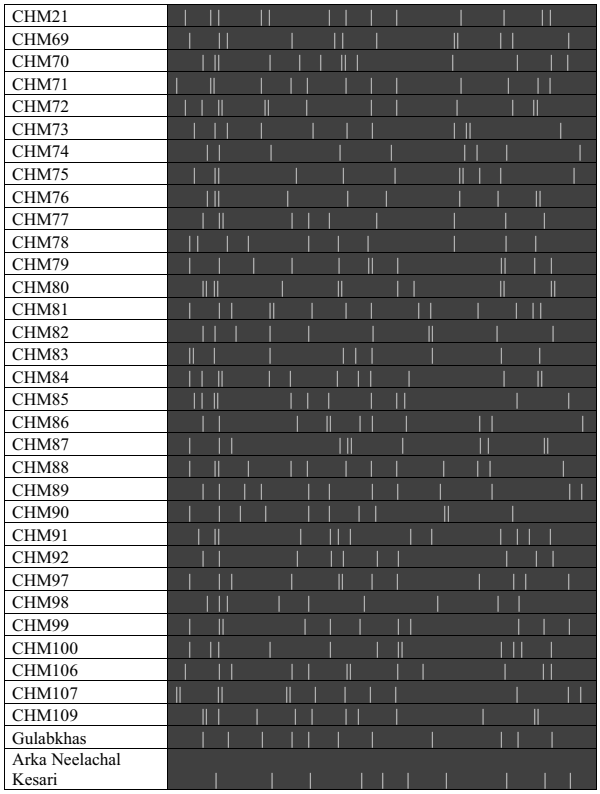
❖ **Establishment of mango gene bank:** A mango gene bank has been jointly established by CHES, Bhubaneswar and Directorate of Horticulture, Government of Odisha at the State Horticulture Farm, Dhenkanal. The *ex situ* establishment of gene bank is first of its kind in which State Department and ICAR jointly perceived the need of conservation of germplasm for their better exploitation. In the first phase, 27 germplasm and 42 varieties of mango have been deposited by the Station.

❖ **Establishment of a colour mango block and custard apple block:** A block of colour mango of 12 varieties/clone (Pusa Surya, Pusa Arunima, Pusa Pratibha, Pusa Peetambar, Pusa Shrestha, Arunika, Ambika, H-949, H-1084, H-1739, Arka Neelachal Kesari, Hamilton Sundari) and an *in situ* grafted block of custard apple var. Arka Neelachal Vikram have been established at CHES, Bhubaneswar.

3.1.3. Germplasm Characterization

❖ **Molecular characterization of mango germplasm**

Molecular barcodes for 32 mango germplasm have been generated by CHES, Bhubaneswar in collaboration with the Division of Fruit Crops, IIHR, Bengaluru. The germplasm showed variation in their genetic makeup. The molecular barcode of Arka Neelachal Kesari was different from Gulabkhas.



❖ **Characterization and genetic diversity analysis of future fruit crop genetic resources**

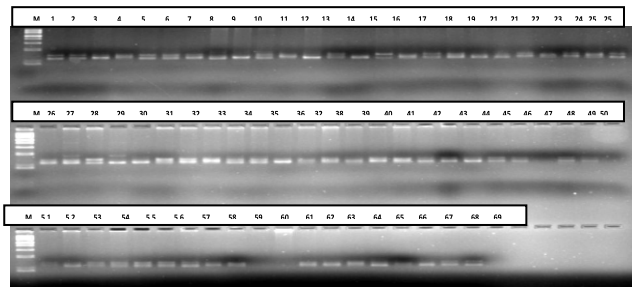
➢ **Governor's plum:** Seventeen *Flacourtia montana* accessions domesticated from S. Western ghats were characterized. Seven polymorphic primers were identified from related fruit species for generating SSR profiles which amplified amplicons with 54.17% polymorphism with Polymorphic Information Content (PIC) values ranging from 0.27 to 0.69. Accessions Fm5, Fm13 and Fm2 recorded high yield. Need to collect and characterize more diverse accessions from Western ghats.

➢ **Jamun:** DNA was isolated from young leaves of 25 accessions of Jamun collected from Srisailam and surrounding forest areas in Andhra Pradesh using CTAB protocol. A set of 48 microsatellite primers designed for guava were experimentally tested for cross amplification and found that 16 SSR primers produced amplification. The identified primers will be used for molecular characterization of Jamun accessions.

- **Pummelo:** For molecular characterization of 30 Pummelo (*Citrus maxima*) accessions in Field Gene Bank at IIHR, Nine EST (Expressed sequence tags) primers (CgEMS-1, CgEMS-2, CgEMS-3, CgEMS-5, CgEMS-9, CgEMS-21, CgEMS-45, CgEMS-51, CgEMS-52 and CgEMS-92) were used. The SSR profiles were generated for 30 accessions using CgEMS-2 and CgEMS-3 primers. SSR profiling of Pummelo (26 accessions) from FGB was carried out to characterize variability present in the germplasm.

❖ DNA fingerprinting and assessment of genetic diversity in horticultural crops germplasm

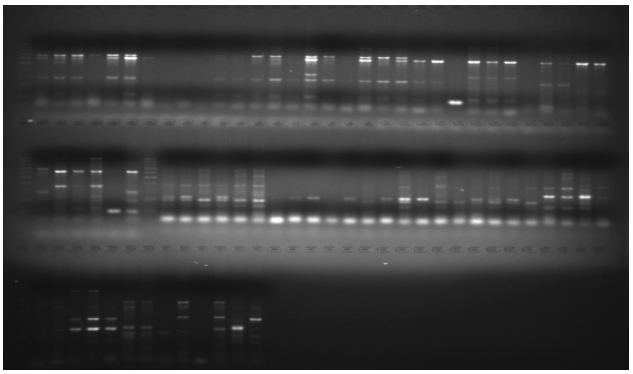
- **Chrysanthemum:** DNA profiles of 69 accessions were generated using thirteen polymorphic SSR primers. A total of 23 SSR primer pairs were screened initially to select primers that can generate informative fragments in 69 accessions maintained in the field. The primers used for DNA profiling were YW A 2-1, YW A08, YW A 15-1, YW A 25, YW A 33, YW B07, YW B08, YW B 13-1, YW B 17-1, YW B 18, YW B 21, YW C 12, YW C 15 that resulted in 51 alleles. 100% polymorphic alleles were generated by SSR loci viz., YW B 21, YWB 18, YWC15, YWB 08 YWB13-1, and YWA 15. Number of alleles ranged from 1-6 (YWB13-1).



SSR profile of 69 Chrysanthemum genotypes using SSR YW B13-1 primer.

- The genetic relationships among the accessions were assessed by a cluster analysis of the similarity matrix. All 69 accessions were broadly grouped into 3 clusters and there are sub clusters within each cluster based on genetic distance. The results showed that Star Pink and Shukla exhibit greater genetic distance.

- **Jasmine:** Thirty nine genotypes maintained (*Jasminum sambac*-23; *J. auriculatum*- 6; *J. multiflorum*-3; *J. grandiflorum*-2; wild species- viz., *J. rigidum*; *J. nitidum*; *J. calophyllum*; *J. flexile*; *J. malabaricum*) were characterized using SSR markers. Primers identified for polymorphism are StvChR_9a, StvChR_267a, StvChR_321b, StvChR_480a, StvChR_605a, StvChR_974a, StvChR_894a, StvChR_343a and StvChR_935a. SSR profiles were generated using the above said polymorphic primers. Number of alleles per primer ranged from 3 to 5 (StvChR_343a). Wild species particularly *J. calophyllum* has generated unique profiles. Genotype specific DNA profiles were generated using the said microsatellite primers.



SSR profile of Jasmine genotypes using 2 SSR primers, StvChR_894 and StvChR_974a primers.

- **Pomegranate:** Isolation of DNA from 29 genotypes obtained from USDA was carried out and these were used to characterize 30 SSR primers. The 30 primers were designed with M13 tail ends to facilitate multiplexing. Amplification was achieved for all the primers. The data obtained by gene scan was analysed using Peak Scanner and Cervus software to obtain the information about the primers and genotypes. Ten primers out of 30 were found to be highly informative with high PIC values (>0.5). The observed and expected heterozygosities ranged from 0 to 1. The mean number of alleles per locus was found to be 11.67 and the mean polymorphic information content (PIC) for 30 primers was 0.73.

❖ Gene expression and analysis

- **Banana:** Expression analysis of genes CUT1 and KCS11 which are involved in the cuticular wax biosynthetic pathway was done using qPCR in the two contrasting banana species *Musa balbisiana* and *Musa acuminata* with 3 different leaves (2nd, 4th and 6th from the top). It was observed that the maximum expression of the gene was seen on the 4th leaf stage in both the species with *Musa balbisiana* showing 9.5

change ($2^{\Delta C_T}$) whereas *Musa acuminata* showing 4.5 fold change ($2^{-\Delta C_T}$) for CUT1. The 2nd leaf was still tender and the 6th leaf had attained drooping state, but the 4th leaf was expanding and active. Also along with CUT1, we also carried out expression analysis of gene KCS11 which is also involved in the formation of VLCFAs. Here we obtained enhanced expression in all the leaf stages of Bee hee Kela. The GC-MS analysis in the above two genotypes showed higher accumulation of C_{28} in *Musa acuminata.*

Whole genome protein sequences of DH-Pahang was used to scan for the HD zip and WRKY TFs domains using it's HMM- Model. The similar sequences were extracted into separate files using Perl scripts and a FASTA file of all the sequences showing homology with respective TFs was created and was used for Phylogenetic tree construction. Using the trancriptome data, we were able to obtain a total of 116 and 227 miRNA members from *Musa acuminata* and *Musa balbisiana* transcriptome. Further, its target prediction showed that 95 and 192 numbers of miRNAs had targets in *M. acuminata* and *M. balbisiana* respectively. Long non coding RNAs were shortlisted from the transcriptome data of both *Musa acuminata* and *Musa balbisiana,* by filtering the coding genes initially by BLAST search, HMMER scan and CPC scan. The results showed that 1146 LnRNAs were similar in case of *Musa acuminata and Musa balbisiana* whereas 325 and 282 LnRNAs were unique for *Musa acuminata* and *Musa balbisiana* respectively.

SSR marker screening for parental genotypes (Calcutta4 and Kadali) was done to shortlist the polymorphic primers which will be further used to screen the F_1 mapping population. About 150 SSRs have been shortlisted that have shown polymorphism between the parental lines. Primers were designed for peroxidase, catalase and xylem sap proteins with the help of the Banana Genome Hub and cDNA library constructed.

In order to study thermo-tolerance, transcriptome analysis of cv. Grand Naine under heat stress was done. The data were generated for all the stages of temperature induction response. Heat map was generated for selected genes for all 6 stages. We also examined the metabolite profile under heat stress using contrasting genotypes by LC/MS.

- **Mango:** The diversity and genetic relatedness of mango genotypes from north-eastern region of India were analyzed using selected eight microsatellite markers. Ninety SSR markers from whole genome sequence data, were tested employing 64 mango genotypes and four Mangifera species, for determination of polymorphism and cross species amplification. We identified 2103 alleles, and allele number per locus ranged from 15 to 36. The majority of these markers amplified DNA in the related species and transferability was 94.4 to 98.8 per cent. The present study has increased sequence coverage of the mango genome and the number of mango specific SSR markers. This is also the first report of the development of genomic SSR markers in mango using next generation sequencing technology. The genomic SSR markers identified in this study will be useful in diversity, identification, mapping and breeding studies

- **Okra:** Twenty nine genotypes were used to analyze diversity by employing 10 SSR markers in the current year. Analysis of 50 SSR markers data showed that, the mean Polymorphic Information Content was found to be 0.5459 and values range from 0.000 to 0.952 and the mean Probability of Identity was found to be $3.949014x\ 10^{-43}$ ranges from 0.0038 to 0.680. We have demonstrated cross species amplification using 5 species *A. ficulineus, A. tetraphyllus, A. moschatus, A.angulsosus var.grandiflorus and A. calliaie*. We have cloned CDS sequences from 6 diverse genotypes and sequenced. We have observed 1 to 15 SNPS per gene and 2 to 4 indels. Indels were present in only two genes.

- **Tomato:** Promoter analysis was done for Lycopene beta cyclase gene. The full length gene of CRTL- b was cloned and sequenced for contrasting genotypes for lycopene content. The sequencing results were compared for the two genotypes IIHR-249-1 and IIHR-2866 and promoter regions were predicted using various software's like Plant Prom DB, PLACE (Plant Cis – acting Regulatory DNA Elements) and Plant Care. We have screened germplasm and breeding lines for *Ty1, Ty2* and *Ty3* markers (for ToLCV resistance) *Ph* markers (Phytopthora resistance) and *Mi* markers (nematode resistance). These markers are being used for gene pyramiding.

- **Garcinia:** *Garcinia gummi-gutta* (L.) Robs.

(Clusiaceae) is an endemic, semi-domesticated, fruit, yielding tree species distributed in the Western Ghats regions of India and Sri Lanka. Various bioactive phytochemicals such as garcinol, benzophenones and xanthones isolated from *G. gummi-gutta* have shown antibacterial, antiviral and antioxidant activities. In order to develop microsatellite markers, we have sequenced total genomic DNA using the Illumina Hiseq 2000 platform and examined sequence data for microsatellite markers. In *Garcinia gummi-gutta* we obtained 241141804 bp high quality data which were assembled into 773889 contigs. In these contigs 27313 SSRs were identified. Among various types of repeats, mono nucleotide repeats were predominant (44.98%) followed by di and tri nucleotide repeats. We were able to design primers for 9964 microsatellites among them thirty three randomly selected SSR primers have been standardized for amplification. Polymorphic Information Content (PIC) values across all 33 loci ranged between 0.867and 0.951 with a mean value of 0.917. The observed and expected heterozygosity ranged from 0.00 to 0.63 and 0.896 to 0.974 respectively. Alleles per locus ranged from 12 to 27. The results of the present study, provides a good number of species specific SSR markers and partial genome sequence. This is the first report on the development of genomic SSR markers in *G. gummi-gutta* using next generation sequencing technology.

Garcinia indica popularly known as *'Kokum'* or *'Murugalu'*, is a medium sized evergreen tree found along the West ghats forests of India. Using next generation sequencing platform Illumina Hiseq 2000, we have sequenced partial genome of *G. indica* and identified 3725 microsatellites. Forty eight microsatellite markers were analysed using 30 accessions. Polymorphism information content (PIC) values ranged between 0.718 and 0.968 with a mean value of 0.922. Allele per locus ranged from 3 to 33 per locus. Probability of identity values ranged from 0.00329 to 0.30489. Cross species amplification of SSR primers in the related species, showed 12.5 % (for *G. morella*) to 18.7 % for *G.gummigutta*) transferability.

Garcinia morella (Gaertn.) Desr. (Family Clusiaceae) is popularly known as 'Indian gamboge' is a fruit yielding tree of tropical rain forests of Western Ghats of India. In order to develop microsatellite markers, we have sequenced genomic DNA using the IlluminaHiseq 2000 platform and examined sequence data for microsatellite markers. In *Garcinia morella*, we obtained 10653 Mbp high quality data which were assembled into 1613263 contigs. In these contigs, 121199 SSRs were identified. Among various types of repeats, di nucleotide repeats were predominant (42.5 %) followed by mono and tri nucleotide repeats (30.4 and 7.9 per cent, respectively). We were able to design primers for 52901 microsatellites. Genetic analysis of 48 SSR loci, showed PIC values ranging from 0.067 to 0.939 with a mean value of 0.7547. The mean values of observed and expected heterozygosity are 0. 2026 and 0.7852, respectively. The allele per locus ranged from 2 to 24 with a mean of 13.

3.1.4. Evaluation of Germplasm for Yield and Quality

- At IIHR, Hesaraghatta, Bengaluru, 36 varieties of mango were described as per 'Bioversity International' Descriptor. Thirty varieties maintained in the FGB were evaluated for fruit characteristics. The variety 'Papaya' recorded maximum fruit weight (600 g). The bisexual percentage was observed to be maximum in the variety Pacharasi (36.04). Screening of varieties for fruit fly and stone weevil showed that under exposed condition the variety EC 95862 did not record any infestation.

- Thirty six underutilized fruit varieties are maintained in the Field Gene Bank at IIHR, Hesaraghatta, Bengaluru. Evaluation of 24 sweet Karonda types showed that maximum fruit size of 3.98 g was recorded in Acc. No. 4/11 and maximum yield (6.46 kg/plant) was recorded in Acc. No. 8/12. Governor's plum (*Flacourtia indica* L) having dark brown with round shaped fruits with an average fruit weight of 6.55 g and sweet to taste with a TSS of 24.5°B was found to be promising.

- At IIHR, Hesaraghatta, Bengaluru, twenty two pummelo accessions were characterized for 17 traits by using the 'Bioversity International' descriptors. Maximum fruit weight was recorded in Accession-3 (1.77 kg/fruit) and the minimum was recorded in Accession-4 (0.5 kg/fruit). The accessions *viz.,* 6, 11, 12 and 19 were observed to have pink pulp. Two less bitter selections were made from Accession-8 and Accession-19.

❖ At CHES, Chettalli: More than 500 accessions of underutilized fruits *viz.,* mangosteen (12), durian (5), rambutan (200), avocado (50), kokum (45), malabar tamarind (85), karonda (45), pummelo (65) *etc.* were evaluated and maintained at CHES, Chettalli.

➢ Pummelo collections (65) were evaluated for growth yield and fruit quality parameters. Maximum plant height was recorded in CHESP-12. The plant spread (E-W) ranged from 1.2m to 9.50m. Plant spread (N-W) ranged from 1.0 m to 9.25m. The number of fruits ranged from 5 to 375 fruits /tree. The highest number of fruits was recorded in CHES P-17 (375 fruits) followed by CHES P- 41(341 fruits) CHES P-16(305 fruits), CHES P-15(280 fruits) CHES P-14(25 fruits). The fruit weight ranged from 399g to 1606g. Highest weight (1606g) was recorded in CHESP-27 while lowest fruit weight (399g) was recorded in CHESP-2. The number of seeds/fruit were lowest (15) in CHESP-15 and highest (113) in CHESP-52. The fruit yield ranged from 3.64 kg to 86 kg. The highest in CHESP-41 (286 kg) followed by CHESP-(271kg), CHESP-(259 kg) and CHESP-46(231 kg). Over all CHESP-6 2 , CHESP-41, CHESP-37, CHESP-13, CHESP-8, CHESP-12 were found better than others.

➢ Among Rambutan accessions, highest yield was recorded in CHES R-8 (1281 fruits), CHES R-28 (1177 fruits). Among the accessions planted in 2006, highest yield was recorded in CHES I-2(615 fruits), CHESR-XIV-10 (521 fruits), CHESR -III-9 (362 fruits), CHESRXIX-4 (619fruits) and CHSR-XIII-(610 fruits). Most of the accessions planted in 2010 are yet to start flowering. As far as fruit weight is concerned, it ranged from 16.92 g to 56.34 g. Highest fruit weight (56.34 g) was recorded in CHESR-XVIII-5. The accessions such as CHESR-XIV-7, CHESR-XIV-8, CHESR-XIV-10, CHESR-XIX-11, CHESR-XV-3,CHESR-XV-7, CHESR-XVI-4, CHESR-XVII-5, CHESR-XVIII-2, CHESR-XVIII-5, CHESR-XIX-2, CHESR-XIX-3, CHESR-XIX-4, CHESR-XIX-5 recorded more than 30 g fruit weight. The TSS ranged between 11.01 to 21.8 °Brix. Higher TSS was recorded in CHESR-7 (21.8 °Brix), CHESR-8(20.4), CHESR-32(21.1 °Brix) CHESR-I-3(21.4 °Brix), CESR-VI-9 (21.5 °Brix) CHESR-VI-9 (20.4 °Brix). Among the new collections CHESR-III-11, CHESR-IX-10, CHESR-X-9, CHESR-XV-7, CHESR-XVIII-5 were found better with respect to fruit weight, yield than other accessions.

➢ Growth, yield and fruit characters were recorded and analysed for 56 collections of avocado. The plant girth ranged between 33 to 65.5 cm. Plant height ranged 460 cm to 945 cm. The plant spread (E-W) ranged between 360 m to 790 m while plant spread (N-S) ranged between 460 cm m to 695 cm. Highest yield (478 fruits) were recorded in CHESPA-VIII-1 followed by CHESPA-III-1 (465 fruits), CHESPA-XIII-1 (418 fruits) and CHESPA X-1 (325fruits). Fruit weight ranged 243g to541g. The highest fruit weight (541 g) was recorded in CHESPA-III-4 while lowest weight (243g) was recorded in CHESPA-IX-4. TSS ranged from 6.7 to 12.8 °Brix. Highest TSS was recorded in CHESPA_III-4 followed by CHESPA_X-4 (12.0 °Brix) and CHESPA_IX-2 (11.00 °Brix) followed by 11.1° Brix in PA III-2. The vitamin C content was low in all the accessions. Over all PA VII-1, PA-VII-3 and PA-XIII-1 were found promising.

➢ Twenty five accessions of passion fruit were multiplied for planting in new blocks as the existing block was severely affected by rot and other diseases. The multiplied accessions were planted in the new block during September 2014 and some more collection were planted in August.

➢ The Growth and yield parameters of 106 collections of karonda were recorded. The number of fruits per plants ranged from 84 to 3540 fruit per plant. The fruit yield ranged from 0.93 kg to 69.56 kg per plant with highest in CHESK-I-2 followed by CHESK-I-8 (64.29 kg).The fruit weight ranged from 2.83 g to 2.63 g with highest in CHESK-I-3 (21.69 g). The lowest fruit weight (2.83g) was recorded in K-V-II followed by K-V-II-2 (3.11g) and K-V-8 (3.2g). The TSS ranged from 11.6 ºBrix to 18.9 ºBrix. Over all the accessions, K-II-7, K-V-6, K-V-10, K- VII-11 and K-VIII-1 were found superiors than others with respect to most of the characters. These superior lines have big size fruit (12- 16g), less number of seeds (<1.0) and higher TSS (120 °Brix).

➢ The growth and yield characteristics of 29 Malayan apple accessions were recorded. The yield ranges from 880 to 3764 fruits/plant in CHESM-I-1. The fruit weight range from 45 g in M-I-1 to 92g in CHESM II-1. The number of

seed per fruit ranged from 3.2 in M-I-1 to 5.8 in M-I-3. The TSS ranged from 7.2 ºBrix inM-I-1 to 10.6 ºBrix in M-I-3. CHES 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 yield ranged from 36.4 to 287 kg /plant. The fruit weight ranged from 46 to 90g. The TSS ranged from 7.0 to 9.0 °Brix while acidity ranged from 1.5 to 3.0 %.

- Mangosteen collections (16) were evaluated for growth and yield characteristics. The plant height ranged from 0.88 m to 3.5 m. The fruits weight varied from 76 to 98 g and fruit colour was dull red. The fruit have higher TSS with very low acidity.

- More than 45 accessions of *Garcinia indica* were evaluated. Plant height ranged from 205 cm to 685 cm. The numbers of fruits were ranged from 84 to 1234 per tree. Highest number of fruits/tree was recorded in CHESGI-V-4. Fruit yield (kg/ plant) ranged from 3.2 kg to 58.9 kg and it was highest in CHESGI-V-4. Fruit weight ranged from 28.4 g to 84.4 g, CHESG- VI-2 and CHESGI-V-8 recorded lowest and highest respectively.The TSS ranged from 11.9 to 16.4 °Brix while acidity ranged 2.4% to 7.4%. Among all the accessions, GI V-8, GI -V-4, GI-VII-4, GI-VIII-5 were found promising with respect to yield and quality parameters.

- The growth, yield and fruit characteristics of 103 accessions of *Garcinia xanthochymus* were recorded. Plant height ranged from 1.70 m to 3.90 m while the plant spread (E-W) ranged from 0.95 m to 3.50 m. Fruit yield ranged from 0 to 118 fruits/tree in accession CHESGX-IV-6 and fruit weight ranged from 76 g in CHESGX-VII-3 to 155 g in CHESGX- IV-10. TSS ranged from 13.6 °Brix to 14.8 °Brix. Among all the accessions in CHESGX-II-6, CHESGX-II-10, CHESGX-VI-I were found better than other accessions with respect to yield and fruit quality.

At CHES, Bhubaneswar:

- Rose apple (*Syzygium jambos*), CHRA-1 and CHRA-2 were evaluated for their yield potential and fruit quality.CHRA-1 was promising in terms of fruit weight (35.4), fruit yield (14.5 kg/plant) and fruit quality (TSS – 13.8; pulp – 84.5%).

CHRA-1

- Among two germplasm of star gooseberry CHSG-1 has been found promising in fruit weight (3.8), fruits/plant (928), fruit yield (3.8 kg/plant), TSS (7.1 Brix), edible portion (92.5%) and vitamin C content (93 mg/100g).

CHSG-1

- Among the four carambola (*Averrhoa carambola*) germplasm, CHCM-4 found promising in fruit weight (95.7g), fruits/plant (173.5), fruit yield (14.3 kg/plant), TSS (11.2 °Brix), edible portion (91.3%) and the seeds/fruit (2).

CHCM-4

- Eleven bael (*Aegle marmelos*) germplasm were evaluated, CHBL-9 found promising in fruit weight (1.07kg), fruits/plant (48.5), TSS (42.9 Brix), pulp (75.2%) and skull thickness (2.5mm).

CHBL-9

- Among the four tamarind germplasm, CHTM-3 found promising in yield (18.5 kg/ plant), pod length (10.8 cm), pod weight (18.5g), TSS (35.3 Brix), pulp content (50.47%), TSS / acid ratio (3.8) and the number of seeds/pod (8.3).

CHTM-3

In vegetable crops at IIHR, Hesaraghatta, Bengaluru

- A total of 40 germplasm lines in tomato were raised for maintenance during *rabi* 2014 of which CLN 3150 A-5 (33.4 t/ha), Arka Vikas (26.6 t/ha) and CLN 3070J (24.4 t/ha) were the top yielders. Four lines (IIHR-2895, 2902, 2896 and 2907) were completely free from ToLCV incidence.

- In capsicum, 42 germplasm lines were evaluated and 75 germplasm lines maintained.

- Among 15 germplasm lines of brinjal, nine lines in green variegated background (IIHR-559, IIHR-586-A, IIHR-637 IIHR-640 IIHR642 IIHR-567, and NGP Green Oval, IC0585684 and Rampur local) and six lines (IIHR636, IIHR641, IIHR-644 (Ravaiya type) IIHR-654, IIHR-657 and IIHR-659) in purple background were evaluated for yield and fruit quality. The yield per plant ranged from 1.50 kg to 2.5 kg with excellent fruit quality. Among the germplasm lines evaluated, the line IC0585684 collected from Andaman and Nicobar (Port Blair) was found to be resistant to bacterial wilt with a fruit yield of 2.50 kg per plant and good keeping quality. Good variability was observed for fruit shape, size and colour.

- In French bean, 115 germplasm lines were evaluated for yield and yield attributing traits. Pod width ranged from 0.7 to 1.9 cm. Pod yield ranged between 30-362 g per plant. 21 lines were green and round podded, 58 lines were green with flat pods. Nineteen lines were light green with flat pods, six lines were LG with round pods, seven lines were dark green with round pods, two lines each were purple and green with purple streaks on pods. Major diseases did not appear during the season. The genotypes were highly significant for all the traits. IIHR –129 gave maximum pod yield of 362.5 g per plant.

- A total of 27 germplasm lines were evaluated in cowpea. The pod yield ranged from 8.0 to 26.17 t/ha. EC-769250 gave maximum pod yield of 1.2 kg/plant. Pod maturity ranged from 60 to 65 days. Pod length ranged from 14 to 73.8 cm. Maximum pod length was observed in EC-769255. Variability was observed for pod colour like light green (15), green (2), dark green (9), purple (1), etc. Incidence of cowpea aphid mosaic virus and rust had not appeared.

- In okra, nine new accessions were evaluated for yield, quality and resistance to YVMV and powdery mildew diseases. Among them, Acc. IIHR-317 was found to be highest yielder (1.20kg /plant) with 11.5 cm fruit length and 1.65 cm fruit diameter and resistance to YVMV and PM (0% incidence). Fruits are dark green, smooth, tender and five ridges. It matures early at 43 days after sowing. This is followed by IIJHR-318 (900 g/pl with 0% YVMV). Out of 32 wild species screened, five species namely *A. tetraphyllus* (EC -329394), *A moschatus (IC-140985),) A. angulosus var. grandiflorus* (IC-470751), IIHR-320 A. *cailee, A. tuberculatus* (IC -305676) were found resistant to YVMV (0% incidence) while, the susceptible check ACC 1685 recorded 80 % incidence of YVMV under natural field conditions.

IIHR-317
(1.2kg yield /pl)

IIHR-318
(900g yield /pl)

A. tetraphyllus
(EC -329394)

A. angulosus
var. grandiflorus (IC-470751)

- Thirty germplasm accessions were evaluated with YVMV susceptible line AC-1685 as infector rows. Four accessions namely JP-13-1A, JP-13-57, JP-13-66 and JP-13-82 recorded 0 % incidence of YVMV, while the susceptible check AC 1685 recorded 50% incidence of YVMV. Rest of the accessions recorded less than 35% incidence of YVMV at the 90th day of sowing.

- Seventy five cucumber accessions raised and selected plants were selfed and seeds were collected during Rabi 2014. Among them IIHR-264 and IIHR- 288 from Shimoga was found promising with 3.8 kg and 2.5 kg fruits /plant. The number of fruits ranged from 8-12. IIHR-264, possessed fruits that are green with light green lining, thin, 8-14cm long, 2.5cm diameter, good keeping quality and tolerance to mildews under natural field condition.

IIHR-264

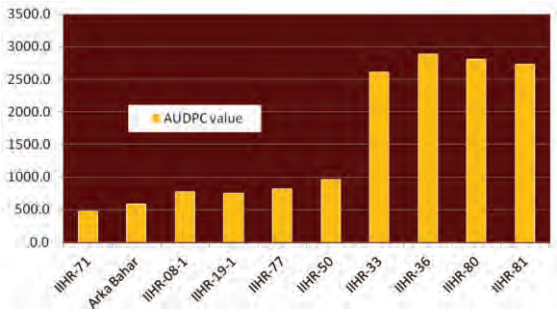
IIHR-288

- Of the two new germplasm accessions collected in ridge gourd, IIHR-114, belonging to *Luffa cylindrica* species, was found to be resistant to downy mildew. Out of the 12 germplasm selections evaluated for fruit yield, IIHR-74-1 (41t/ha) and IIHR-84-3 (36.4 t/ha) were significantly high yielding. One germplasm selection, IIHR-81-10 is a Satputia variety belonging to *Luffa acutangula* var. *hermaphrodita,* and has cluster bearing fruiting habit with small fruits.

IIHR-81-10 (Luffa acutanguala var. *hermaphrodita)*

IIHR-114 (Luffa cylindrica)

- Four germplasm lines of bottle gourd *viz.,* IIHR-8-1, IIHR-19-1, IIHR-77 and IIHR-23 (PDI range from 7.8-10.0) were powdery mildew resistant and with AUDPC values ranging from 477.8 to 2888.9. Seven germplasm *viz.,* IIHR-66, IIHR-18, IIHR-69, IIHR-94, IIHR-97, IIHR-98 and IIHR-22350 were identified to be resistant to CGMM virus in bottle gourd (vulnerability index ranged from 0.0-22.5). Germplasm lines, IIHR-17 (77.4t/ha), IIHR-23 (71.1t/ha) and IIHR-91(65.9t/ha) recorded highest yield during summer and IIHR-17 (49.5t/ha), IIHR-99 (30.5t/ha) and IIHR-94 (28.4t/ha) recorded highest yield during *kharif* seasons.



AUDPC of bottle gourd germplasm for powdery mildew incidence

- Out of the 56 bitter gourd germplasm selections evaluated during kharif, 13 lines recorded maximum yield of 20.0 t/ha - 23.7 t/ha. Among them, IIHR-138-6, IIHR-46-1 and IIHR-114-2 recorded maximum yield of 23.7 t/ha. Three genotypes viz., IIHR-62 for (FRAP content), IIHR-56 (Flavonoids) and IIHR-4 (Phenol content) have recorded maximum values of antioxidants consecutively for the second year.

- A total of 35 accessions of teasel gourd were evaluated for fruit yield and quality traits at CHES, Bhubaneswar and the accessions showed a considerable level of variability. The accession JB/11-178A recorded highest yield per plant (9.80 kg/plant). Fruits of JB/11-179 were in good shape and size even during high temperature i.e. during peak summer while fruits of most of the accessions were deformed and under- weight. JB/11-179 also gave higher yield and is at par with the highest yielder JB/11-178A.

JB/11-179, promising Teasel gourd accession,

In ornamental crops:

- A total of 16 genotypes were maintained in tuberose. The genotypes Calcutta Single, Calcutta Double, Bidhan Rajani 1, Bidhan Rajani 2 and Bidhan Rajani 3 were collected from BCKV, Kalyani. Cultivar, Phule Rajani was collected from MPKV, Rahuri and GKTC-4 from Ganeshkhind, Pune.

- In gladiolus, a total of 69 genotypes having different colour and floral traits were maintained.

- Total of 281 genotypes including twelve species were maintained in rose. All the 12 species were characterized for 21 distinguishing features of foliage, stem and prickles. Flowering was observed only in *R. multiflora*. Thrips incidence was minimal in *R. multiflora*. A total of 257 varieties are maintained and characterized as per DUS testing guidelines. Varieties are maintained in the form of live

repository as well as digital repository.

- In gerbera, a total of 10 genotypes were maintained under naturally ventilated polyhouse and evaluated for flower quality traits.

- A total of 80 genotypes in chrysanthemum and 20 genotypes in China aster were maintained and evaluated for flower quality traits. The genotypes were characterized as per DUS test guidelines.

- Thirty seven accessions in jasmine from four commercially cultivated species *viz., Jasminum sambac, Jasminum auriculatum, Jasminum grandiflorum, Jasminum multiflorum* and four other species (*Jasminum rigidum, Jasminum nitidum, Jasminum flexile* and *Jasminum malabaricum*) were maintained and characterized for morphological descriptors. The morphological descriptors for three species namely *Jasminum sambac, J. auriculatum* and *J. multiflorum* were prepared.

- All the collected species of native ornamental plants were domesticated and evaluated for their suitability as landscape plants. Species namely *Jasminum malabaricum, Lepturus radicans, Clematis guariana, Ixora parviflora, Senecio bombayensis, Senecio belgaumensis, Senecio dalzilli, Turnera ulmifolia, Lavendula lawii, Artimesia japonica* and *Artemisia nilagirica* are maintained.

Senecio bombayensis

Artemisia nilagirica

- At CHES, Chettalli, major orchid species *viz., Dendrobium crepidatum, Vanda tessellate, Liparis viridiflora, Rhynchostylis retusa, Phoidata pallid, Dendrobium aqueaum, Cymbidium bicolor, Aerides ringens etc* are conserved. Some of the orchids have potential for potted orchids and also for cut flower making.

In medicinal crops:

- ***Centella asiatica* (Mandukapani):** A total of nine germplasm lines and one polyploid were evaluated for 12 morphological traits with vallabh medha as check. IIHR - CA -1 was found more robust and recorded highest value for majority of the traits (plant height, plant spread, number and size of leaf, petiole length, internodal length, etc.) while IIHR – CA–9 and IHR – CA–10 recording the lowest values.

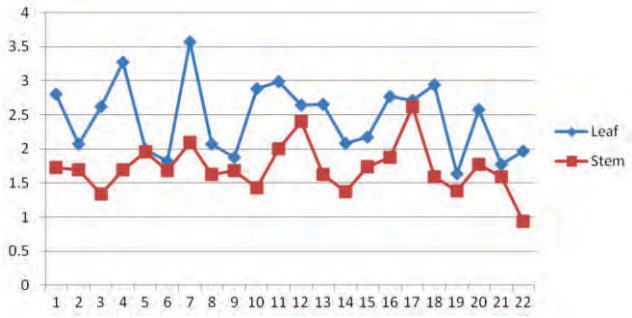
These nine germplasm lines and a polyploid were also evaluated with check Vallabh Medha for biomass yield and quality. The lines IIHR - CA -1 (349.26 g), IIHR - CA - 7 (320.20 g) and IIHR - CA -13 (303.63 g) recorded significantly higher dry leaf yield than the check (249.30 g). Among them, IIHR - CA - 13 had consistently superior quality by recording highest per cent asiaticoside (3.72) and total triterpenes (8.94). IIHR-CA-1 was the highest yielder and comparable to check for ascorbic acid (69.11mg/100g) and total carotenoids (26.58 mg /100g).

- ***Mucuna* sp.:** Total phenols and tannins were estimated in 58 lines of *Mucuna* germplasm consisting of both itchy and non-itchy types. The lowest phenol content was recorded in IIHR MP 11 (2281.90 mg/100g) and highest was observed in IIHR MP 74 (9449.2 mg/100g.). The lowest total tannin content was recorded in IIHR Selection 3 (57.35 mg/100g) and highest was observed in IIHR MP 124 (105.06 mg/100g). The results showed that both phenol and tannin content were low in non-itchy lines and higher in itchy types.

- Fifty eight germplasm lines were screened with 10 polymorphic ISSR primers. The dendrogram showed two major clusters at 62 per cent similarity. The clustering pattern reveals grouping based on presence or absence of trichomes and L-Dopa content. The study shows that ISSR primers are useful in studying the molecular diversity in velvet bean.

- **Kalmegh:** Twenty two (22) germplasm lines were evaluated for morphological traits, yield and andro- grapholoide content. The total herbage yield varied from 9.30 to 16.50 g/plant. Three lines recorded significantly higher dry biomass compared to checks CIM Megha and Anand Kalmegh which recorded herbage yield of 11.8 and 11.9 g/plant. Leaf to stem ratios varied from 0.46 to 1.48. Total andrographolide content among the 22 lines varied from 2.90 to 5.69%. Significant differences for andrographolide, neoandrographolide, 14-deoxy andrographolide and andrograponin

were observed. The studies on andrographolide content in stem and leaves of the germplasm lines showed differences at 120 days of crop growth period. This opens up the possibilities for selection of lines with higher andrographolide content in stem as it forms a major portion of the raw material.



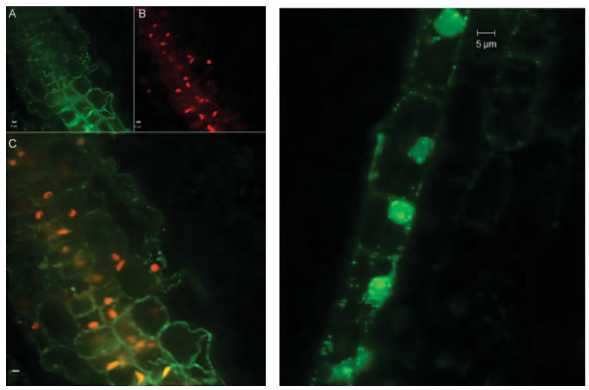
Total Andrographolide content (%) in leaf and stem of 22 Kalmegh germplasm at 120 days

➢ **Molecular studies:** DNA extraction protocols and ISSR primers were standardized in Kalmegh. DNA was extracted from 22 germplasm lines and they were screened with 8 polymorphic ISSR primers to study the molecular variability.

❖ **Screening germplasm introduced from wild and secondary sources for pest and disease incidence**:

In Field bean (*Dolichos lablab*), observation on pods damage (20%) by cowpea pod borer (*Maruca testulalis*) was recorded instead of *Adisura atkinsoni* severity. Abundance and foraging behavior of insect pollinators in relation to genotype variability in different fruit crops recorded. In onion germplasm (E_1R series), thrips damage (0-6; av-1.3%) was observed per plant. In Jamun, damage by Leaf gall (0 - 8 %; Av- 1.7%); leaf miner (0-75%; Av-33.49%); Fruit weevil and fruit flies was observed (<10%). In Aonla, Mealy bugs and defoliators damage observed.

❖ **Cytobacts and Peribacts - The Ubiquitous intracellular colonizing endophytic bacteria:** Staining the tissue sections of different banana cultivars with the Live-Dead bacterial staining kit containing SYTO-9 coupled with confocal laser scanning microscopy (CLSM) has brought out abundant bacterial colonization along the cell boundary. Further investigations adopting bright field microscopy on fresh tissue sections as well as cell, callus and protoplast preparations after proper cell permeabilization treatments showed abundant live intracellular bacteria (Fig. 1b). This is the first time documentation that the plants harbor abundant endophytic bacteria inside healthy cells as living entities. There are two niches of intracellular colonization namely cytoplasmic dwellers and the inhabitants in the perispace between cell wall and plasma membrane. The terms 'Cytobacts' and 'Peribacts', respectively, have been coined to describe the organisms in the above two niches.



LEFT:(A) SYTO-9 stained green fluorescing bacteria along the cell peri-space in banana, (B), nuclear staining by propidium iodide; (C) superimposed image (scale bar = 5 µm); RIGHT: Enzyme permeabilized banana leaf-sheath tissue showing abundant green fluorescing cytoplasmic bacteria with SYTO-9 staining .

3.2. Crop Improvement

3.2.1. Fruit Crops

Mango (*Mangifera indica* L.)

- Inter-varietal hybridization was carried out with seven cross combinations. Interspecific crossability studies were carried out using the species *Mangifera odorata*. The hybrid H-12 from the parentage Amrapali x Arka Anmol was identified by 'Varietal Identification Committee' of the Institute and named as Arka Udaya. It has semi-vigorous growth habit with medium sized fruits (230-240 g). It produces fruits in clusters. Pulp is firm, orange yellow with a TSS of 24-25°B. The fruits have excellent keeping quality.

Arka Udaya

- A catalogue on 47 'Appemidi' mango pickling varieties was brought out under the RKVY project on 'Characterization of indigenous mango varieties'. The catalogue contains information on morphological and molecular characterization. It has information also on chemical profiling of these varieties.

- A booklet on 'Heirloom varieties of important tropical fruits; a community initiative to conservation' was brought out.

- Molecular characterization was carried out for 48 varieties of northeastern region under the DBT project "Morphological and Molecular Characterization of Wild and Indigenous Mango Varieties of Indo-Burma Region (North- Eastern Region)".

- Characterization of 18 indigenous seedling mango varieties was carried out under the 'DUS testing of mango'.

Papaya (*Carica papaya* L.)

- At IIHR, Hesaraghatta, Bengaluru, seven intergeneric progenies (R_5P_{16}, R_6P_{16}, R_7P_{16}, $R_{14}P_7$, $R_{17}P_{16}$, $R_{19}P_1$ and $R_{35}P_{10}$) tolerant to 'Papaya Ring Spot Virus' from a population of 1008 progenies were selected and sibmated. These progenies recorded a fruit weight in the range of 622-1024.8 g, TSS of 9.2 to 12.36°B and a fruit cavity index of 3.83 to 20.5%.

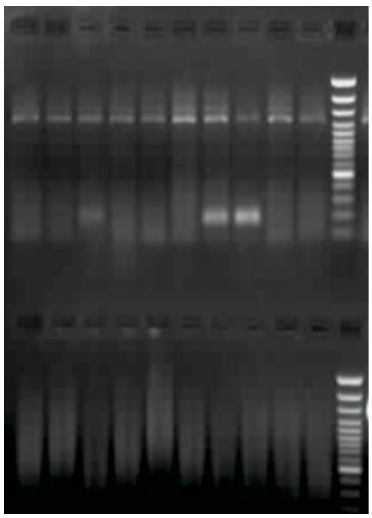
- At CHES, Hirehalli, radiation induced mutation breeding in papaya with seeds of Arka Surya and Arka Prabhat treated with different concentrations of 0,100, 200, 300, 400, 500, 600, 700,800, 900 and 1000 Gy for determination of LD 50 was carried out. Both 400 and 500 Gy were found suitable for mass radiation. The germination percentage varied from 45 to 60 for different concentrations. The treatment control recorded the highest germination percentage (87%).The treatments 400 and 500 Gy showed little difference in germination. The number of leaves was observed to be least in the concentration 500, followed by 400 Gy both at 15 days and 30 days after sowing, maximum number of leaves was noticed in the concentrations 100 and 200 Gy. Plant height and stem girth at 15 and 30 days after sowing was noticed to be maximum in the concentration 400 Gy. LD_{50} was observed at 400 and 500 Gy concentrations.

- Four high yielding stable hermaphrodite types were selected from the sibmated progenies (F_8 generation) in various crosses developed at CHES, Chettalli.

Development of transgenic papaya for resistance to PRSV

- A construct based on dsRNA to counter the silencing suppressor of three distinct strains of PRSV *viz.,* PRSV-P reported from South India & North India, PRSV-W and PRSV-R, reported from Rajasthan, the latter which has less than 85% homology to Indian strains and more than 95% homology to isolates from Taiwan has been developed synthetically. Validation of the construct has been done by electroporating heavily infected young leaves of non-transgenic papaya cultivar Solo, with the DNA of the dsRNA construct. The treated leaves as well as the newly emerging flush had extensive regions free from PRSV. The introduced DNA is expected to transiently produce dsRNA transcripts and the ensuing SiRNA is known to be replicated by the plant RdRP which then travels systemically to induce resistance.

Transiently expressed dsRNA in young infected leaf inducing disease free areas as the leaf expands



RT-PCR for coat protein of PRSV in transgenic papaya. Upper gel indicates presence of the virus in regions of the leaf with symptoms and lower gel shows no amplification indicating absence of the virus

Banana (*Musa* spp.)

Development of transgenic banana cv Rasthali for *Fusarium* wilt resistance

❖ Transgenic banana plants expressing *Ace-AMP1* gene were screened under field conditions for *Fusarium* resistance by root challenging with *Fusarium oxysporum* f. sp. *cubense* (Foc). The transgenic lines 18, 6, 7, 20 showed Percentage Disease Index (PDI) ranging from 46% to 66 % compared to control plant which showed 100% PDI. The transgenic lines 9, 7, 14, 6, 19, 20, 5 and 18 showed Vascular Disease Index (VDI) between 50 to 66 % whereas control plant showed 94 % of VDI.

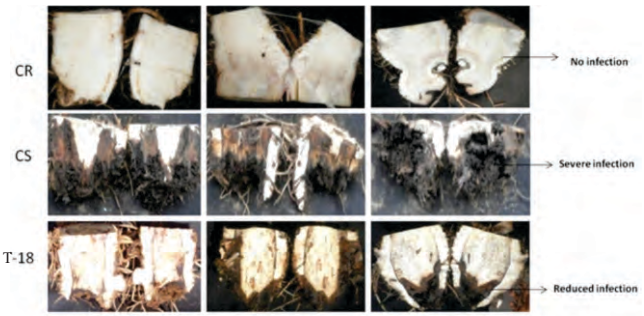


Fig: Vascular discoloration of transgenic banana cv. Rasthali root challenged with Foc race 1 under containment field. CR- Control resistance cv. Grand Nain; CS- Control susceptible cv. Rasthali; T-18 – Transgenic line 18.

Guava (*Psidium guajava* L.)

❖ At IIHR, Hesaraghatta, Bengaluru, one hybrid progeny 3-29 (Kamsari x Purple Local) was identified by 'Variety and Technology Identification Committee' of the Institute and named as Arka Rashmi. It has round fruits with pink pulp, higher ascorbic acid (235.5 mg/100 g), medium Lycopene (4.93 mg/100 g) with a TSS of 12-13°B and medium soft seeds (9.0 kg/cm^2).

Arka Rashmi.

Sapota (*Achras zapota* L.)

❖ The Seedling-7 recorded maximum yield of 13.50 kg and the Seedling-63, selected for dwarf stature recorded 5.04 kg (83 fruits).

Grapes (*Vitis vinifera* L.)

❖ **Rootstock breeding and evaluation of disease tolerant table grapes:** At CHES, Hirehalli, two inter-specific cultivars *viz.,* Frumoasa Alba (Gujalkara x Sevy Villard 2407) and Marquis (Athens x Emerald seedless) were found to be tolerant to mildews, the former for both downy mildew and powdery mildew while Marquis for powdery mildew. Further, they were also found suitable for two crop productions per year. Both have bold berries, green seeded (Frumoasa

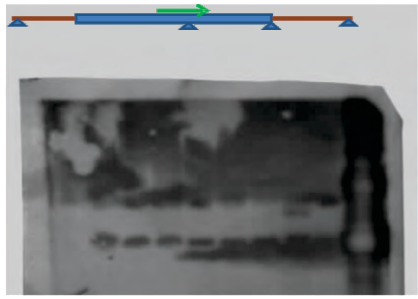
Alba) and seedless (Marquis) with attractive bunches. TSS of the ripe berries was 17-18 °Brix, acidity 0.6-0.8 % with mild muscat flavour (Frumoasa Alba) and labrusca flovour (Marquis). Both were moderate early in ripening with 110-120 days after pruning.

Pomegranate (*Punica granatum* L.)

❖ Screening was carried out in over 1000 pomegranate (Daru) progenies by repeated inoculation and spraying with bacterial (*Xanthomonas axonopodis* pv. *punicae*) suspension. Isolation of pathogen was done and fuscan pigment production and time, temperature, pH and salt sensitivity test were conducted for the identification of isolated pathogen, *Xanthomonas axonopodis* pv. *punicae.* About 150 accessions, which included cultivated, Sub-Himalayan and exotic types were screened for bacterial blight by pin-prick method of detached leaf technique. Twenty eight pomegranate lines with superior characteristics were selected from a population exposed to mutagenic treatments.

❖ **Transformation of cotyledon explants of pomegranate cv Bhagwa with plant ferredoxin like protein (pflp) gene for bacterial blight resistance:** The cotyledon explants of pomegranate cv Bhagwa was transformed with Agrobacterium LBA4404 harboring pCAMBIA2301pflp. The cotyledon explants bulged in size and produced callus at cut end after 15 to 20 days of incubation on selection medium. An average of 70% of the cotyledon explants produced callus on selection medium. After 60 to 75 days, adventitious shoot buds were observed and shoots regenerated in another 21 to 30 days of incubation. On an average 13 to 15% of shoots were observed and among them 30% of shoots rooted on rooting medium supplemented with kanamycin 100 mg l^{-1} and cefotaxime 300 mg l^{-1}. The putatively transformed plants were acclimatized in greenhouse with no morphological difference from the control plants. The presence of the transgene in putative transformants was confirmed by PCR amplification of the pflp gene using gene specific primers. The predicted size of amplification of pflp gene (450 bp) was visualized in seven out of eight T_0 plants and such banding pattern was absent in the control untransformed plant.

❖ **Genetic transformation of pomegranate for resistance to nodal blight with Xa_{21} gene from rice:** T_1 transgenic pomegranate cv Bhagwa plants carrying Xa_{21} gene were subjected to molecular analysis. Total RNA was isolated and RT-PCR was carried out. Twenty out of the 47 tested were positive for expression of the transgene. Southern blot analysis showed single copy integration in selected plants. Challenge inoclation was done five times during the year. An attempt was made to re-isolate the pathogen from inoculated regions which was then confirmed by PCR using published species specific primers. Lesion size was measured with the help of a transparent graph paper. The area around the damage caused by a pin prick turns dark brown but does not increase in size in the case of resistant plants while the lesion diameter increases in the case of susceptible. A total of 17 plants were completely resistant. When the inoculum is applied by a sprayer, without causing a prior damage, it causes a hypersensitive reaction in the resistant plants, while susceptible plants show multiple lesions which eventually cause the leaf to drop.



Southern blot analysis of selected events of T_1 pomegranate the green arrow is the region of the probe the blue arrow heads indicate the location of restriction enzyme cuts. The lower constant band indicates the presence of the transgene. The higher molecular weight bands indicate copy number. The last lane is plasmid DNA as positive control.

Disease free *transgenic pomegranate plants 21 days after being sprayed with 10^8 CFU/ml of X. axonopodis*

Annona (*Annona* spp.)

- Half sib progenies of custard apple cv. Balanagar (135 nos.) were evaluated to select the superior genotype(s) for commercial cultivation. The yield was observed to be maximum in Acc. No.1/14 (15.06 kg per plant) and fruit weight was observed to be maximum in the Acc. No.1/15 (104.3 g). Maximum TSS was recorded in Acc. No. 2/16 (27.5°B).

- Inter-specific hybridization in Annona was carried out with *Annona atemoya* (Island Gem, Bullock's Heart and Pink's mammoth) and *Annona squamosa* varieties (Balanagar, Raidurg, APK-1, Red Sitaphal, Mammoth, Barbados Seedlings, Washington 07005 and Washington 98797).

Jackfruit (*Artocarpus heterophyllus* L.)

- Evaluation of fruit quality attributes for 22 accessions revealed that the fruit weight varied from 4.35 kg in the accession G-58 to 22.00 kg in the accession G-52. The TSS was observed to be maximum (30.5°B) in the accession G-28. Flake to fruit ratio was higher in accession G-12 (0.70) and G-21 recorded the lowest (0.26).

Passion Fruit (*Passiflora edulis* Sims.)

- At IIHR, Hesaraghatta, Bengaluru, observations on vegetative characters on 43 promising passion fruit lines were recorded.

- At CHES, Chettalli, 25 accessions of passion fruit were multiplied for planting in new blocks The multiplied accessions were planted in the new block during August - September 2014.

Strawberry (*Fragaria x ananassa* Duchesae)

- One hybrid progeny of strawberry H-10/4 was identified for crispness, big sized fruits and high TSS at IIHR, Hesaraghatta, Bengaluru. Verti-grow system of production for strawberry was successfully established with soil-less culture up to four tiers.

3.2.2. Vegetable Crops

Tomato (*Solanum lycopersicum L.*)

Development of hybrids possessing multiple disease resistance (ToLCV, bacterial wilt and early blight)

- A total of ten determinate F_1 hybrids were evaluated for yield, quality and reaction to bacterial wilt. Among them, Hybrid-369 with Arka Vikas fruit type possessed triple disease resistance (ToLCV+BW+EB), whereas Hybrid-371 possessed combined resistance to ToLCV and early blight. Hybrid -373 (24 t/ha) was the top yielder on par with the ruling hybrids, Arka Rakshak and Arka Samrat. Hybrid-335 (7.8kg/cm^2) possessed very firm fruits. Hybrid-371 (PKM fruit type) recorded the highest fruit weight (97g). Hybrid-369 (Arka Vikas fruit type) recorded highest TSS (7.3 ^{0}Brix).

H-369: Arka Vikas fruit type

H-371: PKM-1 fruit type

- Twenty five indeterminate F_1 hybrids were evaluated for yield and fruit quality attributes. Highest yield was recorded in IIHR-2042 x IIHR-2834 (76 t/ha) followed by IIHR-2042 x IIHR-2856 (76 t/ha) and PH-4225 (73 t/ha). Fruit firmness was highest in IIHR-2867 x IIHR-2834 (8.7 kg/cm^2). IIHR-2835 x IIHR-2867 recorded the maximum fruit weight (200g). The five top yielding indeterminate hybrids were further evaluated during *kharif,* 2014. Among them, the most promising hybrids for yield and fruit quality are PH-6321 (42.0t/ha) followed by PH-1021 (35.7t/ha) and PH1025 (31.0t/ha). PH-6321 (8kg/cm^2) had very firm, square round, large (115g) fruits with green shoulder, whereas PH-1021 had high round, large (109g) very firm (7kg/cm^2) fruits with light green shoulder. Both hybrids possessed triple disease resistance (ToLCV+BW+EB).

PH-6321

PH-1021

Development of multiple disease resistant lines

❖ Eleven varieties were screened for triple disease resistance to ToLCV+BW+EB. BC_1F_1 26-9-2-35-5-3-7 (IIHR-2890), $BC_1F_1$26-9-2-35-8-3-3 (IIHR-2891) and Vybhav were resistant to bacterial wilt. Marker Assisted Selection (MAS) was employed for pyramiding of Ty-2 and Ty-3 genes into elite tomato lines. Among a total of 60 plants from four backcross progenies selected for marker screening, four plants were homozygous for both Ty-2 + Ty-3; all were homozygous for Ty-2 and 24 plants were heterozygous for Ty-3. MAS for Ty-2 locus was also employed for maintenance of purity of parents and hybrid seeds of Arka Rakshak and Arka Samrat.

Individual plant selections pyramided with Ty2+Ty3

❖ Pre-breeding was carried out for introgression of ToLCV resistant genes from *Solanum habrochaites*. Thirty BC_1F_4 families derived from an inter-specific cross, 15 SBSB X *S. habrochaites* (LA-1777) were screened using Ty-2 & Ty-3 markers. Twenty eight individual plant selections were made for presence of Ty-2 & Ty-3 genes in different combinations (Ty-3/Ty-3:10 plants; TY-2/Ty-2: 3 plants; TY-2/Ty-2 + TY-3/--: 3 plants, T;-3/--: 5 plants; Ty-2/--: 6 plants and Ty-2/-- + Ty3/--: 1 plant).

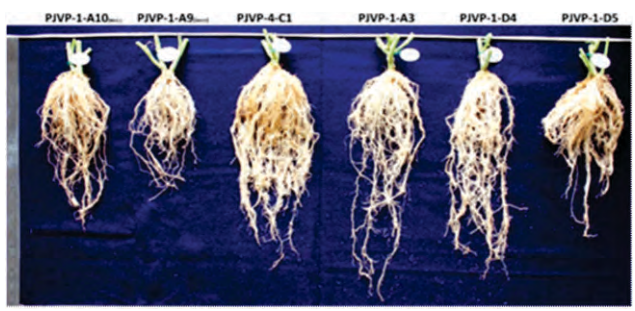
Incorporation of heat and drought tolerance

❖ As part of the NICRA project for incorporation of heat and drought tolerance, two firm fruited tomato lines (IIHR-2834 & IIHR-2835) with good general combining ability (GCA) were crossed with heat tolerant (HT) lines (CLN-3125A & CLN-3125P). Four back cross (BC_1F_2) 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 84 BC_1F_2 plants for further advancement during *rabi*, 2014. A total of 288 F_2 plants of the cross involving large fruited HT line (CLN 3125A) and drought tolerant (RF4A) line were raised and screened for heat tolerance. Seeds were collected from 219 F_3 plants for further advancement during *rabi*, 2014. Temperature Induction Response (TIR) technique was used to screen a total of five genotypes including three F_1 hybrids (H-329, H-331 and H-335), an advanced breeding line (4-4-3-3) and a wild accession (LA-1777 - *Solanum habrochaites*). Among them, H-329 and 4-4-3-3 were tolerant to high temperature stress.

❖ As part of ICAR Network project on Functional genomics in tomato, 189 RIL's (F_6) of the cross IIHR-2202 (HT) x 15 SB SB (HS) were advanced for high temperature tolerance. 108 RIL's (F_5) of the cross RF4A (DT) x 15 SB SB (DS) were advanced for drought tolerance. 300 F_2 plants of cross between 15 SB SB (SP) x LA-1777 (RP) were raised for phenotyping for early blight tolerance. M13 tailed SSR screening was done for six genotypes (LA-1777, 15 SBSB, IIHR 2202, NCEBR-4, CO-3 & RF4A). A total of 406 M13 tailed SSR primers were screened. Among them, 141 primers were polymorphic between LA-1777 and 15SB SB; 109 primers were polymorphic between NCEBR4 and CO-3; 107 primers were polymorphic between IIHR 2202 and 15SB SB; and 96 were polymorphic between RF4A and 15 SB SB.

Development of transgenic tomato

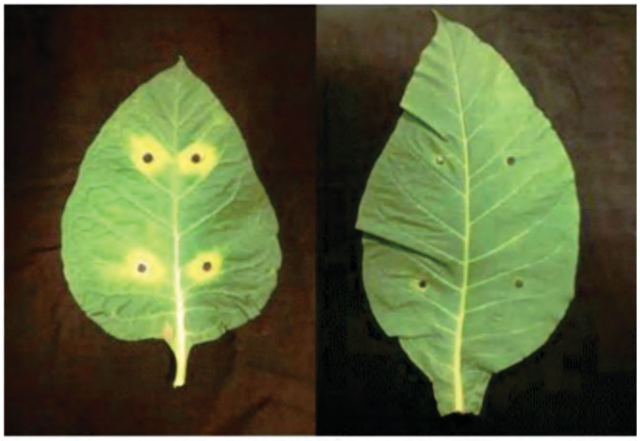
❖ In an effort for gene mining and trait based pyramiding of abiotic stress tolerance in tomato, a novel gene, PjVP1 which was cloned



Root biomass in non-transgenic and transgenic plants of tomato transformed with PjVP gene from Prosopis juliflora

from a hardy plant, *Prosopis juliflora* earlier was functionally validated by developing transgenic tomato plants that over-expressed this gene. The selected transgenic lines have shown enhanced drought and salinity tolerance compared to control plants and had higher fruit yield than the control under drought and salinity stress. Root length and root biomass increased by over 30% and 50% respectively compared to the control plants.

❖ Single gene constructs were not effective against imparting adequate fungal resistance. Therefore the strategy of multiple gene stacking with chitinase, PGIP and NPR1 genes was done, where all three cassettes were incorporated in a single vector between the right and left borders of *Agrobacterium* Ti based plasmid system, for enhanced fungal resistance. In the process of validation of multiple gene construct in tobacco, a total of 158 primary transformants were generated in all combinations of single, double and triple gene constructs using 12 gene constructs. 95/158 plants have been confirmed for the presence of transgene at a transformation efficiency of 60%. The presence and expression of the two/three transgenes in tobacco transformants with double/triple gene constructs have been confirmed in multiplex PCR and RT-PCR reaction. The double or three genes individually have been put under the expression of 35S promoter and the double and triple gene constructs comprised of individual gene cassettes driven by 35S promoter. The expression of transgenes in double and triple gene constructs alleviates the apprehension related to repression of gene expression through the use of same promoters. T_1 tobacco plants were screened against *Alternaria alternata* (brown leaf spot) and *Phytophthora nicotianae* (black shank) through *in vitro* leaf bioassay. Plants of T_1 tobacco expressing enhanced resistance to *Alternaria alternata* (brown leaf spot)and *Phytophthora nicotianae* (black shank) were identified. The results suggest that plants with triple gene construct have the potential to express enhanced tolerance to fungal resistance as evidenced by assay with *Alternaria alternata* and *Phytophthora nicotianae.*



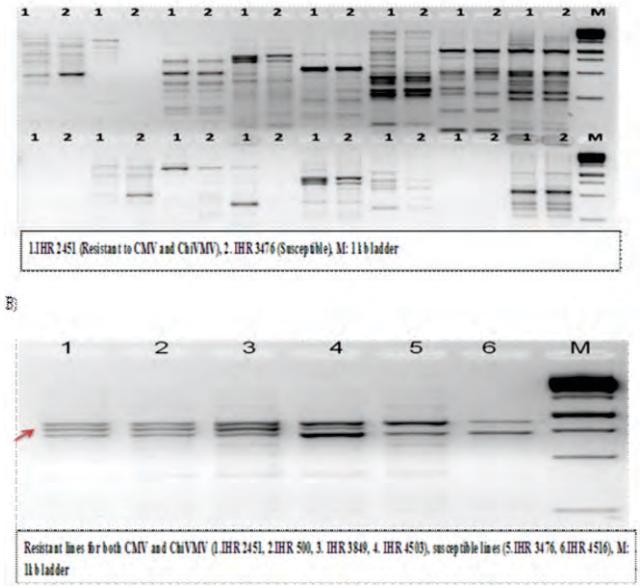
Response of control (L)and transgenic tobacco with triple gene construct (R) to in vitro leaf bioassay with *Alternaria alternata*

Response of control (L)and transgenic tobacco with triple gene construct (R) to in vitro leaf bioassay with *Phytophthora nicotianae*

Chilli & Bell Pepper (*Capsicum annuum* L.)

Breeding for biotic stress tolerance:

❖ Genetics of resistance for CMV and ChiVMV was studied. Resistance was found to be governed by polygenic recessive genes for CMV and a monogenic recessive gene for ChiVMV. Six promising populations of chilli having combined resistance to thrips, CMV & ChiVMV were evaluated and advanced. Intr-ogression of anthracnose fruit rot resistance genes from and PBC81 into cultivated types was carried out and the populations were advanced. Polymorphic RGA marker was identified for ChiVMV resistance and it showed 89% similarity with the Gene bank accession number FJ597541.1 (*C. frutescens*) of L gene. In Bell pepper, five populations with powdery mildew tolerance were evaluated.



Gel profiles of A) survey for parental polymorphism using RGAP markers B) RGA 4 showing polymorphism among the ChiVMV resistant and susceptible chilli accessions

Breeding for abiotic stress tolerance

- Among the 45 hybrids evaluated under drought stress, better parent heterosis (BPH) ranged from -95.86 to 460.57% for yield. Two F_1's, showed significant positive BPH for Instantaneous Water Use Efficiency (IWUE). Further, nine advanced populations of chilli suitable for moisture stress tolerance were also evaluated. The root length ranged from 36.65cm to 64.63cm and significant reduction was observed in the fruit biochemical traits like ripe fruit colour and pungency. Significant increase in Nor-dihydrocapsaicin content was observed in these lines.

- In Bell pepper, two heat tolerant lines (CHT 3-1 & CHT 3-2) were advanced and 15 populations with heat tolerance were developed and evaluated. Molecular markers linked to sterile cytoplasm and restorer gene were validated in four male sterile and six restorer lines.

Brinjal (*Solanum melongena L.)*

Breeding for high yield and quality in Manjarigota fruit types

- Among ten advanced breeding lines evaluated for fruit yield and quality, two pedigree selections *viz.,* IIHR438-2 x IIHR-571-5-3-1-2-7 (2.45 kg/plant), IIHR438-2 x IIHR-571-5-3-1-4-3 (2.00 kg/plant) were promising for fruit yield possessing good fruit quality in non-spiny background. Among seven advanced breeding lines derived from cross between IIHR228 x IIHR-571, one selection viz., IIHR 228 x IIHR-571-6-4-1-9-4 (1.86kg/plant) was promising for yield and fruit quality. The seeds of promising advanced breeding lines were multiplied and collected for further evaluation.

Evaluation of advanced breeding lines for resistance to bacterial wilt

- Four advanced breeding lines namely IIHR-37-36-4-4, (38t/ha) IIHR-37-36-4-20, (35t/ha) IIHR-37-36-13- 7 (32t/ha) and IIHR-37-36- 3-4 (30t/ha) were promising for high yield and resistance to bacterial wilt (0% wilt incidence) compared to susceptible check (Arka Kusumakar) that succumbed to wilt. The plants are tall and spreading with dark green foliage. Fruits are green with green fleshy calyx, medium long, and borne in clusters. The advanced breeding line, IIHR-37-36-4-4 is being evaluated under multilocational trials of AICRP (VC) in AVT-I.

- Among eight advanced breeding lines in manjarigota fruit background evaluated for resistance to bacterial wilt, two pedigree selections viz; 2BMG-1 x IIHR571-2-3-7-6-9 (2.10kg/plant) and 2BMG-1 x IIHR571-2-3-4-6-8 (1.85 kg/plant) were promising for bacterial wilt resistance compared to commercial check MEBH-10 that succumbed to wilt.

- At CHES, Bhubaneswar, 47 brinjal lines were evaluated against bacterial wilt. *In vitro* screening against bacterial wilt revealed that 18 accessions *viz.,* CHBR-1, CHBR-23, CHBR-24, CHBR-27, CHBR-28, CHBR-34, CHBR-35, CHBR-37, CHBR-2, CHBR-10, CHBR-15, CHBR-22, CHBR-18, CHBR-7, CHBR-8, CHBR-30, CHBR-31, CHBR-32 showed partial wilting while three accessions CHBR-4, CHBR-5, CHBR-6 showed no wilting.

Evaluation of segregating progenies in bottle brinjal background

- The F_4 progenies between Arka Keshav, IIHR-586 and IIHR-104 along with their backcross progenies were evaluated and individual plant selections were made based on fruit size (big fruit type), fruit shape (oblong fruit shape), fruit colour (dark purple), yield and resistance to bacterial wilt and advanced to F_5 generation.

❖ Crosses between IC0585684 X Arka Keshav, IC0585684 x IIHR-108 and IC0585684 x Rampur local giant) were made and F_1 seeds were produced in bottle brinjal fruit type with an objective of incorporating the bacterial wilt resistance into green round and oblong backgrounds.

Restoration of fertility in interspecific F_1 hybrid between *Solanum melongena* and *Solanum macrocarpon*

❖ *S. macrocarpon* was confirmed to be a resistant source for brinjal fruit and shoot borer (FSB) based on artificial challenging tests. Out of 31 entries evaluated, the interspecific F_4 plants recorded 2% shoot infestation compared to that of *Solanum melongena,* Arka Keshav and Arka Kusumakar (40-50%). 20 F_4 lines have been identified for biochemical analysis as they are directly correlated with FSB resistance. Sixteen promising entries selected from artificial challenging of F_3 generation are again being tested for resistance. These pre-breeding lines with zero borer damage and fair yield are valuable sources for breeding resistant varieties to FSB.

❖ The fertility status measured as fruit set percent in the interspecific progenies of *Solanum macrocarpon* and *S. melongena* ranged 50-70% in selfing, 53-100% in backcrossing and 81% in backcrosses with S.macrocarpon. F_2 seeds were produced successfully from reciprocal F_1 hybrids between *Solanum macrocarpon* and *Solanum melongena* by natural seed setting. Seed set ranged from 3-6 seeds/fruit in these crosses. In backcrosses, 11 BC_2 seeds were successfully obtained from two BC_1 plants. BC_2 seeds of reciprocal crosses (*Solanum macrocarpon* and *Solanum melongena*) have been produced.

Bt transgenic brinjal

❖ Previously short-listed four advanced generation transgenic lines, 2HA1-1, 2HA-1-2, 2HA-1-3 and 2HA-1-4 in Arka Keshav background were grown. Among these four lines, the line 2HA1-1 was analyzed specifically in detail and found to be resistant. Especially in six plants of this line, there was a distinct difference in resistance as compared to the control plants. Larval survival at 48h-72h post challenge inoculation was recorded and it was evident that no larvae survived on the transgenic line. Further, the finding regarding homing, vein tunneling and feeding behavioural shift observed in the neonates of FSB is remarkably novel and represents key component of initial stages of host-insect larval interactions and holds a method to unequivocally analyze insect resistance trait. This interaction model will be useful in basic and applied research.

Control (left) and Challenged Bt transgenic (right) plants of 2HA1-1 line

Okra (*Abelmoschus esculentus* (L.) Moench)

Evaluation of advanced lines of okra for yield, quality and resistance to pests and diseases

❖ A total of 116 okra advanced lines were evaluated for yield, quality and resistance to YVMV and powdery mildew diseases during summer, 2014. Two lines namely, IIHR-11-1-50 and IIHR-299-1 were found high yielding (23.54 and 27.0 kg /plot of 3.4 m^2 respectively) along with combined resistance to YVMV + powdery mildew (0% incidence). Fruits are 13.5 cm long with 1.5 cm diameter, dark green, smooth, tender and free from hairs coupled with early maturity (50 days after sowing). Other promising lines include IIHR-11-1-86 and IIHR-11-1-36 that recorded 20.0 kg yield/plot with medium fruit length and diameter, smooth, dark green fruits and free from hairs.

IIHR 11-1-50 (25.34 kg/plot ; YVMV+PM)

❖ Further, a total of 43 public sector released okra varieties were screened for YVMV resistance during summer 2014 under natural field conditions. Twenty six varieties were found free from YVMV (0 % incidence). Co-2 and Pusa Makhmali were found to be highly susceptible (47%), while Arka Anamika and Parbhani Kranti recorded moderate susceptibility.

Evaluation of F_1 hybrids for yield, quality & resistance to YVMV

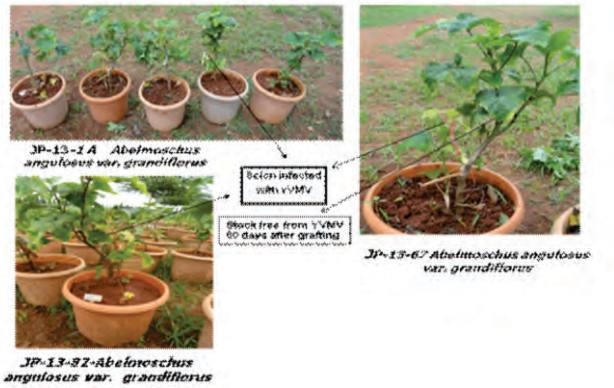
❖ Twenty five F_1 hybrids including two commercial F_1 hybrids as checks were evaluated during summer, 2014. Among them, Hyb-7 gave significantly higher fruit yield (19.23 t/ha) followed by Hyb-5 (17.90 t/ha) and Hyb -3 (16.31 t/ha), compared to the commercial check, Sakthi (14.47 t/ha). The Hyb-7 recorded a fruit length of 11.4 cm and girth of 1.3 cm. The first flower appearance was recorded on 42 days after sowing for this hybrid. Fruits are tender, smooth and dark green in colour. The top three hybrids viz., Hyb -7, Hyb-5 and Hyb-3 showed resistance to YVMV (0 % incidence) under natural field conditions. The susceptible check, Acc-1685 recorded 100 % incidence of YVMV and also symptoms started appearing early (35 days after seed sowing).

Hyb-7 *(Yield: 19 .23 t/ha)*

Hyb-5 *(Yield: 17.90 t/ha)*

Identification of stable sources of resistance to YVMV

❖ A total of 31 wild species were screened for YVMV along with highly susceptible check, Acc-1685 in an observational row trial. Among them, seven accessions of *A. caillei* and 12 accessions of *A. angulosus* var. *grandiflorus* recorded 0% incidence of YVMV, while the susceptible check ACC-1685 recorded 100% incidence of YVMV under natural field conditions. Resistant plants were selfed and seeds were collected for further evaluation. Further, artificial screening of selected okra accessions was carried out against YVMV. Ten selected accessions were grafted with pencil thickness size scion infected with YVMV on 5th June 2014 in a pot culture experiment. Among them four accessions namely JP-13-1A, JP-13-57, JP-13-66 and JP-13-82 were found resistant to YVMV with no symptoms even after two months of grafting. Remaining accessions expressed symptoms of YVMV after 30th - 60th days of grafting.



Artificial screening of selected wild accessions grafted with YVMV infected scion

Onion (*Allium cepa* L.)

Breeding for biotic stress resistance

❖ Twenty crosses were made among purple blotch disease resistant lines by crossing four male sterile disease resistant lines and seven male fertile disease resistant lines. Among them, two F_1's *viz.,* PBRMS 319 x PBRC 339 (26.50 t/ha & PDI 10.50%) and PBRMS 318 x PBRC 338 (24.80 t/ha & PDI 12.20%) were found tolerant to purple blotch disease during rainy season. Among 18 selected advanced lines evaluated for combined resistance, three advanced lines namely UKM 210-10, N-2-4-471-12-1 and PBRBC-480-10 were found to possess combined resistance to purple blotch, basal rot and white rot diseases under field conditions.

Satara local -Susceptible *PBRMS 319 X PBRC 339-Resistant*

F_1 hybrid resistance to purple blotch disease

Breeding for abiotic stress tolerance

❖ For breeding onion varieties possessing resilience to soil moisture stress, 18 advanced lines were evaluated in field and polyhouse conditions during *kharif* season. Stress was imposed by withholding water for twenty five days in field, after 30 days of transplanting under rain shelter and 8 days of stress in poly house condition in pots with the same age of the seedlings. Among these 18 lines, three advanced lines *viz;* MST 690-58-1, MST 45-40-1 and MST 32-31-3 were found resilient to soil moisture stress. Among them, MST 690-58-1 performed consistently well under moisture stress conditions with high bulb yield and qualities.

Screening onion for soil moisture stress

Genotypes suitable for processing

❖ Among 12 advanced processing lines evaluated, three lines viz., WPL 430 -155, WPL 456-160 and WPL 355-138 have been selected for dehydration. The progenies of the crosses made between Arka Swadista (18-20% TSS and 16-18% dry matter content) with inbreds of commercial lines (W-441, W-442, W-444, W-445, W-446 and W-44)7 were evaluated for processing qualities in larger size backgrounds. The progenies were found intermediate in size and quality traits. Isolation of male sterile lines in white onion background from segregating population of cross between three red genotypes (MS65, PBRBC and MS48) with inbreds of commercial white onion lines showed segregation for colour and male sterility.

Genotypes suitable for export

❖ Out of 10 multiplier (MLT) F_1 hybrids developed and evaluated, 3 hybrids *viz.,* MLT MS 89 X MLT 90, MLTMS 91 X MLT 92, and MLTMS 100 X MLT99 were found to give higher bulb yield along with good quality. The male sterile lines *viz.,* Rose-MS 601-20 with maintainer Rose-602;MLT-MS-92 of multiplier onion with maintainer MLT-B-91 and MSYL-29 of yellow onion and its maintainer lines were found stable for male sterility and fertility respectively besides improved bulb yield and qualities.

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

Carrot (*Daucus carota* L.)

Development of high carotene male sterile lines and maintainer lines

❖ Among 44 male sterile and maintainer lines evaluated, two lines namely MS 30-50 and MS 30-52 were stable for sterility and possessed deep orange root with self coloured core, smooth surface and high carotene content (16.50mg/100g). Two maintainer lines viz., MF 48-68 and MF 21-64 were found pure and stable for fertility with good root yield and quality characters. Under the programme of development of pollen parent (C line), 50 lines were evaluated and three lines viz., SL 56, SL 112 and SL114 were found promising with high TSS, deep orange root with self coloured core, smooth surface and other quality characters. Three advanced lines *viz.,* HC-12 (17.91 mg), HC-15 (17.06 mg) and HC-229 (16.55 mg & male sterile line) were found to have high carotene content with good quality characters.

Male sterile line: MS 30-50

Breeding for powdery mildew resistance

❖ Twenty five advanced carrot lines were evaluated along with the susceptible check, Nantes and resistant check, Arka Suraj. The line NL-78(8% PDI) showed resistance to powdery mildew disease compared to susceptible check, Nantes (65% PDI) and the resistant check, Arka Suraj (14% PDI). NL-78 had long roots (15cm), good root size (3.5-4cm), root weight (80g), high carotene content (15mg), deep orange, self core, cylindrical smooth roots, flowering freely and produces seeds under Bengaluru condition.

Line NL 78 showed resistance to powdery mildew disease

Garden Pea (*Pisum sativum* var. *hortense*)

High temperature tolerant lines

❖ Advanced breeding lines of the F_6 generation of the crosses (Arka Ajit x Arka Sampoorna)-12-3 x (Arka Pramodh x Oregon sugar) and (Arka Pramodh x Oregon Sugar) x Arka Priya were evaluated during summer, 2014. Among the tall types, maximum pod yield was recorded in the line IIHR-15-15 (7.3 t/ha) followed by IIHR-21 and IIHR-19 (6.9 t/ha and 6.6 t/ha respectively). Among the medium height types, maximum pod yield was recorded in IIHR-15-6 and IIHR-15-2 (6.6 t/ha and 6.0t/ha respectively). The podyield in the check variety, Magadi local was 2.4 t/ha.

IIHR 15-6 IIHR 15-15 IIHR 15-21

Selected advanced breeding lines of heat tolerant peas

Early group peas

❖ Six advanced breeding lines (F_6) of the cross between high yielding lines (IIHR-1, IIHR-18, IIHR-18 X Oregon 1-2) and early lines (10/PVAR-5 and AP3) were evaluated in replicated trial along with the check variety, Arkel during *kharif* and *rabi* seasons. (10/PVAR-5) x (IIHR-18 X Oregon 1-2)-5-13 (IIHR 15-13) recorded maximum pod yield of 4.7 t/ha and 7.5 t/ha during *kharif* and *rabi* respectively followed by (10/PVAR-5) x (IIHR-18X Oregon 1-2)-2-9 (IIHR 15-9) with an yield of 4.5 t/ha and 7.2 t/ha; and IIHR 15-6 with an yield of 4.3 t/ha and 7.0 t/ha respectively. In Arkel, pod yield was 3.5 t/ha in *kharif* and 5.8 t/ha in *rabi* seasons.

IIHR 15-13 IIHR 15-9 IIHR 15-6

Selected advanced breeding lines of early group peas

Dolichos (*Lablab purpureus*)

❖ Thirty pole type photo-insensitive advanced breeding lines (F_6) of the crosses NM04-146 x NM05-43, DOLPVAR-1 x NM05-43, NM05-43 x DOLPVAR-1, Arka Amogh x DOLPVAR-1 were evaluated for pod yield during *kharif* and *rabi* seasons. Seven high yielding advanced breeding lines *viz.,* IIHR15-5, IIHR 15-7DG, IIHR 15-7G, IIHR 15-8, IIHR15-15, IIHR 15-21 & IIHR15-23 (with pod yield ranging from 30-35 t/ha) with dark green to green colour and different pod types and photo-insensitive traits were selected.

IIHR 15-5 IIHR 15-15 IIHR 21

IIHR15-8 *IIHR 23* *IIHR 15-7DG*

Selected advanced breeding lines of Dolichos

- Six promising selections (IIHR62-1, IIHR146-IPS1, IIHR146-IPS 2, IIHR146-IPS 3, IIHR 25 IPS-2 and IIHR 105-IPS 1) with high yield and different pod types were made from *Dolichos* germplasm with yield potential of 25-30 t/ha in 120 days. IIHR 62-1 and IIHR 146-IPS1 are resistant to rust and have flat and oval pod respectively. IIHR 146-IPS3 has flat, green and broad pod. IIHR 25-IPS2 has flat greenish purple pod and IIHR 105-IPS 1 has pink pods.

IIHR 62-1 *IIHR 146-IPS1* *IIHR 25-IPS2* *IIHR 105-IPS1*

Selected Dolichos genotypes with different pod types

French bean (*Phaseolus vulgaris* L.)

Identification of a high yielding, MYMV resistant variety

- Resistance to MYMV was originally identified in an accession, IC 525260 and used for hybridization with IC 525283 (high yielding, round stringless and smooth podded). Transgressive segregants with resistance to MYMV were selected in F_2 generation of this cross and were further advanced following pedigree method. In F_6 generation, a promising line (IC 525260 X IC 525283)-07-1-6-5 with stringless, round, smooth green pods along with resistance to MYMV and high yield was selected. This was identified by VTIC for release as Arka Arjun during October 2014.

  Salient features of Arka Arjun: Plants are bushy, vigorous and photo-insensitive. Pods mature in 48 days with green pod yield of 17 t/ha in 70 days. Pods are green, stringless with smooth surface. Suitable for both *rabi* & summer seasons.

French bean variety Arka Arjun resistant to MYMV along with susceptible check and resistant plant showing pods.

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 check varieties (Arka Suvidha and Arka Anoop) were evaluated for stem fly tolerance. The yield ranged from 9.0 to 16.0 t/ha. Pod yield was maximum (16.0 t/ha) in (IC 525235 X Arka Anoop)-3 BS-1. Stem fly larvae were lower in the resistant breeding line (1.5 larvae/plant) compared to check varieties (17.8 larvae/plant).

Evolving varieties tolerant to high temperature

- Seven breeding lines of the cross IC 525224 X IC 525239 along with parents and high yielding varieties (Arka Komal and Arka Anoop) 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 maximum yield of 12.5t/ha. The yield range was 8.0 to 12.5 t/ha.

Evolving pole type varieties with resistance to rust and MYMV

- In order to improve the pod quality and resistance to MYMV in pole type rust resistant breeding lines, crossing was done between rust resistant pole type breeding lines and Arka Arjun, IIHR 231 and IIHR239. F_1 seeds have been collected for further evaluation.

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

Evolving cowpea variety resistant to rust

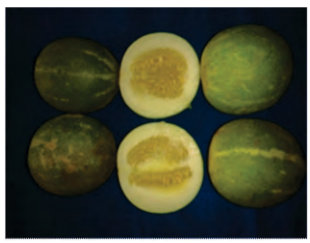
- Replicated yield trials of six rust resistant selected lines along with parents and popular varieties were carried out for resistance to rust and pod yield. The yield ranged from 14.5 to 17.5 t/ha. The maximum pod yield was recorded in the line IIHR-16 (17.5t/ha with 2.5% PDI). As the pod quality of this breeding line was more towards pulse type, crossing has been attempted with Kashi Kanchan.

Cucumber (*Cucumis sativus* L.)

Evaluation of cucumber advanced lines for yield, quality and resistance to mildews

❖ Fifteen advanced lines were evaluated during *rabi,* 2014 for yield, quality and resistance to powdery and downy mildew diseases. Among them, IIHR-Cu-1107-1/11 recorded the highest fruit yield of 3.5 kg/plant, cylindrical green fruit with fruit maturity in 38 days along with resistance to mildews (5% incidence). This was followed by IIHR-Cu-2013-68 (3kg/pl), while the check variety Swarna Agethi recorded an yield of 1.5 kg/plant with round fruit and 12% incidence of powdery mildew and 33% incidence of downy mildew diseases. Both the selected lines are free from bitter taste.

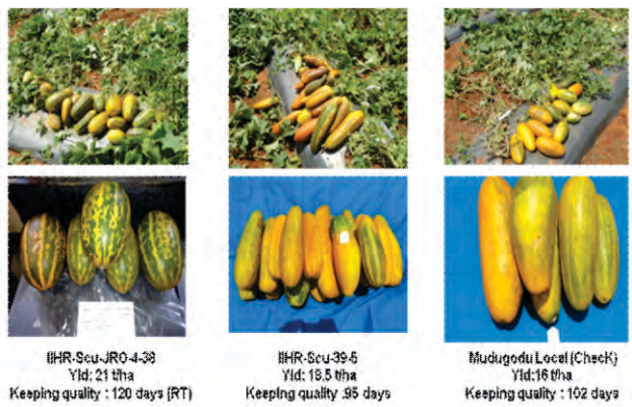
IIHR-Cu-1107-1/11,



IIHR-Cu-2013-68

Evaluation of *Cucumis melo* var. *conomon* (Samber sauthe) advanced lines for yield and keeping quality

❖ Ten vegetable types of *Cucumis melo* var. *conomon* along with local check (Mudugodu local) from KAU, Thrissur were evaluated for yield and quality during *rabi*, 2014. Among them, IIHR-Scu-JRO-4-38 gave the highest fruit yield of 21 t/ha, followed by IIHR-Scu-39-5 (18.5t/ha). However check variety, Mudugodu local recorded an yield of 16 t/ha. These accessions had more than 100 days shelf life under ambient conditions.



Evaluation of inter-specific hybrid derivatives for yield, quality and resistance to downy mildew

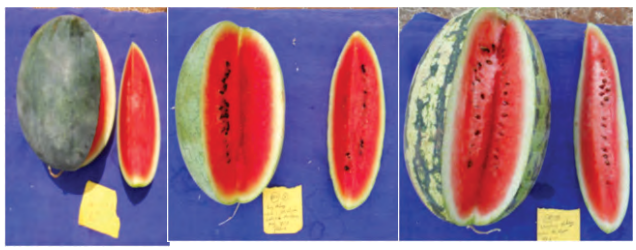
❖ Three F_2 segregating populations of inter-specific cross between wild species *C. hardwickii* X IIHR-20-10, SM-12735 X IIHRCu-81 & PCU-1 X SM -12375 were evaluated for yield, quality and resistance to downy mildew during *rabi*, 2014. An IPS from F_2 generation of (PCU-1 X SM -12375)-4 was found to be predominantly gynoecious with sequential fruiting and resistance to downy mildew.

PCU-1 X SM -12375 F_2 pt 4 gynoecious and sequential fruiting

Watermelon (*Citrullus lanatus* L. Thunb)

Evaluation of advanced lines of watermelon in icebox background for yield and quality traits

❖ A total of 6 pedigree populations in icebox background have been evaluated during *rabi*, 2014. The TSS ranged from 8.8-13.5% in dark red flesh types and 9-12.5 % in yellow-orange flesh types with different rind patterns. Selections for high TSS with dark red, crispy flesh have been made and advanced to F_4 stage. Inbred-57 (1.2kg, 11.8% TSS), Inbred-189 (1.7kg, 11.0% TSS) and Inbred-198 (2kg, 10.0% TSS) were found the most promising.



Selected icebox lines of watermelon with different rind patterns

Evaluation of Arka Manik x *C. lanatus* var *citroides* genotypes for yield, quality and disease resistance

❖ A total of 337 recombinant and backcross inbred families of this cross have been evaluated for yield, quality and *Fusarium* wilt resistance. Two back cross inbred lines 56 (8.2%TSS; 13% PDI) and 106 (8.0% TSS; 0% PDI) were selected to possess desirable characters of both parents in terms of quality and resistance.

Artificial screening of Arka Manik (left) and Arka Manik x C. lanatus var citroides derived inbred (right) for Fusarium wilt

Screening of selected lines for confirmation of WBNV resistance under natural infection conditions

❖ A total of 105 inbred lines found to be tolerant during the previous summer (2013), were evaluated in paired rows along with susceptible checks, NS-295 and Arka Manik. Three sister lines of IIHR-19 (106, 107, 108) recorded a slower disease progress compared to check varieties and set fruits and seeds while no fruits were obtained in the other lines and the check varieties. These lines shall be crossed to transfer resistance into icebox backgrounds.

❖ As the F_1's between *C. lanatus* and *C. colocynthis* (highly resistant to WBNV) were self-sterile they were crossed to inbred lines of the cross *C. lanatus x C. citroides*. More than 150 seeds were obtained. However, none of them germinated even under *in-vitro* culture conditions.

Muskmelon (*Cucumis melo* L.)

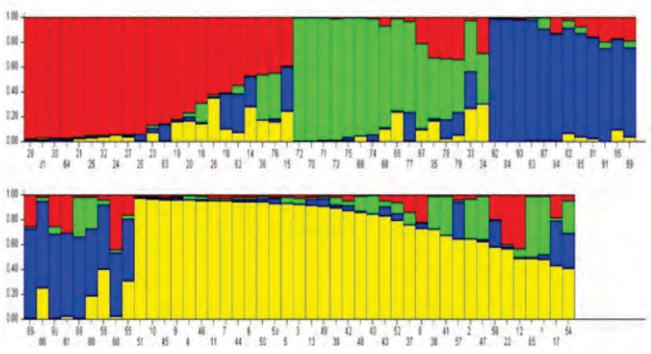
Evaluation of promising advanced lines of muskmelon for yield and quality

❖ Seventy six advanced inbred lines from four pedigree populations were evaluated during *kharif*, 2014. Among them six lines belonging to Canary yellow (39, 42 and 47), Galia (68) and Western shipper (57 and 71) backgrounds have been selected for replicated yield trials and evaluated during *rabi*, 2014. The selections 39 (Brown yellow rind, 11.5% TSS), 47 (Yellow green tinge rind, 12.0% TSS) and 24 (Shiny yellow rind, 11.7% TSS) in Canary yellow background are being proposed for release. Promising selections in other market backgrounds include Sel-306 (Galia) and Sel-288 (Western shipper)

Selected lines of muskmelon in Canary yellow, Western shipper and Galia backgrounds

Population structure of Indian melon landraces with special reference to disease and insect resistance loci

❖ The genetic diversity and population structure of Indian melon landraces was studied employing 36 SSR markers along with seven markers at disease/ insect resistance loci. Model-based structure analysis revealed the presence of four groups in Indian melons and the delineation was mostly based on geography with improved varieties as a separate group. Indian accessions possessing resistance alleles for multiple diseases have been identified.



Population structure of Indian melon landraces

Pumpkin (*Cucurbita moschata* Duch. ex Poir)

Evaluation of promising advanced lines of pumpkin for yield and quality

❖ 21 F_2 families of the cross *C. maxima x C. moschata*; 11 F_2 families in crosses made for high carotene content into different market backgrounds of *C. moschata*; 2 F_2 families in summer squash and butternut types (*C. pepo*) have been evaluated during *rabi*, 2014 and selected lines have been selfed and advanced to F_3 generation.

Selected lines of C. moschata, C. maxima x C. moschata and C. pepo (butternut)

Ridge gourd (*Luffa acutangula* (L.) Roxb.)

Breeding for yield and quality

❖ Sixteen individual plant selections have been made in four pedigree populations and advanced to F_5 generation based on multiple selection criteria viz., plant vigour, earliness, fruit weight, fruit length, fruit girth, fruit color, ridge shape and downy mildew resistance. Among the 23 hybrids evaluated during summer for yield and disease resistance, IIHRRGH-63 (42.9 t/ha), IIHRRGH-64 (38.7 t/ha) and IIHRRGH-52 (33.3 t/ha) were significantly high yielding compared to the commercial check hybrids, Naga (28.6t/ha) and Mallika (29.5t/ha). None of the hybrids were resistant to powdery mildew (PDI ranged from 38.9-77.7) and ToLCND virus (incidence ranged from 1.7-5.3 out of 0-5 scale). Out of the nine hybrids and seven parents evaluated during *kharif* for yield and disease resistance, IIHRRGH-64 (42.1 t/ha), IIHRRGH-46 (42.0 t/ha), IIHRRGH-52 (41.5 t/ha) and IIHRRGH-63 (33.9t.ha) were significantly high yielding compared to the commercial check hybrids, Naga (33.9t/ha) and Ruma (40.7t/ha). None of the hybrids were resistant to downy mildew (PDI ranged from 29.4-89.0). However, two hybrids IIHRRGH-64 and IIHRRGH-52 recorded lower incidence of powdery mildew (10.2 and 12.4 PDI respectively).

IIHRRGH-52 *IIHRRGH-64*

High yielding ridge gourd hybrids

Genetics of pollination control mechanisms

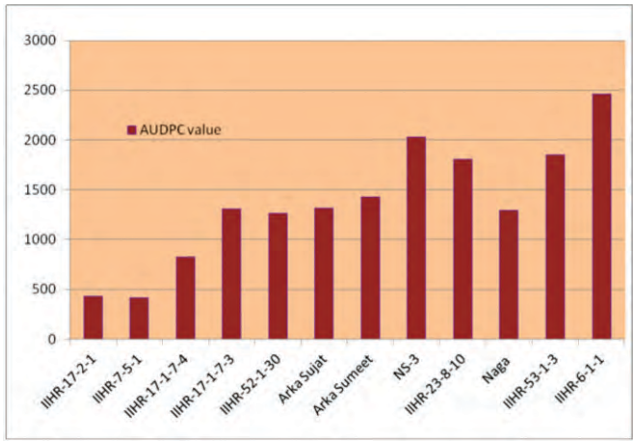
❖ Studies were carried out to evaluate male sterile and andromonoecious (AM) x monoecious (M) crosses. All the F_1 plants of male sterile x male fertile (monoecious) crosses were male sterile indicating the cytoplasmic inheritance of male sterility in ridge gourd. F_2 population of AM x M cross segregated in 3:1 ratio of M and AM plants and BC_2 population segregated in 28 M and 34 AM plants i.e., in 1:1 ratio indicating single recessive gene inheritance of andromonoecy in ridge gourd.

Andromonoecious flowers of ridge gourd

Breeding for downy mildew resistance

❖ Four downy mildew resistant advanced inbred lines, two advanced breeding lines along with six susceptible checks were screened against downy mildew during *kharif*, 2014. Among these, two advanced inbred lines,

namely IIHR-7-5-1 (PDI-10.3 and 13.6t/ha), IIHR-17-2-1 (PDI-10.1 and 10.8t/ha) were found to be downy mildew resistant consecutively for the second year with moderate yield. These two selections also recorded low AUDPC (417 and 430 respectively) and also low 'r' values (3.3 and 3.9 respectively) compared to susceptible checks, IIHR-52-1-30 (1263 AUDPC and 8.5 r values) and IIHR-23-8-10 (1808 AUDPC and 10.8 r values).



AUDPC values of ridge gourd advanced inbred lines for downy mildew disease

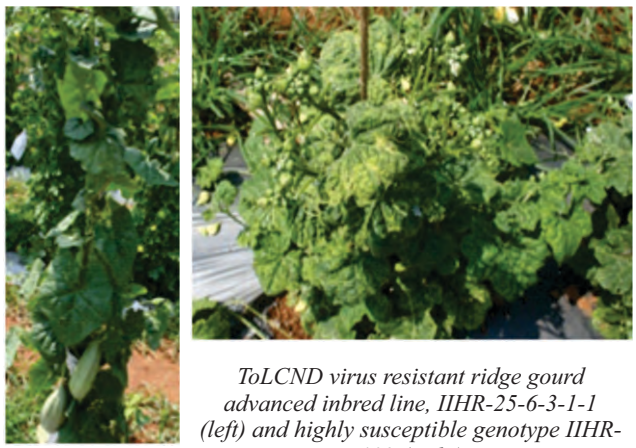
❖ To develop mapping populations for the identification of molecular marker linked to downy mildew resistance, 138 F_2 plants of two crosses, viz., IIHR-23-8-10 x IIHR-7-5-1 and IIHR-52-1-30 x IIHR-17-1-7-4 were advanced by single seed descent method. In another five BC_2F_1 populations (MR x R crosses), 27 resistant IPS were advanced for further evaluation.

IIHR-7-5-1(R) ***IIHR-23-8-10(S)***

Downy mildew resistant (left) and susceptible (right) lines of ridge gourd

Breeding for ToLCVND virus resistance

❖ Eight advanced resistant inbred lines along with a susceptible line, IIHR-102 were artificially screened with virulent whiteflies under controlled conditions against ToLCVND virus during summer. Out of these, only 11 IPS of four advanced inbred lines, IIHR-25-6-3-1-1(2,10), IIHR-25-6-3-1-2(3,4,5,6,10), IIHR-34-1-5-1-6 (8,9) and IIHR-25-2-5-1(1,8) were free from the virus symptoms throughout the crop growth period and selfed seeds of these selected plants were produced for further evaluation.



ToLCND virus resistant ridge gourd advanced inbred line, IIHR-25-6-3-1-1 (left) and highly susceptible genotype IIHR-102 (right)

Bottle gourd (*Lagenaria* siceraria (Molina) Standl.)

Evaluation of hybrids for yield and disease resistance

❖ Six hybrids, IIHRBGH-36 (53.7t/ha), IIHRBGH-30 (53.5t/ha) and IIHRBGH-10 (49.0 t/ha) evaluated during summer and, IIHRBGH-8 (77.0t/ha), IIHRBGH-36 (76.3t/ha) and IIHRBGH-10 (74.6 t/ha) evaluated during *kharif* recorded significantly higher yield compared to the commercial check hybrids, Raveena (48.7t/ha) and Ruma (48.3t/ha).

High yielding bottle gourd hybrid, IIHRBGH-10

Bitter gourd (*Momordica charantia* L.)

Identification, maintenance and hybridization of gynoecious plants

❖ Six gynoecious plants with short, dark green fruit type have been identified in two germplasm lines, viz., IIHR-61 and IIHR- 1 4 1 and were maintained by spraying silver nitrate. These gynoecious plants were crossed with the germplasm lines having different genetic background like, long/medium long fruits, dark green/cream fruit color *etc.* F_1 seeds of these crosses were collected for further evaluation.

Breeding for mildew resistance

❖ Out of the 56 germplasm selections screened for powdery mildew resistance during *kharif*, 2013, two selections, namely IIHR-143-2 and IIHR-144-2 were highly resistant with no disease incidence. At CHES, Bhubaneswar, 30 germplasm lines of bitter gourd were screened against downy mildew and all the lines were found to be highly susceptible.

Powdery mildew resistant line, IIHR-144-2 (left) and the highly susceptible line, IIHR-26 (right)

Underutilised Cucurbits

Screening for viral disease incidence in *M. suboica*

❖ At CHES, Bhubaneswar, incidence of viral diseases in Arka Neelachal Shanti (interspecific hybrid *M. suboica*) has been recorded. Out of 572 surviving plants, 97 plants were free from viral symptoms, while 339 plants had very mild symptoms. Remaining 164 plants had mild to moderate mosaic symptoms. None of the plants was found to have severe to very severe incidence. Presence of Potyvirus was also indicated by the report on identification of causal strain of the virus in the plant sap. As Arka Neelachal Shanti (*Momordica suboica*) is susceptible to virus, possibility of selection of virus resistant/free plants from the F_2 population of *M. suboica* was undertaken.

❖ A wide variability was observed in the segregating F_2 progeny of Arka Neelachal Shanti and out of 25 F_2 lines screened a line having closer resemblance to teasel gourd (F_2-MS-TG) and a line similar to spine gourd (F_2-MS-SG) have been identified. However, these two lines still retain the basic characters of *M. suboica* like natural pollination and adventitious root propagation. The fruits of F_2-MS-TG are attractive, parrot green coloured and soft seeded even after attaining 80-90 g fruit weight while its parent Arka Neelachal Gaurav becomes hard seeded when it attains 50-60g. The fruits of F_2-MS-SG are ovate light green coloured weighing around 10-15g and exactly resembles its male parent i.e. *M. dioica*. These two lines are being further evaluated at CHES, Bhubaneswar.

Variation in F 2 of M. suboica

Interspecific hybridization in *Momordica* sp

❖ The pollen fertility in BC_2F_1 derived from the cross *M. dioica* × *M. cochinchinensis* was around 62-65% and natural fruit set was recorded up to 55%. The fruit yield was 5.25 kg fruits/plant/annum. The fruits are round green soft spined weighing around 30g. BC_2F_1 was further advanced and different populations like BC_3F_1 and BC_2F_2 were developed.

DUS testing of vegetable crops for PPV&FRA registration

❖ DUS testing of a total of 84 entries in tomato, 89

entries in Brinjal and 49 entriesin okra has been carried out. Further, DUS testing guidelines have been developed and reference varieties are being maintained for chilli, cucumber,watermelon, muskmelon, pumpkin, bottle gourd, bitter gourd, ridge gourd, amaranth and palak.

3.2.3. Ornamental Crops

Tuberose (*Polianthes tuberosa* L.)

- **Breeding for quality and tolerant to nematodes:** Hybrid 1 x 6(1) and an open pollinated seedling of Shringar were identified as promising for tolerance to nematodes (*Meloidogyne incognita*). Hybrid 1 x 6(1) possesses more flowers per spike, while open pollinated seedling of Shringar has tall, straight, sturdy spikes, with upward looking florets.
- **Clonal selection from Arka Nirantara:** A clonal selection from Arka Nirantara having straight spikes has been identified and purified.

Gladiolus (*Gladiolus hybrida* L.)

- **Selection and multiplication of promising hybrids:** Six promising hybrid selections and a mutant were selected based on qualitative traits. The promising hybrid selections from orange-red group (IIHRG-3), yellow group (IIHRG- 4), red-purple group (IIHRG-6 and 7) and purple-violet group (IIHRG-12), at pre-release stage were further multiplied.
- **Evaluation of intervarietal hybrids:** A total of 701 F_1 hybrids from seven different crosses were evaluated for flower quality traits and reaction to *Fusarium* disease under field condition.
- **Identification of promising hybrid selection:** Two new hybrid selections i.e. Arka Aayush and Arka Manorama have been identified for release by VTIC. The Arka Aayush has open-faced florets, thick, slightly ruffled, double row, red (41.C) having red (41.A) margin, blotch red (46.B) with yellow (13.C) border is recommended for its flower quality and resistance to *Fusarium* wilt. The Arka Manorama has open-faced florets, medium, wavy, good, red-purple (65.B) having red-purple (62.A) streaks, red-purple (67.B) splash, is recommended for its attractive flower quality.

Arka Aayush

Arka Manorama

Rose (*Rosa* sp.)

- **Breeding for cut flower in polyhouse:** IIHR 9-6 tested under public-private partnership was found to be performing well under polyhouse and was resistant to spider mites.
- Line SG-1 was identified as better 'seed parent' for its higher seed germination ability and transfer of desirable traits of stalk length and vase life to the progeny. However, in pollen parent, it failed to transfer such desirable cut flower traits to the progeny.
- **Breeding for open field:** Line 11-2 was found to have higher production potential (1.5 kg/plant/year) in comparison with Ruby Star, Charisma, Sopha Gold and Spray Orange. Among spray roses highest yield was recorded in Button rose (5.5 kg/plant/year). Single Orange, Five Star Buttons, Muguti and Button roses were found to be yielding higher than 11-2. Shelf life of 11-2 was recorded high (4.5 days) and on par with Charisma, Single Orange and Sopha Gold.
- Based on genetic distance, varieties were classified into three groups *viz.,* Crifton Duty, Lily Merlene from group I and Five Star button and Suma from group II were identified for hybridization program.
- **Breeding for resistance to black spot:** Among the progeny lines, 11-3, 9-16, 13-16 and IIHRR 4-15-12 were found to be resistant to black spot with PDI ranged 0-0.5. Among the resistant

IIHRR 4-15-12

progenies, IIHRR 4-15-12 was identified as seed parent considering its ability to seed set, floriferous and ideal for landscape.

❖ **Breeding for resistance to powdery mildew:** IIHRR 13-4 recorded powdery mildew resistance in field consecutively for last five years, confirmed to be resistant by artificial inoculation.

❖ In order to overcome seed dormancy, attempts were made to harvest hips when they were immature and compared with seeds extracted from matured hips. Results indicated the advantage of harvesting immature hips for better germination percentage compared to delayed harvest till they mature.

Carnation (*Dianthus caryophyllus* L.)

❖ **Evaluation for quality cut flower:** The advanced breeding line IIHRCH-5 was on par with all the checks for stalk length, flower size and stem girth during the second year of evaluation. Seed setting (18-20 seeds/cross) was recorded in cross between 'Liberty' and 'Bizet', were cultured *in vitro*.

❖ **Screening for *Fusarium* incidence:** Screening varieties for resistance to different isolates of *Fusarium*, found that variety Arka Flame was resistant to IIHR isolate and susceptible to IARI C4 and Pune isolates indicating the variability in the pathogenicity of pathogens as well as resistance in the host germplasm. However, variety Arka Tejas was susceptible to all the four isolates of *Fusarium oxysproum* f. sp. *dianthi* (IARI C4, Pune-1, Pune-3 and IIHR-7) collected from Delhi, Pune and Hesaraghatta.

Gerbera (*Gerbera jamesonii* Bolus ex. Hooker F.)

❖ **Breeding for cut flower:** Forty two half-sib hybrids were initially evaluated for cut flower traits under polyhouse. Hybrids IIHR3-34, IIHR15-7, IIHR6-18 and IIHR8-1 were found promising for flower quality traits.

❖ Three IIHR hybrids with one commercially grown genotype Elite were evaluated for flower quality traits under naturally ventilated polyhouse. Hybrid IIHR-2 recorded maximum flower stalk length (60.00 cm) which was at par with Elite (62.10 cm). Hybrid IIHR-3 recorded maximum flower diameter (11.80 cm) and stalk diameter (6.80 mm).

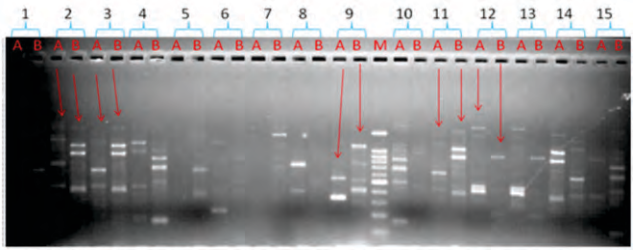
Chrysanthemum (*Dendranthema grandi florum* L.)

❖ **Breeding for quality traits:** A total of 209 open pollinated seedlings from Pink Cloud, Lalpari, Red Stone, Flirt, Autumn Joy, Shukla, Sunil, Liliput and White prolific were evaluated for their desirable flower traits. Seedlings selections 5-9, 2-13 and 2-16 were found early flowering and have attractive flower. Promising lines 5-9, 5-7, 5-10, 4-8, 9-20 and 9-12 were selected for pot culture.

China aster (*Callistephus chinensis* (L.) Nees)

❖ **Breeding for cut flower:** Ten F_1 hybrids were evaluated for quality traits for cut flower. The cross Kamini x Shashank and Violet Cushion x Shashank found promising for their flower colour and pompon type. Three purelines have been developed by individual plant selection for cut flower *viz.,* IIHR-G-13 (light purple), IIHR-CC 5-1 (purple blue) and IIHR-J-3 (pink). In pink group (10 lines), white (5 lines) and purple/violet (5 lines) were evaluated for quality floral traits. Varieties Arka Aadya and Arka Archana were DNA fingerprinted using SRAP markers.

IIHR G-13 *IIHR CC5-1* *IIHR J-3*



Gel picture representing amplification pattern for fingerprinting analysis with SRAP markers 1-15; A=Arka Aadya, B= Arka Archana, M=100bp ladder

❖ **Evaluation and seleciton from F_2 population for cut flower**: F_2 population from 10 different crosses involving IIHR varieties and purelines were evaluated. There were four distinct flower

form *i.e.* single, semi-double, pompon and powderpuff and six flower colours *i.e.* light pink, pink, brick red, white, purple and violet were recorded. Desirable selections were made for cut flower traits for further evaluation and selection.

❖ **Registration of purelines with NBPGR, New Delhi:** Four purelines namely IIHR CAH13A (INGR14048), IIHR CAJ17 (INGR14049), IIHR-35 (INGR14050) and IIHR-42 (INGR14051) have been registered with NBPGR, New Delhi for their novel traits.

Crossandra (*Crossandra infundibuliformis*)

❖ **Breeding for novel colour:** Crossandra genotypes were maintained in field. Arka Shravya was highly floriferous and was suitable for landscape. A new variant with respect to flower colour and plant type was identified for further multiplication and evaluation.

❖ **Screening for wilt disease:** Under field conditions, Arka Ambara, Arka Kanaka, Arka Shravya and Arka Shreeya were found to be moderately resistant to wilt disease in comparison with the Local variety.

Arka Kanaka *Arka Shravya*

Marigold (*Tagetes* sp.)

❖ **Male sterility:** Based on flower structure, apeatloid and petaloid types of male sterile flower types were identified, while on mechanism of inheritance, three types of male sterile system have been identified. IIHRMYS-1 (yellow) and IIHRMOS-1 (orange) GMS lines with sterile and fertile plants segregating at a ratio of 1:1. IIHRMOC-1 is gynomonoecious type with petaloid male sterile flowers and is valuable in hybrid development with cytoplasmic inheritance of sterility.

IIHRMOC-1, cytoplasmic male sterile line

Jasmine (*Jasminum* sp.)

❖ **Collection and evaluation for pollen germination media:** Ten different species have been collected. *In vitro* pollen germination media has been standardized. The media consisting of sucrose (10%), boric acid (100 mg/l) and sucrose (5%) gave 14.5% germination with average pollen tube length of 419.6 microns.

3.2.4. Medicinal Crops

Ashwagandha (*Withania somnifera* Dunal)

❖ Eight selected lines of Ashwagandha evaluated were superior (>12g/plant) for dry root yield as compared to check JA-20 with 6 g/plant in the third year of evaluation. These were superior to check for both dry root yield and withanolide content in previous two years of evaluation with withanolide content ranging from 0.316 to 0.723 %.

❖ Twenty eight F_6 families were evaluated for total withanolide content which ranged from 0.182 to 0.552 %. Considering the two important traits *viz*., dry root yield and withanolide content, eight lines distinctly superior to existing varieties were selected in F_6 and forwarded to F_7 generation. They were also superior to existing varieties in field reaction to pests and diseases.

❖ Eight advance breeding lines (F_7 populations) were evaluated along with three national checks (JA-20, JA-134, RVA-100) and Arka Ashwagandha. All the advance breeding lines were clearly distinguishable from currently cultivated varieties based on the morphological traits, especially for fruit colour (red *v/s* yellow), which will be useful for varietal identification and protection. All the advance breeding lines were distinctly superior for dry root yield (569.5 g to 1624.3 g/4m row to currently cultivated (JA-20, 206 g; JA-134, 260.5g; RVA-100, 261.2g ; Arka Ashwagandha, 432.3g/4m row).

Garcinia sp.

❖ **Evaluation for high yield:** During the current year, forty plants of *Garcinia* sp have fruited as

against 32 plants during the last year. Among these, 17 plants were of seedling category while 23 plants belonged to graft category of plants. IIHR + trees fruited maximum (11 trees) while three plants each from *G. indica* local and *G. indica* from Vengurla category have fruited. Among the graft category, maximum fruiting was observed in *G. indica* local and *G. cowa* grafted plants (6 trees in each). Red graft and Amruth Kokum trees were on the median (4 and 3 plants) while white graft –two trees fruited against a single tree in *G. cambojia* graft.

❖ Polymorphic nature of flowering was observed in trees either being male, female or bisexual. The fruit yield and the number of fruits per tree varied considerably. The mean fruit yield per tree was highest in IIHR + tree which recorded a fruit yield of 70.16 kg with 1160 fruits. The lowest mean yield of fruits was observed in *G. indica* Vengurla (9.92 kg) with 737 fruits. *Garcinia indica* local recorded the lowest number of fruits/tree (606) but its fruit yield was higher (19.02 kg). Among the graft category *G. indica* local grafts recorded the highest fruit yield per tree (11.02 kg) with 963 fruits. The fruit yield of other trees was lower than 5 kg and 4 kg, respectively.

❖ The fruits were assessed for acidity, anthocyanin content, TSS in pulp and rind including HCA content. The mean for these parameters did not vary much between fruits of seedling v/s graft category of plants. However, the white graft recorded in general lower values for most of the parameters like acidity, anthocyanin content, TSS in rind and pulp including HCA content. However, the FW to DW of rind ratio was highest in fruits of white grafts.

Mucuna sp.

❖ Promising advance breeding lines IIHR PS 10-2 and IIHR PS 10- 1 recorded higher seed yield and L-dopa content (310 g; 5.38%; 275 g; 5.03%, respectively) over the check Arka Dhanvantari. IIHR PS 10-6 (330g; 5.25%) which matures in 150 days showed consistent performance with good yield and high L-dopa content (304g, 4.82%) over the check IIHR- Sel 8 (216.65g; 4.12%). Promising selection IIHR PS 10-16, a short duration line with high seed yield and high L-dopa yield/plant (207.5 6; 4.72%) was found promising as compared to Arka Aswini (199 g, 4.60 %).

❖ Twelve high L-dopa selections isolated from different crosses (lines with non itchy trichomes/wild lines, itchy trichomes) recorded L-Dopa content upto 6.7%. The selections IIHR 12-6 and IIHR 12-9 combined higher seed yield with high L-dopa content (173.41g; 6.73%; 260g; 5.48%, respectively).

❖ **Evaluation of novel seed coat colour variants:** The variability observed among the segregating population for seed coat colours was used to isolate lines with novel seed coat colours. These seed coat colours can be used as genetic markers for maintaining the purity of lines if incorporated in the promising selections. Eight seed coat colour variants have stabilized with varied seed coat colours from light green to dark red colour. They were evaluated for seed yield and L-Dopa content. The L-dopa varied from 5.0 to 5.7% and seed yield varied from 158 to 273 g/plant.

Coleus forskohlii

❖ Promising hybrids Hy 08-129 recorded significantly higher root yield (58.93 g) over check K-8 (45.73). Hy 08-53 recorded higher forskolin content of 0.667% with a root yield of 57.33 g/plant. Hy 06-5, Hy 39-5, DHS 10 and Hy 06-8 have recorded significantly higher root yield/plant (60.67; 58.30; 58.93 and 62.10 g) over the check K-8 (52.73 g).

3.2.5. Mushroom

❖ Two wild *Pleurotus* isolates from Madhya Pradesh were evaluated for agronomical parameters. The spawn running period of pink strain (IIHR-MP1) varied from 16-25 days, pinhead production of 1-5 days, cropping cycle of 27-58 days and average yield varied from 32-130g/kg wet substrate. The sporophores were pink with eccentric stripes. IIHR-MP2 showed spawn running period of 16-21 days, pinhead production of 2-7 days, cropping period of 41-57 days and the average yield varied from 141-312 g/kg wet substrate.

IIHR-MP-1(Pink isolate)

IIHR-MP-2 (white isolate)

3.3. Crop Production

3.3.1. Fruit Crops

Mango

- **High density planting:** Maximum productivity (5.58 t/ha) in Alphonso was obtained during the fifteenth orchard year at 1,111 trees / ha (with 3m x 3m spacing) on Vellaikulamban rootstock without paclobutrazol while conventional planting density of 100 trees / ha yielded only 1.28 t/ha. All the fruit samples were free from paclobutrazol residues in their pulp and peel, following continuous application for several years in spite of its soil build-up (0.432–2.874 mg/kg). High density planting of 'Alphonso' at 1,111 trees/ha on 'Olour' rootstock with annual paclobutrazol application from fourth year at 0.250 or 0.125 g/tree/year of age, stabilized by the tenth year and gave more than five-fold increase in the productivity of fruits during the initial fifteen orchard years (94.99 and 93.95 t/ha, respectively) over the conventional planting at 100 trees per hectare on random rootstock (17.48 t/ha).

- **Intercropping:** Intercropping with cowpea, dolichos bean and red gram in pre-bearing orchards did not affect vegetative growth of different mango varieties *viz*. Arka Puneet, Dashehari, Raspuri and Amrapali.

Efficacy of paclobutrazol in mango and its residue analysis

- Paclobutrazol (PBZ) was applied @ 0.25, 0.50 and 0.75g a.i/m canopy in the collar region of plant during September in 17-years-old trees of mango var. Arka Neelachal Kesari. Application of PBZ @ 0.75g a.i was found effective in advancing flowering by 10-12 days, increasing flowering intensity (77.5%), perfect flower (26.5%) and yield (74.5kg/tree). However TSS was unaffected with the treatment.

- Under high density plantation (Y shaped trellis; spacing 3 x 4 m) PBZ was applied through three different methods; collar drench, ring method and dibble method and among the application method of PBZ @ 0.75 a.i. through collar drench significantly increased the flowering intensity (87.6%) and yield (14.2 t/ha). Whereas, KNO_3 was found ineffective in manipulating flowering in mango.

Fruiting under HDP (Y shaped trellis)

- Residue of PBZ was analyzed in soil, leaf and in panicle after three months of application. It was observed that soil application of PBZ @ 1.0 g and 0.50 g had the residue level 4.976 ppm and 1.403 ppm, respectively, whereas, leaves and panicles had no residue under different applications.

- PBZ residue was analyzed under different application methods and the highest residue (7.504 ppm) was recorded when PBZ was applied @ 1.0 g a.i through dibbling method whereas minimum (1.656 ppm) was recorded in ring application.

Canopy architecture management

- Manipulation of plant architecture in Arka Neelachal Kesari with four primary and three secondary branches was found to be the best tree architecture treatment in terms of yield (11.66 kg/tree) followed by plants with four primary and two secondary branches. However, the effect of different tree architectures on physico-chemical attributes of fruit quality were found to be non-significant.

Micronutrient management

- Field trial was conducted to study the effect of different micronutrient foliar formulations on yield and quality of mango variety Banganapalli. The results showed that application of IIHR Mango special (during flower bud differentiation, flower initiation and marble stage of fruit growth) was effective in improving fruit yield (28.54 kg/tree) and quality (TSS-18.9°B).

Optimizing water productivity

- With a view to increase water use efficiency in mango variety Amrapali, three levels of mulching (organic mulch, plastic mulch and no mulch) from fruit setting to the fruit maturity were evaluated. It was found that irrigation and

mulching has positive impact on yield. With increasing levels of drip irrigation there was increase in yield levels. Highest fruit yield (29.89 kg/tree), number of fruits (156.23/tree) and fruit weight (205 ± 19.6g) were recorded in 75% ER drip irrigation treatment followed by 50% ER. Both organic and plastic mulches have been found equally effective over no mulch in retaining soil moisture and harvesting good fruit yield with enhanced fruit quality in terms of TSS.

Development of organic production technology for mango in eastern India

- **Organic production:** In organic trial, fruit yield of mango cv. Alphonso was very poor (2.0 to 3.1 kg/tree). However, fruit quality parameters such as sugars, ascorbic acid, carotenoid and shelf life were best with 100% RDF alongwith FYM + Azo + PSB + VAM.

- Organic production technology is being standardized in mango var. Mallika at CHES, Bhubaneshwar. Highest number of fruits per plant and fruit yield per plant was observed in RDF plot. Soil quality parameters and microbial dynamics have been monitored regularly through soil testing. Soil enzyme activities which are indicative of soil microbial activities, was lowest in case of the control plot, followed by 5 kg, 7.5kg, RDF and 10 kg FYM/plots. Soil nutrient parameters were inconsistent across different laboratories. Plant growth parameters viz., plant height, TCA, CA of primary and secondary branches were higher in the treatment plots as compared to the control plot. Highest mean plant height was observed in 10 kg treatment plot (517.32 cm) followed by RDF plot treatment (510.77 cm) and the lowest plant height was in control plot (436.89 cm). Plant height is consistently higher in 10 kg plot over the last four years.

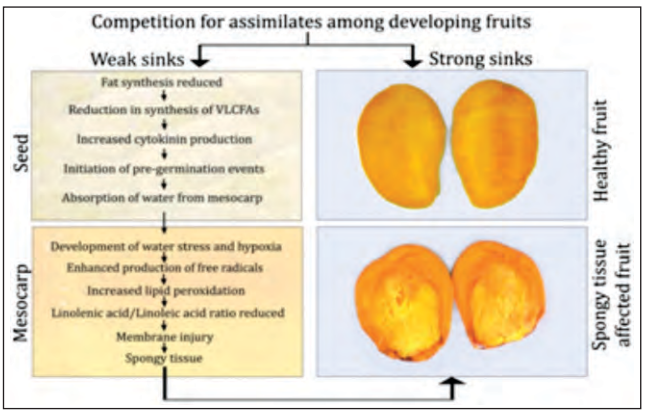
Jelly seed, a physiological disorder in Amrapali

- Seed hormones estimated by HPLC showed that the concentrations of GA_3 and IAA were higher in jelly seed (JS) affected Amrapali mango compared to healthy seed while ABA was higher in healthy seed. The activities of starch phosphorylase, amylase and acid phosphatase enzymes were significantly higher in jelly seed compared to healthy seed. Acid phosphatase is involved in the generation of inorganic phosphate needed for the action of starch phosphorylase which converts stored starch into simple sugars.

  Concurrently, the contents of total and reducing sugars in seed of jelly seed affected fruits showed an increase (70.3 and 24.1 units) compared to HS (62.7 and 20.5 units), while starch content decreased from 377.5 units in HS to 297.2 units in JS, supporting the increased rate of degradation of starch in JS seed. The activities of pectinolytic enzymes like, PG and PME were found to be higher in JS fruit pulp compared to H pulp showing that the rate of degradation of pectin was higher in JS fruit compared to H fruit which explained the jelly texture of the JS affected fruit. The calcium content of the jelly seed was higher at 379.6 mg/g compared to 238.1 mg/g in healthy seed indicating the possible migration of the element from pulp to seed during JS development. It was clearly evident from the results that germination associated events had begun in the seed of JS affected fruit.

Spongy tissue of Alphonso

- Based on crucial experimental evidence, 70% fruit maturation stage was identified as the critical phase of fruit growth at which the transition to germination occurs in Alphonso mango. Results have conclusively shown that a reduced content of seed fats during fruit growth led to a reduced concentration of Very Long Chain Fatty Acids (VLCFAs) like, tetracosanoic acid (C_{24}) and hexacosanoic acid (C_{26}). These, in turn, triggered an increased production of cytokinins in seed eventually leading to premature germination while seeds with the normal fat content produced higher level of VLCFAs and hence germination occurred after full maturity of fruit. Consequently, fruits in



which seeds showed early inception of germination events were found to be affected by the spongy tissue malady. The above finding is of paramount importance for effective prevention of ST disorder since treatment of developing fruits on the tree should be completed before the onset of seed germination events.

Vivipary

❖ The data obtained with respect to the close link existing between reduced seed fat content, lowered levels of VLCFAs and stimulation of cytokinin biosynthesis leading to premature germination in Alphonso mango, offers a satisfactory explanation for the occurrence of vivipary in mango, a characteristic phenomenon wherein mango seed shows germination during fruit ripening and storage.

Isolation of antioxidants from mango kernel

❖ A method for the isolation of kernel antioxidants from defatted mango kernels was standardized. The yield of antioxidants on dry weight basis was 10 to 12.5 %. DPPH and FRAP activities of the isolated antioxidants were 30 and 10 % more than the ascorbic acid respectively. Total flavonoids were 44.03 mg / g. Extracts were found to be stable when heated up to 200° C for 30 min and when boiled for 30 min in aqueous medium. The extracts were also stable at pH 4 and pH 9. Measurement of acidulant capacity of the extract showed that 0.1 % addition of the extract to water decreased the pH to 4. Addition of 0.15% kernel antioxidants to biscuits prevented lipid peroxidation by 62 % over control when tested after three months of storage. The kernel antioxidants also exhibited antibacterial activity against *Bacillus cereus* and *Enterobacter* strains which are common food borne pathogens.

Morpho-physiological interventions to overcome staggered flowering behaviour in Alphonso mango (NICRA)

❖ Variable responses of tree shoots to similar environmental stimuli appears to be one of the major causes of staggered flowering behaviour in older Alphonso mango trees. Observations on leaf net P_N revealed that more than 70% of the older leaves (> 6 to 8 months) on the tree were photosynthetically less efficient (-7.7 to 1.5 µ moles m^{-2} s^{-1}) compared to younger leaves (3 to 11.5 µ moles m^{-2} s^{-1}) irrespective of the month in a year. Complete defoliation of trees resulted in highly synchronized vegetative shoot formation with the primordia getting activated within 5 to 7 days irrespective of the month in a year. On the contrary, selective pruning of tertiary branches not only resulted in the loss of active primordia but also altered the canopy architecture. In defoliated trees, the newly formed leaves were photosynthetically active 35-45 days after emergence and contributed consistently to the buildup of carbohydrate reserves leading to vegetative shoot formation and synchronized flowering. Flowering occurred 30-50 days earlier compared to the undefoilated trees. Flowering was not observed in those trees which had flowered and yielded in the previous year due to their alternate bearing nature. Trees that were defoliated in 2012 flowered in the current year, but the fruit number and yield were reduced by 30 to 50% depending on the physiological status of the tree. Yield data revealed that the average fruit weight was 250g in the defoliated trees compared to 180g in the undefoilated trees.

Papaya

Optimizing productivity under salinity and drought stress

❖ NaCl- induced salinity stress in papaya (3.83 ds m^{-1}) was found to delay the number of days taken to flower and alter the sex ratio. Salinity stress increased the proportion of male plants in a population together with a decline in pollen viability. The effect was more prevalent in Red Lady than in CO-4. Under salinity stress, the ratio of female: male plants and number of fruits decreased by 21% and 36% in CO-4 and CO-61 and 37% in Red Lady, respectively. Inoculation with the endophyticmycorrhizal fungus, *Piriformospora indica* increased leaf RWC, stomatal conductance and stem diameter in control plants while offsetting the decline in salinity stress-induced plants.

❖ Drought stress in papaya cultivars increased the contents of soluble and reducing sugars with a decline in starch content.The extent of increase of soluble sugars was higher in Arka Prabhat (54.3%) and of reducing sugars in CO-4 (137.5%). The decline in starch content under drought stress was minimal in Arka Prabhat. Red Lady recorded the least increase of soluble and reducing sugars and the highest decline in

starch content. Papaya plants responded to drought stress with a consistent decline in sucrose and an increase of glucose and fructose contents. *p*-Coumaric acid, caffeic acid and ferulic acids accumulated rapidly under drought stress with ferulic acid being the most responsive to stress in cvs. CO-4 and Arka Prabhat (142.5 and 112.0% increase respectively) followed by Red Lady (62.4%).

Grapes

❖ The grape variety Crimson Seedless trained on Y trellis showed good fruitfulness during the first year of harvest.

Pomegranate

❖ Pomegranate var. Bhagwa plants grafted onto Daru rootstock were observed to be dwarf when compared with tissue cultured and air layered plants. However, fruit rind and aril colour were not affected.

Guava

❖ **Rainfed production:** Application of black polythene mulch on the sloping surface in the interspaces followed by 10 cm thick coir waste mulch in the basin retained 41 to 50% more moisture over the control after 75 days of rainfall cessation.

❖ **Planting density:** 4,000 plants/ha recorded highest vigour parameters like plant height (2.57 m), plant spread (2.04 m), plant girth (39.81 cm) and land utilization index (131.8%) while the lowest plant density (1333 plants/ha) recorded least values.

Canopy architecture management

❖ Pruning trial was conducted in headed back guava orchard, planted at different spacings (5m x 5m, 5m x 2.5m, 3m x 1.5m and 2m x 1.25m) for yield improvement and crop regulation. May pruning was found ineffective to yield winter season crop. December pruning at 70% intensity was found effective in producing more number of fruiting laterals (55-60%). An exploratory trial on branch bending was conducted for enhancing the yield in guava. Branch bending during January and February resulted into more yield improvement over the control as compared to other branch bending treatments.

Branch bending in guava for improved yield

Annona

❖ Treatment combinations involving three intensities (25%, 50% and 75% pruning of previous season shoot) and time (60 days, 75 days and 90 days after harvest) of pruning in Arka Sahan for crop regulation showed shoot emergence to be less and flowering to be more in earlier pruning but flowering tended to decrease with pruning intensity for the earlier two pruning dates.

Sapota

Corky tissue of sapota

❖ An enhanced reverse flow of water from developing fruits to young shoots under drought stress was found to be the major contributing factor for the formation of corky tissue disorder in sapota. It was significant that although reverse flow occurred under normal conditions, the process was enhanced under conditions of soil moisture stress in those fruits in which seed viability was low leading to corky tissue development. This fact explained why corky tissue occurred in only some fruits on a panicle or branch and not all fruits on a tree. Thus, the mechanism by which drought stress induced development of corky tissue in sapota fruits was firmly established by the study.

Fig

❖ The performance of two varieties of fig viz., Poona and Deanna studied under five spacings (5.0m x 2.0m, 5.0m x 2.5m, 5.0m x 3.0m, 5.0m x 3.5m, 5.0m x 4.0m) showed that growth, yield and fruit quality were unaffected by the treatments, except fruit weight in Deanna, which was maximum in the closest spacing and minimum in the wider spacing. The productivity increased with increase in planting density from 12.5 to 30 q/ha in Poona and from 25.5 to 48 q/ha in Deanna.

Coorg Mandarin

Refinement of technologies for improved productivity

- 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) on shade tree of *Erythrina lithosperma*. Simultaneously, Coorg mandarin seedling plants are also grown along with coffee (C X R) and black pepper on *E. lithosperma* as check.
- Plant height of Coorg mandarin under different treatments varied between 4.10 and 4.98 m. The stock girth varied between 43.7 and 49.6 cm while bud joint and scion girths varied between 40.9 and 45.8 and 35.2 and 44.1 cm. There was no significant effect of treatments on these growth parameters whereas the plant spread found to have significant difference with the influence of different treatments and values ranged from 3.67 to 4.13 m and 3.15 to 3.55 m for North–South and East-West direction.
- Fruit yield in budded Coorg mandarin plants varied from 12.3 to 21.2 kg/plant which was relatively higher when compared to seedling plants (12.3 kg/plant). There was no significant difference of various treatments on yield and yield contributing characters and number of fruits per plant ranged from 103.6 to 194.3.
- As regards the yield of coffee (green) and pepper (dry), coffee yield varied between 2.23 to 3.10 kg/plant and pepper yield ranged from 1.85 to 2.84 kg/plant. There was no definite trend noticed among the treatments on yield of coffee and pepper.
- Further, no significant difference was noticed in fruit biochemical, soil and leaf nutrients status of Coorg mandarin based cropping system.

Jamun

- Planting density of 4,000 plants/ha recorded higher vigour parameters like plant height (2.57 m), plant spread (2.04 m), plant girth (39.81 cm) and land utilization index (131.8%) while the lowest plant density (1,333 plants/ha) recorded least values.

Aonla

Canopy management

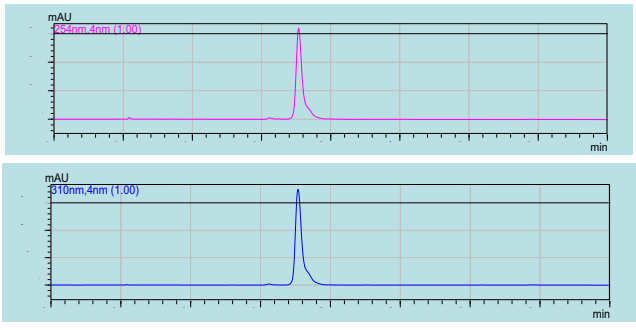
- A field trial on canopy management in grown-up aonla trees planted at 5m x 5m spacing was conducted to generate preliminary information on effect of heading back on fruiting. Flowering was observed only in July and November headed plants. Flowering was advanced by 20 days under July heading back with more number of productive branchlets ranging from 40.4% (Krishna) to 82.4% (Kanchan). However, November heading back recorded more number of female flower per branchlets ranging from 1.60 (Francis) to 8.53 (NA-6).

Jackfruit

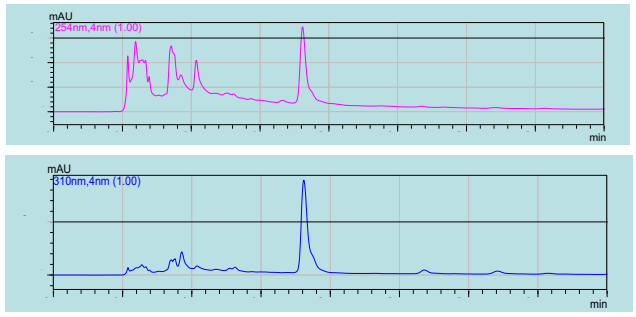
- Seedlings of the jackfruit cv. Gumless recorded higher values for plant height (4.22 m) and stem girth (46.18 cm) compared to grafted plants. Flowering was observed in *A. hirsuta* and seedling trees.

Effect of inflorescence rot on fruit set

- There is a myth that inflorescence rot in jackfruit severely affects fruit set. Studies on flowering behaviour indicated that the rot of inflorescence (spike) due to *Rhizopus* was limited to male spike only, whereas female spike were not at all affected by *Rhizopus* rot at



Standard Caffeic acid



Caffeic acid from jackfruit flower

any stage of maturation and ensured 100 per cent fruit set. The pollen dehiscence phase was followed invariably by the decay of male spike caused by *Rhizopus* rot. It is confirmed that though *Rhizopus* rot causes decay of all male spikes, pollen production is not affected. The biochemical analysis of infected male spike and female spike was also done to investigate active defense system which indicated variation in the caffeic acid content.

Factors influencing pollination and bee production

- *Apis cerena, A. dorsata, A. florea* and *Tetragonula* sp. were observed on rambutan. There were no butterflies, ants, syrphids found on rambutan flowers. *A. florea* was predominant pollinator observed in this crop.
- The peak foraging hours for *A. florea* was from 8.00 am to 12.00 pm noon at mean number of 3/ bunch/5minutes. *A. cerena* and *A. dorsata* were observed at lower numbers with a peak foraging hours between 6.00 am to 9.00 am. *Tetragonula* sp. was also observed at lower numbers (0.7/panicle/5minute) from 8.00 to 14.00 hrs.
- In Avocado flowers A. *cerena, A. florea*, *Tetragonula* sp. were found to be the main pollinators excluding *A. dorsata.* Along with dipteran flies, syrphids, coleopteran beetles, ants and wasps were found on avocado flowers. Peak foraging period for *A. florea, Tetragonula* sp. was from 9.00-12.00 hrs. *A. cerena* starts foraging from 6.00hrs in the morning and continues till 12.00 hrs.
- Dipteran flies and syrphids form the major group observed on avocado flowers during this period. Peak foraging hours starts from 9.00 to 12.00 hrs, with an average number of 15 syrphids/bunch. Coleopteran beetles, ants and wasps were found at lower numbers.

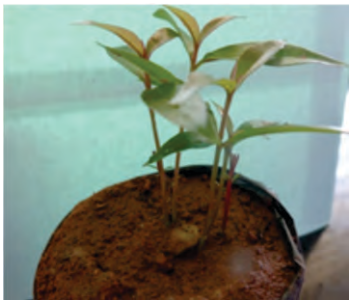
Underutilized fruit crops

- Propagation technique has been standardized at CHES, Bhubaneswar for elephant apple (*Dellinia indica* L.), rose apple (*Syzygium jambos* Alst.), watery rose apple (*Syzygium aqueum* Alst.) and star gooseberry (*Phyllanthus acidus* (L.) Skeel). In *Dellinia* the maximum success in terms of rooted layers (84.5 ± 3.8%) was obtained when 8-10 mm thick branch was air layered during July 16 to August 16 and Rootex-G was applied. The maximum success in terms of rooted layers (72.4 ± 4.2%) was obtained in rose apple when air layering was done with Rootex-G during July 1 to August 1 in 8-10 mm thick branch. During this period layers took minimum days to initiate primary root (34.5). In watery rose apple the maximum success (78.5 ± 3.4) was recorded when air layering was done with rootex-G during July 1 to August 1. The optimum shoot thickness for air layering was found to be 6-8 mm. By layering during this period, root initiation started after 31 days. In star gooseberry, layering in 10-12 mm thick branch during July 16 to August 16 with Rootex-G gave the highest success (78.4 ± 3.8) and took minimum days to initiate primary roots (31.5).

Rooting in watery rose apple

Polyembryonic behavior of rose apple

- Polyembryonic behaviour in *Syzygium jambos* was studied to understand their significance in plant propagation. Apomixis in *Syzygium jambos* was characterized by autonomous adventive embryony which in turn gives an indication of fertilizer-independent endosperm formation to nourish developing embryos. It is a highly polyembryonic species with the average clutch size of 3.24. The morphotypes ranged from duplets to sextuplets; however triplets were most frequent with the intensity of more than 1/3rd of the seed population.



Multiple seedlings in S. jambos

Grafting technique in custard apple and tamarind

❖ Grafting technique in custard apple and tamarind has been standardized. In custard apple var. Arka Neelachal Vikram grafting (wedge) of 15-20 cm long scion containing 8-10 active buds at the height of 20 cm between mid-December to mid-January gave the maximum success (76.5%). *In situ* grafting gave better graft success (88.6%) and had better plant growth. In tamarind, grafting (wedge) of procured semi hard scion at 20-25 cm height during November gave better graft success (62.8%).

Graft success in custard apple

❖ Experiments of standardization on multiplication methods revealed that cleft grafting was found successful in passion fruit. The multiplication of karonda through cutting was not found successful. The multiplication of Malayan apple through hard wood cutting gave 26 percent success.

3.3.2. Vegetable Crops

Tomato

❖ **Summer cultivation under net-house:** Five tomato hybrids were grown under cost effective net house during summer season of 2014. Indeterminate hybrid Valaro-RZ recorded highest yield (173.2 t/ha) followed by determinate hybrid Arka Rakshak (141.1 t/ha).

❖ **Rain-shelter cultivation:** In peri-urban Bengaluru, about 50 per cent of the annual rainfall occurs during the months of July to September. As a result of continuous wet spell crop suffer from the foliar diseases and saturated soil moisture conditions. To overcome this situation an experiment was conducted to study the effect of rain protection through rain shelter and different levels of fertilizers on growth and yield of hybrid tomato, Arka Rakshak during *kharif* 2014. Rain shelter grown tomato recorded significantly higher yield (95.4 t/ha) compared to open field cultivation (80.5 t/ha).

❖ **Shade net cultivation:** The experiment was conducted during summer season of 2014 with three coloured shade nets (white, green and red) and two percentage of light cut (50 & 30 %) in hybrid tomato, Arka Rakshak. Highest yield of 88.1 t/ha was observed in 30% cut white shade net, which was on par with control, 30% cut red shade net and 30% green shade net. However 50% cut shade nets produced more vegetative growth and yields were significantly lower compared to control (85.4 t/ha).

❖ **Field phenotyping of tomato genotypes under moisture deficit stress (NICRA)**: Among ten tomato genotypes, namely RF4A, 2338, 433, 53752, SH-1, LA1 777, 15SB, 833, Pusa Ruby and Arka Rakshak screened under moisture stress imposed at flowering and fruiting stages, genotypes SH-1 and LA1 777 performed better while 15SB showed better pollen germination.

❖ **Responses of tomato grafts to moisture deficit stress:** Response of plants of cv. Arka Rakshak grafted over hyb SH-1 and brinjal rootstocks showed improvement in plant performance over BMG-1 under limited water stress (8 -10% soil moisture).

❖ **Bio-priming with bacterial consortium under water stress (NICRA):** Bio-priming with *Citricoccus zhacaiensis* B–4, an osmotolerant actinobacterium isolated from banana rhizosphere on mannitol supplemented medium (-2.92 MPa osmotic potential). improved the percent and rate of germination of onion seeds (cv. Arka Kalyan) and seedling vigour at osmotic potentials up to -0.8 MPa and is therefore, suggested as a viable option for promotion of onion seed germination under drought stress.

Chilli and Bell pepper

❖ **Organic farming:** In chilli hybrid Arka Meghana, the treatment substituting 100 per cent recommended nitrogen through farm yard manure recorded dry chilli yield of 2.71 t/ha followed by 75 per cent nitrogen through FYM (2.61t/ha). However, integrated system involving FYM, chemical fertilizers and plant

protection chemicals recorded significantly higher dry chilli yield of 3.84 t/ha compared to all the organic treatments.

- **Diatomaceous earth (DE):** It is a natural Silica source which in association with applied chemical fertilizer, is capable of enhancing fertilizer use efficiency by the vegetable crops. To assess its performance, trials were carried out during *kharif,* 2014 with chilli hybrid Arka Meghana. In general, dry chilli yields were higher with FYM+NPK+DE application treatments (2.14-3.15 t/ha) as compared to only FYM, NPK and DE applications. On the basis of performance, application of 100 % RD of NPK + FYM + DE (150 kg) has performed better in terms of dry chilli yield (3.15 t/ha).

- **Fertigation under protected cultivation:** Eight bell pepper hybrids were raised in a naturally ventilated polyhouse with six fertilizer treatments. NPK fertigation with Water Soluble Fertilizer @ 200:150:200 kg N: P_2O_5: K_2O/ha recorded significantly higher yield (103.7 t/ha) compared to other fertigation treatments. Among the colour capsicum hybrids tested, Triple star and Inspiration (red), Sunny and Bachata (yellow) recorded significantly higher yields (94.9 to 102.7 t/ha) compared to regularly grown hybrids i.e. Bomby and Orobelle (78.2 & 84.6 t/ha)

- **Root stock studies**: Green capsicum hybrid Indra was grafted on seven chilli cultivars during June 2013 and was transplanted inside a nylon net house during last week of August, 2013. The main objective was to manage the bacterial wilt, nematode and *Phytopthora* collar rot in capsicums in polyhouses. The graft success was found to be above 90 per cent. Net house grown grafted green capsicum hybrid Indra on chilli rootstock gave significantly higher yield (115.4 t/ha) compared to non-grafted Indra hybrid (103.6 t/ha). Pungency and other quality parameters were on par in grafted and non-grafted capsicums. However, Inter-generic grafting of bell pepper with wild species of tomato and brinjal was not successful.

- **High Temperature in capsicum:** Four genotypes of capsicum, Arka Gaurav, Arka Mohini, PBC 848 and CHT 3 were studied under different temperature conditions using temperature Gradient Tunnel, Controlled Growth Chamber and natural environmental conditions. The maximum and minimum temperatures varied from 20 to 36 °C under natural condition, 20 to 37 °C under TGT and fixed at 36/26 °C day/night under controlled growth chamber. Pollen formation was not observed at 36/26 ^{0}C, Day/ Night.

Okra

- **Optimizing water productivity and nutrient management:** In fertigation trial on okra (Arka Anamika) during *kharif* season, weekly application of 100 % dose of NPK (180:120:120 kg/ha) through water soluble fertilizers has resulted in highest yield (22.81 t/ha) followed by biweekly application of the same amount of nutrients through water soluble fertilizers (21.87 t/ha). Reducing the dosage of NPK fertigation by 25 per cent did not reduce the yield substantially in comparison to 100 % NPK application weekly or biweekly basis through water soluble fertilizers. The use of common fertilizer as soil application or through fertigation (50 % NK) resulted in lower yields compared to all fertigation treatments with water soluble fertilizers.

Onion

- **Diatomaceous earth :** A trial was conducted during *Kharif* 2014 to assess the effect of diatomaceous earth as a source of silicon alone or along with chemical fertilizers in onion variety Arka Kalyan. Higher bulb yields were observed with recommended dose of FYM + NPK application with or without DE as compared to other treatments. Highest bulb yield of 44.3 t/ha was recorded with recommended FYM+NPK and DE application @300 kg/ha.

- **Ultra drying for seed storage:** In onion cvs. Arka Kalyan and Arka Niketan, both ultra-dried seeds (≈ 3% moisture content) and seeds with moisture content of 5.2% maintained germination and vigour even after 50 months irrespective of storage temperatures (ambient and at 15 ^{0}C). The germination was above 90% in both varieties.

Watermelon

- **Precision farming in Icebox water melon :** Ice box watermelon hybrid Sugar queen grown during summer 2014 (65 days duration) recorded significantly highest yield (53.2 t/ha) when the precision farming practices were followed compared to furrow irrigation

(35.6 t/ha). The precision farming practices included are: Seedling raising using protray and transplanting, raised bed method of cultivation, drip irrigation, fertigation, polyethylene mulching and foliar nutrition.

Cucumber

❖ **Optimizing water productivity and nutrient management :** In a fertigation trial on cucumber (Vaani), irrespective of the dosage (100 & 75 % of RDF) and frequency (weekly & biweekly) the application of NPK through water soluble fertilizer resulted in higher yields (55.44 - 62.83 t/ha) than other treatments. Weekly application of 100 % dose of NPK (75:56:75 kg/ha) through water soluble fertilizers resulted in highest yield (62.83 t/ha) followed by bi weekly application of the same amount of nutrients through water soluble fertilizers (58.97 t/ha). The soil application of the nutrients recorded significantly lower yield compared to all other treatments (37.49 t/ha)

❖ **Seed vigour :** Proteome wide characterization of viable and non-viable seeds in relation to seed vigour was studied in cucumber. Results revealed that viable seeds showed upregulation of proteins which mostly involved in metabolism and energy transfer whereas non-viable seeds showed down regulation of proteins mostly stress related and pathogen defense. Besides, proteins like isocitratelyase, methionine t-rna ligase were not found in non-viable seeds. In seed priming studies, Q-PCR analysis clearly showed significant upregulation of ICL gene upon priming when compared to unprimed seeds indicating that isocitratelyase gene plays a pivotal role in seed vigour of cucumber seeds.

Pole bean

❖ **Organic farming:** Production practices for pole type French bean have been standardized. Treatments involving synthetic chemicals recorded an average yield of 16.6 t/ha compared to organic treatments that produced marginally lower yield (15.5 t/ha).

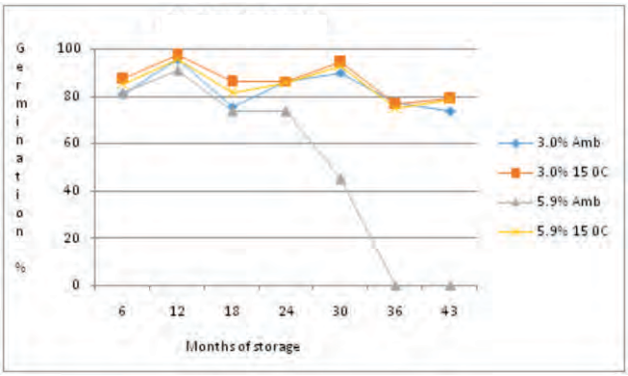
Iceberg lettuce

❖ **Protected cultivation:** Iceberg lettuce variety Raider, Grishma and Balmoral were grown in a naturally ventilated poly house during early summer (March to April 2014). Among the varieties, Raider recorded significantly higher yield (22.0 t/ha) compared to other two varieties. Among the three spacing compared (75 x 30 cm, 75 x 45 cm & 50 x 30 cm), spacing of 50 x 30 cm has found to be the best (28.2 t/ha).

3.3.3. Ornamental Crops

China aster

❖ **Ultra drying for seed storage :** In China aster cv. Arka Kamini, seeds with normal moisture (5.9%) and stored in ambient conditions showed zero germination whereas seeds at 15^{0}C maintained original germination irrespective of seed moisture content. Ultra dried seeds maintained high germination (74%) and vigour even under ambient conditions but showed sign of decline when compared to controlled temperature storage (germination 79 %) after 43 montths.



Seed germination as affected by seed moisture and storage temperature over 43 months of storage in China aster cv. Arka Kamini

❖ **Foliar application for seed yield:** Foliar application of mixture of micronutrients *viz.,* $ZnSO_4$, $CuSO_4$, $MnSO_4$, $FeSO_4$, ammonium molybdate and boric acid @ 0.5% sprayed three times at 15 day intervals starting from 45 days after transplanting resulted in the highest seed yield (294.12 kg/ha) in China aster cv. Arka Kamini. The control recorded the lowest seed yield (149.02 kg/ha). Foliar application of any of the micro nutrients and their mixture did not affect seed quality.

Cut foliage - Leather Leaf Fern

❖ **Substrates and nutrient scheduling**: The substrate combination of cocopeat + soil + vermicompost (1:1:1 v/v) + 2% Arka microbial consortium (AMC) along with application of N

and K at bi-monthly intervals in 6 equal split doses to the substrate @ 100:30:60 kg NPK/ha/year produced maximum number of cut foliage/plant/month (10.94), length of lamina (30.13 cm), length of stipe (24.28 cm), length of frond (54.27 cm), width of frond (25.24 cm) and benefit cost ratio (1.97) in Leather Leaf Fern *(Rumohra adiantiformis*). During the rainy season (July to October), the cut foliage of Leather leaf fern had the longest mean vase life (44.2 days) and shortest (28.9 days) during winter (November to February) in distilled water under room condition. Analysis of chemical and biological properties of the substrates revealed that cocopeat + soil + vermicompost (1:1:1 v/v) + 2% AMC recorded near neutral pH (6.43), EC (0.85), maximum Fe (60.42 ppm) and Zn (68.88 ppm) contents. Microbial population in the rhizosphere ranged from 10^4 to 10^6cfu g^{-1} after three months of inoculation and higher colonization was recorded by fluorescent *pseudomonads* followed by *Azotobacter* and phosphate solubilizing microbes.

❖ Photomorphogenic effect of colour shade nets on leather leaf fern indicated that plants grown under red shade net recorded maximum production of leaves/plant/month (10.58), length of lamina (22.52 cm), length of stipe (17.29 cm), diameter of stipe (1.82 mm). Maximum photosynthesis rate was recorded in plants grown under white shade net (4.81m moles (CO_2) $m^{-2}s^{-1}$) which was on par with red shade net (4.28 m moles (CO_2) $m^{-2}s^{-1}$).

Philodendron 'Xanadu'

❖ **Production and quality under coloured shade nets:** Plants of *Philodendron* 'Xanadu' grown under white shade net recorded maximum production of leaves/plant/month (38.06), which was on par with green shade net (34.22) and black shade net (29.22). Plants under green shade net recorded maximum length of stalk (21.16 cm) and width of lamina (5.23 cm). The highest Phyllocron (4.34 leaves/plant/month) which was on par with white (3.74 leaves/plant/month) was also under the green shade net. Photosynthesis rate was maximum in red (9.38 m moles (CO_2) $m^{-2}s^{-1}$) and was on par with white (9.28 m moles (CO_2) m^2s^1) and green (8.73 m moles(CO_2) $m^{-2}s^{-1}$) shade nets.

3.3.4. Medicinal Crops

Coleus

❖ A field experiment with date of planting and harvesting at different stages was carried out during *kharif* in *Coleus* variety K8. Planting in September and harvesting 180 days after planting has produced maximum dry tuberous root yield (1849.0 kg/ha) with forskolin content (0.712%) and yield (13.16 kg/ha).

Ashwagandha

❖ Variety JA 20 was sown at monthly interval during *kharif* season. The maximum root yield of 272.46 kg/ha and seed yield of 227.0 kg/ha was obtained with July planting.

Kalmegh

❖ In organic trial in Kalmegh, planting was done at monthly interval during *kharif* season. Harvesting at 120 days after planting and subsequent three ratoons (monthly interval) produced maximum dry biomass of 1788 kg/ha with August planting.

3.3.5. Mushroom

❖ The optimum conditions for pure culture growth and maintenance of *Hericium erinaceus* was temperature of 25±2°C , PDA, PMA and MEA media and pH of 5.5 to 7.0. Fructification was obtained on paddy straw, paddy straw powder, sawdust, Shiitake SMS and decomposed coir waste. The nutritional analysis of this mushroom showed 24.39 % protein and 41.5% carbohydrate (dry weight basis). This species is rich source of amino acids leucine, isoleucine and tryptophan, Vitamin B, iron, potassium and zinc. The antioxidant values of DPPH and FRAP was 2.0 and 2.31mg ascorbic acid equv./g dry weight

Culinary medicinal mushroom Hericium erinaceus

❖ Water requirement and time for substrate preparation could be effectively reduced by 71.42 and 80% respectively by reducing the straw particle size. It also led to better energy efficiency.

Effective input water management through reduction of substrate particle size

Biofortification of substrate for production of iron rich mushrooms

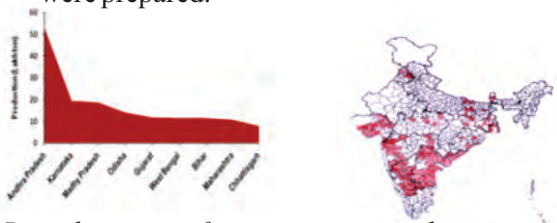
❖ Fortification of the substrate with Ferrous sulphate (0.05%) resulted in enrichment of *Hypsizygus ulmarius* (Elm oyster mushroom) by 39-45% with iron as compared to control. There was no impact on yield or other agronomical parameters due to iron enrichment. The bio-availability of iron from iron-enriched mushrooms was 21.67% as compared to 17.72% from normal mushrooms and 13% from control without mushroom. There was reduction in weight gain by 20.7- 27% when normal mushroom and iron enriched mushroom was fed to rats as compared to control.

3.3.6 Soil Health Management

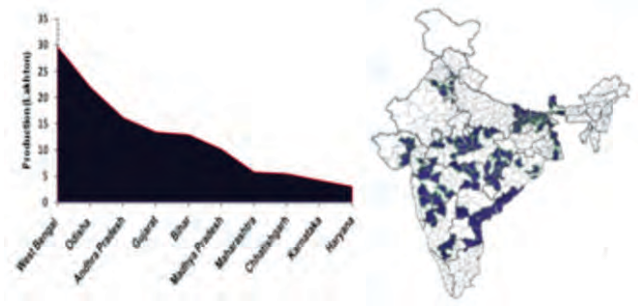
Micronutrient related constraints in fruits and vegetable crops for correcting nutrient imbalances

Development of boundary maps for Solanaceous vegetable crops

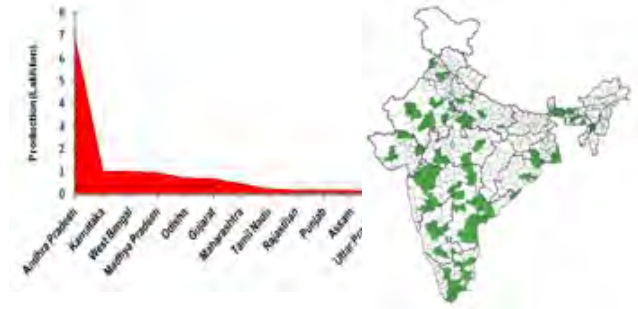
❖ Area and production data pertaining to tomato, brinjal and chilli was collected. Data was categorized based on region in different agro-ecological zones and identified potentially growing states with respect to production. District-wise area and production data was categorized based on consecutive last five year production information from published data. Boundary maps for tomato, brinjal and chilli were prepared.



Boundary map of prime tomato producing states



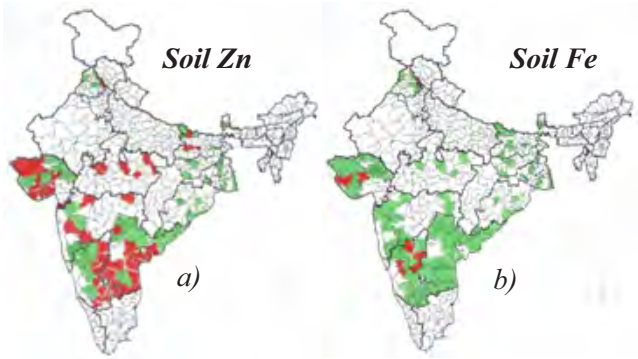
Boundary map of prime brinjal producing states



Boundary map of prime chilli producing states of India

Development of crop based micronutrient delineation maps

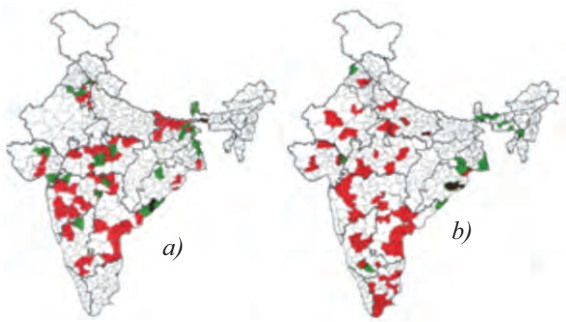
❖ Information on micronutrients status of soils (district-wise) was collected from published reports. Nutrient deficiency/ sufficiency levels in each district were identified. By superimposing boundary map with nutrient status, district wise nutrient delineation maps for tomato, brinjal and chilli were prepared.



Deficient area - Predictable response to application

a) District wise zinc delineation map for tomato
b) Iron delination map for tomato

❖ One hundred thirty six districts were identified as prime tomato producing districts from nine states. Fifty six districts (44%) were found deficient in zinc. Predictable response to Zn application by tomato especially in sandy loam soils of Andhra Pradesh was high. Nearly 55-60 p e r cent soils in twenty eight districts showed zinc deficiency.



Deficient area -
Predictable response to application

a) Zinc delineation map for Brinjal
b) Zinc delineation map for Chillies

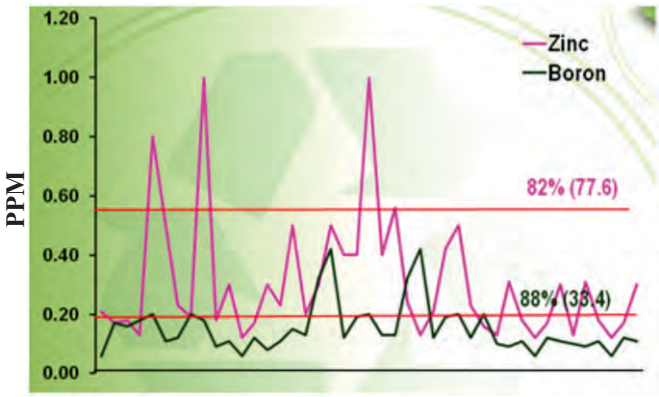
❖ One hundred and forty three districts were identified as leading brinjal producing regions from ten states. Among them ninety six districts (67%) under brinjal were found deficient in zinc. Predictable response to applied Zn by brinjal was up to hundred per cent in Andhra Pradesh, Bihar, Maharashtra and Madhya Pradesh.

❖ In chillies, 116 districts identified as prime chilli producing districts from twelve states. Nearly 84% of areas under chillies were found deficient in Zn. The extent of Zn deficiency under chillies varied from 50-65 per cent in Andhra Pradesh, about 75 per c e n t in Uttar Pradesh and Tamil Nadu and 45-50 per cent in Madhya Pradesh, Gujarat and Maharashtra.

❖ Generating database on soil micronutrient status especially for delineation of micronutrient deficiencies and superimposing specific crop area helped in prioritizing the micronutrient need of the fruit and vegetable crops.

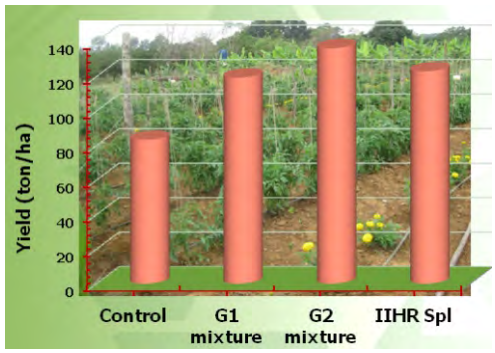
Development of soil test based foliar micronutrient formulations for solanaceous vegetable crops

❖ The survey conducted in Bangalore rural district of vegetable growing fields indicated that the magnitude of zinc and boron deficiency was high and deficiency of these elements was fairly wide spread although the concentration of individual micronutrient elements varied widely.

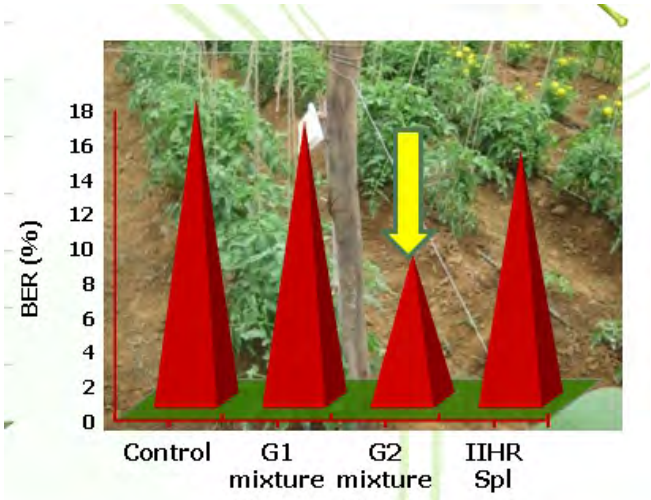


Zinc and boron status in vegetable growing soils of Bengaluru rural

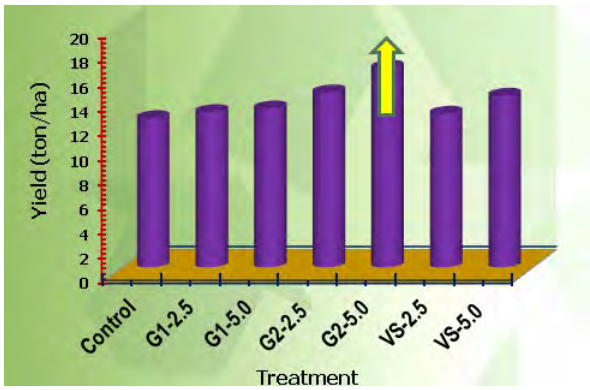
❖ Considering the status of micronutrients in soils and predominate disorders in solanaceous vegetable crops, two grades of multi-micronutrient mixtures (G1-Grade 1: Zn 3%, B 2.4%, Mo 0.0025, Cu 0.2%, Fe 0.2% $MgSO_4$ as filler substance; G2 – Grade 2: Zn 4%, B 3.2%, Mo 0.0025, Ca and Mg as filler substance) were prepared and evaluated with Arka vegetable special. Application of G2 micronutrient mixture at 5g l^{-1} resulted maximum fruit yield in tomato (136.3 t/ha.) and it was found considerably superior compared to Arka vegetable special. The highest yield of brinjal (16.54 t/ha.) and chillies (11.48 t/ha.) was recorded in the plots (15 sq. m) sprayed with G2 mixture at 5 g l^{-1}. The response of okra and ridgegourd to application of G2 mixture was also superior as compared to other treatments.



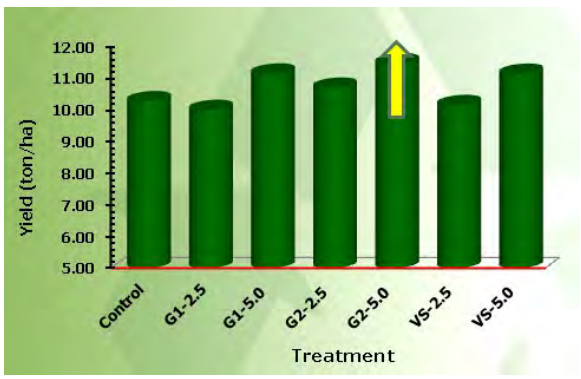
Tomato Yield as influenced by different micronutrient mixtures



Influence of foliar spray of micronutrient mixture on BER of tomato



Brinjal yield as influenced by different micronutrient mixtures

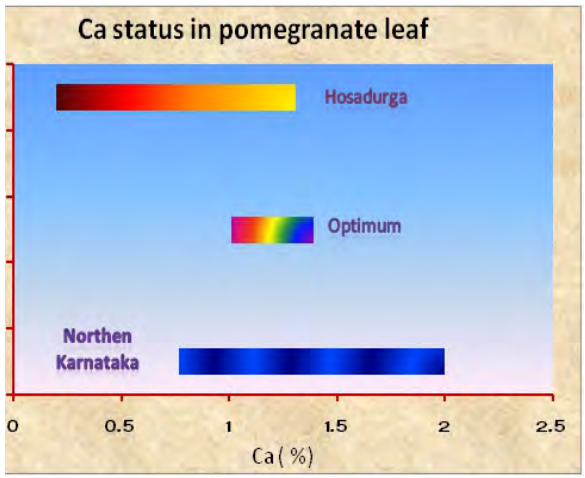


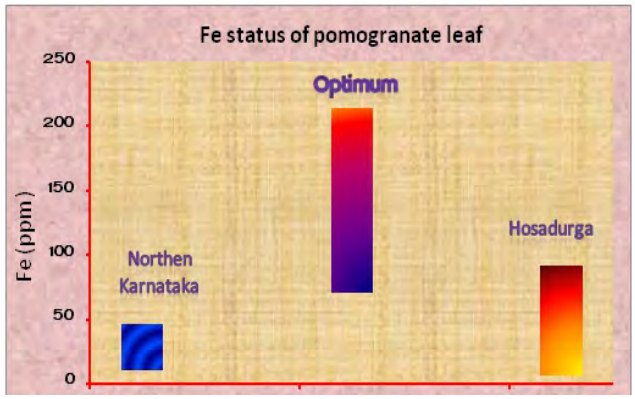
Influence of foliar application of micronutrient mixtures on chillies

Multivariate foliar chemical composition and nutrient contour maps for developing diagnostic norms for fruit crops

Leaf nutrient diagnostic norms for pomegranate

❖ Nutritional survey was carried out in well performing pomegranate orchards of northern part of Karnataka and in Hosadurga regions to study the present nutritional status and to develop diagnostic norms. Among the major nutrients, P concentration in leaf was not yield limiting factor and in many cases had marginally higher P in leaf and nearly 40% of the leaf samples had high P content in leaf. All the samples were in optimum range with reference to K when compared to the earlier established standard. The Ca concentration was generally high ranging from 1.01 to 1.39%, while Mg concentration was in optimum range in majority of orchards compared to norms developed elsewhere. Among the micro-nutrients, the Fe concentration was low often exhibiting deficiency symptoms. Both Zn and Cu concentration was in general on the higher range. Boron concentration showed wide variation in leaf ranging from 6 to 59 ppm. Majority of the samples were low in boron with a mean value of 14 ppm and only 20% of the samples were above threshold level of 18 ppm. Molybdenum concentration ranged from 2.98 to 3.18 ppm with a mean value of 5.89 ppm.





Concentration of Ca (a) and Fe (b) in pomegranate leaf samples

Multivariate norms for pomegranate

- The CND norms are function of the nutrient concentration in leaf and the norms consider the overall imbalance of a given nutrient in question with all other nutrients and that of dry matter accumulation. Nitrogen concentration in pomegranate leaf showed only marginal difference between northern part of Karnataka and Hosadurga region, the CND norms also did not differ between these two regions. Nitrogen showed low level of interaction with other nutrients in pomegranate. The CND norms for Hosadurga region were higher for P, K, and Ca when compared to other part of Karnataka. The differences in CND norms between the two regions surveyed indicated that B is more a limiting factor for pomegranate in Hosadurga region when compared to other part of Karnataka. The Mo concentration and diagnostic norms showed no difference between the two regions.

Microbial Interventions for Horticultural Crops

Actinobacterial Consortium for Soil and Plant Health Improvement

- In India, while bacterial and fungal inoculants are available for many crops, not much information is available on Actinobacterial inoculants. A novel "Actinobacterial Consortium" has been developed for use in horticultural crops. This is a carrier based product containing three *Streptomyces* spp., which have ability to solubilize insoluble P & Zn, produce phytohormones and a variety of enzymes involved in organic matter recycling. Th product can be stored for 4-6 months under room conditions without deterioration of its quality. It can be applied either through seed, seedlings, soil, irrigation water (drip irrigation/soil drenching) or through enrichment of compost/FYM/cocopeat. A liquid formulation of the actinobacterial liquid inoculum has also been developed. After six months of storage under ambient conditions, population levels of 0.3 to 1.8 x 10^7 cfu ml^{-1} were recorded. This Actinobacterial consortium has been released as Arka Actino-Plus, by the ICAR-IIHR. Application of actinobacterial consortium @ 15 kg ha^{-1} (or) 10 L. of liquid inoculum ha^{-1} along with 75% of the recommended N&P fertilizer levels, significantly increased the vegetative growth, plant nutrient uptake and yield (8.7%) of tomato (Arka Rakshak). Enhanced activities of soil enzymes *viz.,* dehydrogenase, acid phosphatase and alkaline phosphatase were also recorded in the consortium applied plots compared to the plots that received 100% inorganic fertilizers alone.

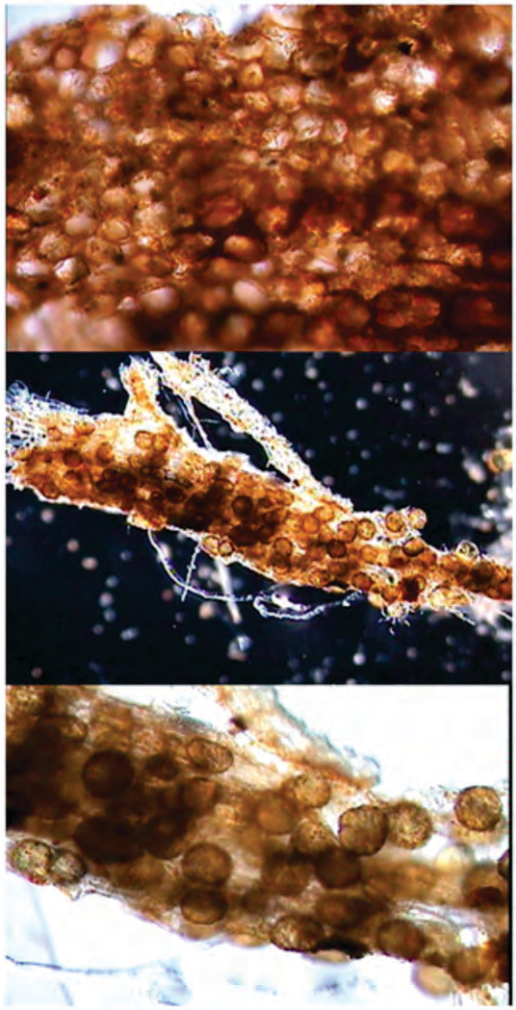
- Regular application of the actinobacterial consortium over a six monthly period in a young guava orchard resulted in the reduction of the bronzing symptoms.

- Combined application of the Arka Microbial Consortium and the Actinobacterial consortium (50 g^{-1} plant) at bimonthly intervals resulted in an overall improvement of pomegranate plant health.

- Field evaluation of the Arka Microbial and Actinobacterial consortia in pepper plantations of Kodagu district of Karnataka, indicated that combined application of a suspension of the Arka Microbial and Actinobacterial consortia @ 2- 5 lit per vine (20 g inoculum per lit of water), at bi-monthly intervals could recover pepper vines from wilt like symptoms.

Soilless Arbuscular Mycorrhizal Fungal Inoculant Technology

- A fermented cocopeat based AM fungal inoculum production technology has been developed. This technology utilizes sterile fermented cocopeat as the sole substrate for host plant growth, with the intervention of a beneficial bacterium (applied at the rate of 0.5 kg of carrier based inoculum per 1000 kg fermented cocopeat substrate), for the purpose of enhancing the host plant root growth, AM fungal colonization and proliferation within the host plant roots. The AM fungal inoculum so derived contains nearly fivefold higher numbers of infective propagules than the existing substrate based AM production methods and is free of cross contamination. The entire process can be carried out in a time span of 45 to 60 days either under outdoor conditions or in glass house conditions. The fermented cocopeat based AM fungal inoculum can be used as a bio-inoculant for raising vegetables, fruits, ornamental and plantation crops. This technology facilitates the production of mycorrhizal colonized seedlings and planting materials, which are a prerequisite for successful horticultural crop production.



AM fungal colonization of host roots raised on fermented cocopeat

Utilization of compost teas as a phytos-timulator in horticultural crop production

❖ Compost teas produced using stabilized grass and ridge gourd residue composts ($Q_{4/6}$ ratios of 2.82 and 4.89 respectively), were evaluated for their phyto-stimulatory effect on cabbage, palak and amaranth under pot culture conditions. Prior to evaluation, the compost teas were analyzed for their nutrient contents and phytotoxic effects. The concentration of water soluble carbon and nitrogen were higher in the ridge gourd residue compost tea compared to the grass residue compost tea. Both compost teas recorded germination indices above 1, indicating the absence of phytotoxic effects. Application of the compost teas significantly increased growth parameters *viz.,* shoot length, root length, dry weight and the uptake of major nutrients *viz.,* N, P and K in cabbage, palak and amaranth, over the water applied controls. In cabbage, grass compost tea application increased the number of leaves by 13.63%, root length by 37.34 % and dry matter production by 31.61% over the water applied controls. Grass compost tea application in palak resulted in the improvement of root length by 67.27 % and dry matter production by 31%. Similarly in amaranth grass compost tea resulted in the improvement of shoot length by 16.37%, root length by 43.05% and dry matter production by 46%.

Control Grass ***Compost Tea*** ***Ridge Gourd Compost Tea***

Effect of compost teas on head development of cabbage under in vitro conditions

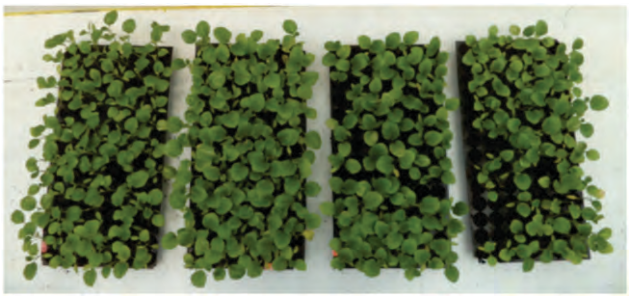
Control Grass ***Compost Tea*** ***Ridge Gourd Compost Tea***

Effect of compost teas on amaranth growth under in vitro conditions

Utilization of diluted compost teas for vegetable seedling production

❖ The effect of diluted compost teas on seed germination and seedling growth of tomato, radish, chilli and brinjal under protray conditions revealed that diluted compost teas had a significant effect on seed germination compared to water treated controls. Seed germination of all test crops has significantly improved due to the application of diluted compost teas. The use of 1:5 dilutions (v/v) of both grass residue and ridge gourd residue based compost tea was found to improve seed germination and seedling growth of tomato and brinjal. Dilution of 1:20 (v/v) of both compost teas was found to be suitable for improvement of most parameters of radish and chilli

seedlings. The use of diluted compost teas offers nursery entrepreneurs an easy and affordable option for producing vigorous seedlings.



Water 1:5 dilution 1:10dilution 1:20 dilution

Effect of diluted grass residue compost tea on tomato seedling production under protray conditions

Nutrient dynamics and management in horticultural crops under salt stress conditions

- The effect of FYM (@0.5% (10 t/ha) in reducing the adverse effect of water salinity in four onion varieties viz. Arka Kalyan, Arka Niketan, Arka Bindu and Arka Pragathi which were grown under four levels of water salinity viz. 0.3, 2.5, 5.0 and 7.5 dSm^{-1} were studied in pot culture experiment. All growth parameters were affected severely at 7.5 dSm^{-1} level. Application of FYM alleviated the adverse effect of salinity. The low level of salinity (2.5 dSm^{-1}) caused about 11-13% increase in bulb fresh weight in Arka Kalyan, Arka Niketan and Arka Bindu varieties and negligible increase in Arka Pragathi variety. Salinity levels of 5.0 and 7.5 dSm^{-1} caused about 6.0-23.0% decrease in fresh weight of bulbs. Application of FYM caused improvement in bulb fresh weight in all the varieties.

- Increase in salinity levels caused significant increase in Na content in all the varieties. The Na content was lowest (0.56%) in Arka Niketan at 7.5 dSm^{-1} and highest (0.82%) in Arka Bindu variety. Application of FYM @0.5 % caused significant reduction in Na content in all the varieties. Increased salinity levels caused decrease in leaf K content in all the varieties. The decrease in K content at 7.5 dSm^{-1} was lowest (13.4%) in Arka Niketan and highest in Arka Pragathi (24%) followed by Arka Bindu (23%).

- Application of FYM improved K content in onion leaf samples at all salinity levels. Increase in salinity levels continuously increased Cl levels in all the varieties. Leaf Cl content at all salinity levels was lowest in Arka Niketan and highest in Arka Bindu variety. Application of FYM caused decrease in leaf Cl content in all the varieties to the extent of 8- 22%.

Nutrient dynamics (N, P, K) of conventional and speciality fertilizers under drip fertigation in horticultural crops (banana, papaya, tomato and brinjal)

- Speciality fertilizers in fertigation significantly improved growth of Grand Naine banana in terms of height and girth. The total fruit weight ranged from 27.66 to 41.28 kg/bunch. The highest yield of 41.28 kg/bunch was obtained when 75% RDF of NPK given as speciality fertilizers in fertigation. The increase in yield was about 33% than the control treatment where 100% N P K given as basal and 20% more than T3 treatment where 75% N P K was given through conventional fertilizers in fertigation. The soil NPK increased in 20-40 cms depth in the treatments where speciality fertilizers were given through fertigation. This was due to increased solubility of water soluble fertilizers and consequent leaching to lower depth where majority of root growth of banana was there.

- Speciality fertilizers have not shown any significant effect on tomato cv. Arka Rakshak. growth. The height of tomato was better when N & K was given through speciality fertilizers. Not much variation was noticed in number of branches with different treatments. The yield was highest in treatment where 75% of N & K given through conventional fertilizers in drip fertigation and P applied as basal dose. Speciality fertilizers have not shown any benefit in terms of yield in tomato.

- Fertigation with 100% RDF of N& K given through conventional fertilizers recorded higher

Banana bunch obtained by application of 100 % NPK through conventional fertilizer as basal application (left) and 75% of NPK through specialty fertilizer (right)

available N, P and K in soil. Nitrogen and P concentration in leaf was higher in 100% RDF of N&K given through speciality fertilizers and P through conventional fertilizers as basal application.

3.3.7. Pesticide Residue Studies

Mango

Residue of azoxystrobin and trifloxystrobin in/on mango from pre- and post-harvest treatments

❖ Azoxystrobin (250 SC) pre and post harvest treatments were given to mango crop at 1.0 and 2.0 mL/L, respectively. Residues on the mango whole fruits from pre-harvest treatments were 0.268 and 0.641 mg/kg which degraded with the half-life of 6.5 and 7.3 days, and remained up to 30 and 35 days, respectively. The pre-harvest interval (PHI) was one day for both treatments (MRL 0.7 mg/kg).Azoxystrobin residues on the mango whole fruits from post-harvest treatments were 0.423 and 0.926 mg/kg. The residues remained beyond 20 days and the PHI was 1 and day 7 days, for treatments at 1.0 & 2.0 mL/L, respectively. Residue levels in the fruit pulp were very low from both treatments. Trifloxystrobin (50 WG) pre- and post harvest treatment was given to mango at the recommended and double doses of 0.5 and 1.0 mL/L. The residues on the mango whole fruit from pre-harvest treatments were 0.422 and 0.753 mg/kg from standard and double dose treatments. The residues remained on the fruits up to 25 and 30 days and degraded with the half-life of 9.2 and 10.5 days, respectively. The pre-harvest interval calculated based on the persistence study and maximum residue limit (MRL) of 0.5 mg/kg was 1 and 7 days, respectively. Trifloxystrobin residues from post harvest treatments were 0.651 and 0.943 mg/kg, from treatment at 0.5 and 1.0 mL/L. The required post-harvest interval was 6 and 16 days. Traces of residues were detected in the fruit pulp from post-harvest treatment only.

Pomegranate

Residue study of dimethoate, imidacloprid, indoxacarb and thiamethoxam

❖ Dimethoate (30 EC) application was given to pomegranate crop variety "Bhagwa" at the recommended and double the recommended doses of 1 mL/l and 2 mL/l and residue analysis of pomegranate whole fruit and aril was carried out over 40 days. Initial residue deposits were 0.645 and 1.358 mg/kg. Dimethoate residues remained for 30 days at standard dose and 40 days from double dose treatments. Residues mostly remained on the surface with minimal movement to the fruit pulp. The residues dissipated with the half-life of 7.0 and 9.5 days. Based on the MRL of 0.02 mg/kg recommended by European Union is 0.02 mg/kg the pre-harvest interval of 35 and 54 days was recommended for treatment at the recommended and double the recommended doses. Imidacloprid (17.8 SL) application was given to pomegranate crop variety "Bhagwa", at the recommended and double doses of 0.3 and 0.6 mL/L twice at 15 day intervals. Residue analysis of pomegranate whole fruit and aril was carried out after the second spray for a period of 60 days. Initial residues of imidacloprid were 0.215 and 0.374 mg/kg. The residues dissipated slowly and remained for 25 days from recommended and 40 days from double dose treatments. The edible part, aril was free from imidacloprid residues. The pre-harvest intervals based on the MRL of 0.05 mg/kg were 26 and 36 days, respectively. Field soil did not contain any residue. Indoxacarb (14.5 SC) application was given to pomegranate crop variety "Bhagwa" at the recommended and double doses of 0.5 and 1.0 mL/L twice at 15 day intervals. Analysis of pomegranate whole fruit and aril was carried out after the second spray for a period of 60 days. Initial residues of indoxacarb were 0.37 and 0.63 mg/kg. The residues remained for 25 days from recommended and 30 days from double dose treatments. The edible part, aril was free from indoxacarb residues. The residues dissipated at the half-life of 7.4-8.4 days. The pre-harvest intervals based on the EU MRL 0.02 mg/kg were 31 and 42 days, respectively. Field soil did not contain any residue. Thiamethoxam (25 WG) application was given to pomegranate crop at the recommended and double doses of 0.25 and 0.5 mL/L twice at 15 day intervals. Residue analysis of pomegranate whole fruit and aril was carried out over 60 days. Initial deposit of residues was 0.262 and 0.393 mg/kg on the fruit surface that persisted for 30 and 40 days. Residue deposit of thiamethoxam on the fruit surface only and there was no movement to

the aril. The waiting periods were 25 and 42 days before harvest of the fruits based on the MRL of 0.05 mg/kg (EU).

Residue studies of carbendazim, metalaxyl and propargite

❖ Carbendazim (50 WP application) was given to pomegranate crop variety "Bhagwa" at the recommended and double doses of 1 and 2 g/L twice at 15 day intervals. Residue analysis of pomegranate whole fruit and aril was carried out after the second spray for a period of 60 days. Initial residues of carbendazim were 1.36 and 2.35 mg/kg. The residues dissipated slowly and remained for 60 days from both treatments. The edible part, aril contained carbendazim residues up to 30 and 40 days. The pre-harvest intervals based on the MRL of 0.1 mg/kg were 65.4 and 103.4 days, respectively. Field soil contained up to 0.48 mg/kg residues. Field soil contained up to 0.48 mg/kg carbendazim residues. Metalaxyl (Metalaxyl 8% + Mancozeb 64%) was given to pomegranate crop variety "Bhagwa" at the recommended and double doses of 2.5 and 5 g/L twice at 15 days intervals. The first application was given at fruit growth stage and the second application was given 15 days later. Residue analysis of pomegranate whole fruit and aril was carried out after the second spray for 60 days. Initial residues of metalaxyl were 0.182 and 0.43 mg/kg. The residues remained for 40 days and 60 days from recommended and double dose treatments. The edible part, aril contained metalaxyl residues on the 5th and 10th only from the double dose treatment. The pre-harvest intervals based on the MRL of 0.05 mg/kg were 31.5 and 63.4 days, respectively. Propargite (57 EC) application was given to pomegranate crop variety "Bhagwa" at the recommended and double doses of 1 and 2 mL/L twice at 15 days intervals. The first application was given at fruit growth stage and the second application was given 15 days later. Residue analysis of pomegranate whole fruit and aril was carried out by GC-MS after the second spray for a period of 60 days. Initial residues of propargite were 1.443 and 3.041 mg/kg. The edible part, aril was free from propargite residues. The residues dissipated at the half-life of 6.1 and 7.9 days. The pre-harvest intervals based on the MRL of 0.01 mg/kg were 46 and 64 days, respectively.

Sapota

Residue study of dichlorvos and dimethoate

❖ Dichlorvos (76 EC) application given to sapota at the recommended and double the recommended dose of 1.0 and 2.0 mL/l twice at 15 day intervals. Dichlorvos residues from treatment at the recommended and double doses were 2.92 and 4.53 mg/kg. Residues remained for 5 days from recommended dose and 10 days from double dose treatments, respectively. The fruit pulp was free from dichlorvos residues. The residues degraded at the half-life of 1.8 and 2.0 days and required safe pre-harvest intervals were 10 and13 days. Field soil was free from dichlorvos residues. Dimethoate (30 EC) residues on sapota were 3.11 and 5.2 mg/kg from treatments at 1 and 2 g/L treatment which remained beyond 30 days. The fruit pulp contained highest of 0.37 to 0.84 mg/kg dimethoate residues on the 5th day. The residues remained in the pulp up to 30 days. The residues degraded at the half-life of 6.0 and 7.5 days. The required safe pre-harvest interval was 36 and 52 days, respectively (MRL 0.05 mg/kg). In field soil dimethoate residues were detected upto 10 days, but reached below detectable limit at harvest.

Residue study of cypermethrin, profenofos and quinalfos

❖ Cypermethrin (25 EC) spray applications were given to sapota crop at the recommended and double doses of 1.0 and 2.0 mL/l twice at 15 day intervals. Cypermethrin residues from treatment at the recommended and double doses were 2.25 and 3.52 mg/kg. Dissipation of cypermethrin residues was fast in the initial stages, but became slower in the later stages. Residues remained for 30 days from recommended dose and 35 days from double dose respectively. The fruit pulp was free from cypermethrin residues. The residues degraded at the half-life of 6.5 and 7.3 days. The required safe pre-harvest interval was 36 and 45 days (MRL 0.05 mg/kg). Field soil was free from cypermethrin residues at harvest. Profenofos (50 EC) applications were given to sapota crop at the recommended and double doses of 1.0 and 2.0 mL/L twice at 15 day intervals. Profenofos residues from treatment at the recommended and double doses were 2.53 and 4.605 mg/kg. The residues remained on sapota for 35 days from recommended dose and 40

days from double dose treatments, respectively. The fruit pulp was free from profenofos residues. The residues degraded at the half-life of 8.7 days from both treatments. The required safe pre-harvest interval was 50 and 57 days, from treatment at the recommended and double doses (MRL 0.05 mg/kg). Field soil was free from profenofos residues. Quinalfos (25 EC) spray applications were given to sapota crop at the recommended and double doses of 2.5 and 5.0 mL/L twice at 15 day intervals. Quinalfos residues from treatment at the recommended and double doses were 3.32 and 5.56 mg/kg. Residues remained for 30 days from recommended dose and 35 days from double dose treatments, respectively. The fruit pulp was free from quinalfos residues. The residues degraded at the half-life of 6.2 days from both treatments. The required safe pre-harvest interval was 38 and 43 days, from treatment at the recommended and double doses (MRL 0.05 mg/kg). Field soil was free from quinalfos residues.

Effect of microbial consortium on residue levels

- Effect of microbial consortium treatment was evaluated on residues of lambda cyhalothrin in spinach and onion greens. Lambda cyhalothrin residues (initial 0.185 ppm and 0.369 ppm respectively) in spinach and onion greens persisted for 15 days with half lives of 2.3 and 5.6 days. The waiting periods established were 1 and 4.8 days respectively. However, microbial consortia treatment of the crops resulted in faster degradation of the residues initially up to 5 days. Thereafter, there was no significant difference in residues in microbial consortia treated crop and untreated crop where the half lives for dissipation of lambda cyhalothrin were 4.6 and 5.1 days respectively.

Residue study of tebuconazole + trifloxystrobin in coloured capsicum

- Coloured capsicum grown in polyhouse was treated with tebuconazole + trifloxystrobin combination formulation along with dimethomorph, and residues analysed at periodic intervals starting at 0 day. It was seen that the residues of all the three fungicides persisted for more than 20 days. The residues of dimethomorph was the highest at deposit and also later.

Methodology developed

- A multi-residue analytical protocol for analysis of fifty two pesticides was standardized by LC-MS/MS in capsicum and okra. Matrix matching was carried out to remove errors due to matrix. The mass analytical parameters for all pesticides were individually optimized before developing the MRM method.

- An analytical method was developed for analysis of acetamiprid, difenoconazole, imidacloprid, indoxacarb, propiconazole and thiamethoxam in pomegranate by LC-MS/MS at the limit of quantification of 5 µg/L (ppb).

- An analytical method was developed for analysis of fifty two pesticides in capsicum and okra by LC-MS/MS method at the limit of quantification of 2 ppb.

3.4. Crop Protection

3.4.1. Fruit Crops

Mango

❖ **Pest Surveillance**: Thrips (*Scirtothrips dorsalis*), mite (*Oligonychus mangiferus*) (Rhaman and Sapra) and leaf weevils (*Rhynchaenus mangiferae* Fab.) are emerging as serious pests. The incidence of thrips on fruits (lemon size) was highest (24.5%) in Banganapalli and < 5% in Totapuri. Thrips infestation among dropped fruits ranged from 12-15%. The fruit borer (*Citripestis eutraphera* Meyrick) recorded enhanced infestation of 4.5% in Alphonso and 1-2% in Banganapalli. The unopened buds of Alphonso were found to be infested with blossom midge (*Procantarina* sp.) to the extent of 15-28% at different periods. Both male and female flowers were affected**.** The mite infestation on leaves prevailed almost throughout the year, peak during July – August. Among hoppers, *Amrascas plendens* Ghauri dominated in vegetative phase while *Idioscpus nitidulus* (Walker) was the dominant species (>90%) during blossom period distantly followed by *I. nagpuriensis* Pruthi (7%) across the varieties.

Infestation of mango fruit borer (Citripestis eutraphera)

❖ At CHES, Bhubaneswar, mango inflorescence midge infestation ranged from 10 to 93%. Surveys indicated that the mango inflorescence midge was common in West Bengal, Orissa and Jharkhand but not in Chhattisgarh. Screening of 30 varieties and hybrids for inflorescence midge indicated that the damage ranged from 0.0 to 93.10% and highest in H-39. The leading varieties like Amrapalli and Mallika sustained severe flower bud damage (>85%) and the fruit set was affected.

Management of hoppers and thrips

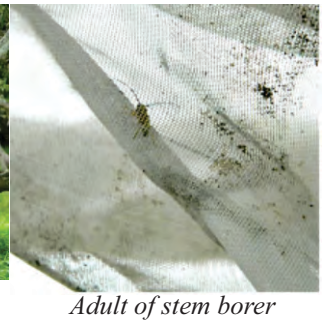
❖ Entomopathogens, azadirachtin and insecticides were evaluated for the management of leafhoppers (*Idioscopus* sp.), and thrips (*Scirtothrips dorsalis*). Four sprays of oil formulation of *Metarhizium anisopliae* (0.5 mL/l) at weekly interval resulted in 83.5% reduction in hopper population compared to 87.2% with two applications of imidacloprid @ 0.25 mL/l. It was also effective against thrips and brought 60% reduction in thrips population.

Stem borer diversity

❖ A simple mesh trapping technique was standardised to collect and monitor tree trunk borers. With this technique, it was found that besides trunk borer (*Batocera rufomaculata* De Geer), two other species of Cerambycidae *viz., Gleneam ultiguttata* Guerin-Meneville and *Coptopsa edificatory* (Fab.) were infesting mango. It also helped in recording the precise timing of adult emergence. The trunk borer (*B. rufomaculata*) was the first to emerge and the maximum emergence (4/10 trees) was recorded during second week of July. The next species to emerge was *G. multiguttata* in the fourth week of June followed by a buprestid and *C. aedificator.* Of these, *G. multiguttata* was numerically the most dominant species (mean 9.0/tree). *B. rufomaculata* emerged out from trunk of the mango tree while the other three species had emerged out of lateral branches.

❖ There was a positive correlation between stem borer infestation and tree age (+0.68). The lowest point of the occurrence of borer was 15 cm and the highest was 72.5 cm. Maximum number of bored holes was recorded at the first branching junction. The variety Alphonso and Langra had the highest infestation (20-25%) while Banganapalli had the lowest. Infestation was significantly more (42%) in high density plantation (3 x 3 m) than normally spaced trees.

Stem borer infested mango tree wrapped with mesh



Adult of stem borer caught in the mesh trap

Diversity of mango stem borers

Batocera rifomaculata

Glenea multiguttata

Coptopsa edifator

Unidentified Buprestid

- The effect of irradiation on pupae of fruit flies, *Bactrocera dorsalis* was studied. The pupae were irradiated at Bhabha Atomic Research Centre (BARC), Mumbai at different doses. A dose of 40-50 Gy was found to be optimum to induce sterility while the dose above 60Gy resulted in complete mortality.

- At CHES, Bhubaneswar, management studies indicated that summer ploughing + soil application of chlorpyriphos @ 10 kg / ha + bud burst stage spray of carbosulfan @ 2 mL/l had lowest infestation of inflorescence midge and highest fruit set. It was 52% superior to untreated control. Summer ploughing + spray of neem oil @ 3mL/l had very little impact on pest incidence.

Mango flower midge infestation

Leaf and flower webbers

- Eighteen varieties and hybrids of mango were evaluated for leaf webber and flower webber infestation. The damage of leaf webber ranged from 10.26 to 58.65% canopy area being highest in Arka Aruna.

Disease incidence in Orissa

- Survey for disease incidence in mango in Orissa showed severe incidence (Score 4 out of 5) of anthracnose in Sai Sugandh and Prabha Sankar, whereas Arka Nilachal Kesari, Arka Aruna, Arka Neel Kiran, Himsagar, Sindhu, Sundar, Langra and Swarna Jehangir were free from anthracnose. In Arka Neelachal Kesri, powdery mildew appeared in January whereas in Amrapalli, it was in February.

Disease management

- As a post-harvest dip treatment, Zimmu, lemon grass oil and palmarosa oils were evaluated on fruits of susceptible var. Sai Sugandh. At CHES, Bhubaneswar, it was observed that Zimmu leaf extract @ 5% extended the shelf life of fruits to two more days compared to control fruits. Application of hexaconazole (0.05%) at 50% flower opening (first sign of disease appears on panicle) and at the time of fruit set was effective in managing powdery mildew disease by 91.8% followed by first spray with sulphur (0.3%) and second spary with hexaconazole (0.05%).

Banana

- An outbreak of the banana skipper, *Erionotathrax* (Lin.) was recorded from several banana growing areas in Hasan, Mysuru, Chikmagaluru, Kodagu and Tumakuru in Karnataka, parts of Kerala and Andhra Pradesh. The caterpillars feed gregariously by folding the leaves along midrib. The infestation was up to 60% in different fields.

- Application of 2 kg farm yard manure enriched with *Bacillus subtilis* 1% A.S. (10^9 cfu/g) and *Paecilomyces lilacinus* (10^6 cfu/g) per plant at the time of planting and at an interval of six months was found effective in reducing infestation of lesion nematode, *Radopholus similis* (85.2%) and root knot nematode, *Meloidogyne incognita* (87.4%) and increasing the fruit yield (27.4%).

- On Grand Naine fruits, dark coloured depressed spots of up to 3- 4 mm in diameter was observed which was totally different from banana fruit diseases already reported to occur on fruits in India. Pits appear on immature as well as on matured bunches. Disease was severe during and after heavy rainfall. Symptoms appeared on trees as presence of spots on leaves, petiole,

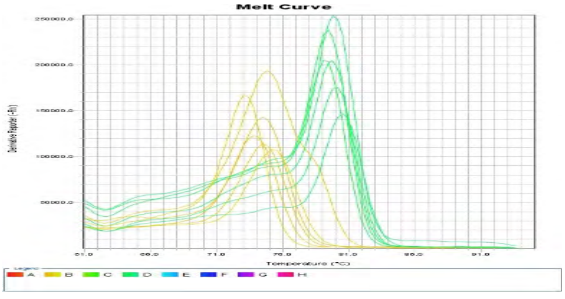
midrib, pseudostem, peduncle of fruits, fruits as well as on cushions of fruits. Similar symptoms appeared on tissue culture plants of Grand Naine and Banthal varieties. The identity of the pathogen has to be confirmed.

Black spot symptoms on Grand Naine fruits

Citrus

Citrus Tristeza Virus (CTV) and Citrus Greening Bacterium (CGB)

❖ Protocol for detection of Tristeza virus in aphids was validated. RNA was extracted from single aphid *Aphids citricola* and Citrus Tristeza Virus could be detected using Real Time PCR methodology. At CHES, Chettalli, deltamethrin, imidacloprid and dimethoate were found to be superior in reducing the red scale population significantly. Deltamethrin gave consistent results in the reduction of scale population on mandarin.



Detection of Citrus Tristeza virus by Real Time PCR from aphid vector

Decline in Coorg mandarin

❖ At CHES, Chettalli, a survey was carried out to study the status of citrus decline caused by *Phytophthora.* Highest disease incidence and severity was recorded in Amla-Coorg mandarin block *i.e.* 38% and 13% respectively. In four orchards nearby Chettalli having coorg mandarin intercropped with coffee and pepper maximum disease incidence and severity was recorded in Bellatti estate (30% and 12%, respectively). Lowest disease incidence and severity was recorded in Greenview estate. *Phytophthora* isolates were cultured and based on morphological characters they were categorized into two groups.

Grapes

Epidemiology and management of rust in grape var. Bangalore blue

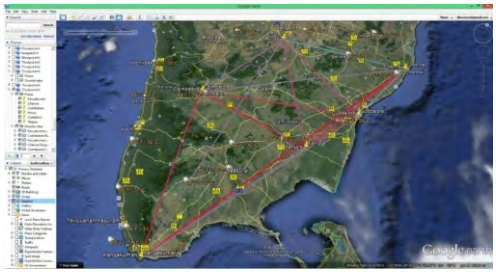
❖ Rust incidence due to *Phakospora vitis* (Thuem.) Syd. was recorded during 21st meteorological week in traces when minimum and maximum temperature was 19.1 °C and 28.1 °C, respectively with RH at 7:20 hrs and 14:20 hrs was 94% and 67 %, wind speed at 12.3 km/h, bright sunshine for 1.4 hr 3 & 2.4 octas of clouds at 7:20 hrs& 14:20 hr. The total rainfall of 0.65 mm occurred in one rainy day with evaporation rate at 3.3 mm/day. The disease recorded a peak of 64.67 (PDI) during the 41st meteorological week. The average of the weather parameters for the week during the occurrence of disease: Minimum temperature 19.2 °C; Max. Temp 28.9 °C; RH at 7 30 hrs: 94.00 % RH at 1:30 hrs 53.00% wind speed 5 km/h; Bright sunshine 3:0 h with 2 octas of clouds at 7:20 hrs & 14:20 hrs, respectively with 156.6 mm rain during the 5 rainy days during the week and Evaporation 3.0 mm/day. The severity of the rust disease was negatively correlated with maximum temperature (r=-0.44) and minimum temperature (r =-0.50) wind speed (r=-0.41), pan evaporation (r =-0.59 and sunshine hrs (r=-0.34) The disease severity recorded a positive correlation with relative humidity both during morning (r=0.44) and evening hours (r=0.34) and rainfall (r=0.39). No of rainy days (r =0.36) and amount of clouds. Among different fungicides evaluated application of azoxystrobin (0.1%) was the most effective with 15.33 PDI followed by propiconazole (0.2%) and flusilazole (0.1%) with respective PDI of 18.67 and 19.33 whereas in control the PDI was 66.00.

Papaya

Phylogeographic Analysis for the spread of PRSV

❖ Phylogeographic analysis in discrete space was carried out on a simulated data set of Papaya

Ring Spot Virus coat protein RNA data set using the software, CLUSTAL, BEAST, and Tracer. The molecular phylogeny was printed using FigTree and a KML file of the animation was prepared using SPREAD, which was opened in Google Earth. This enabled the visualization of the spread of the disease with relevance to the appearance of new isolates.



Phylogeographic analysis of spread of virus

Visual Analysis of high density multi-year, multi-centre multi- treatment data

❖ Analysis of high density multi-year, multi-center multi-treatment data has become essential to compare and select the best treatment / performance. The data was read as a (*csv) file and was graphed to enable easy comparisons. The script was able to color based on the year / treatment/ centre/ and was also able to color based on the data values.

Nematode management

❖ Application of *Bacillus subtilis* and *Paecilomyces lilacinus* in papaya reduced reniform nematode, *Rotylenchulus reniformis* by 77.6 % and *M. incognita* by 79.1% and increased fruit yield by 23.8%.

Pomegranate

Management of nodal blight

❖ Sequential application of Bordeaux mixture 1.0%, zantholin 2.0 mL/l, copper oxychloride 0.3% + K-cyline 500 ppm, zantholin 2.0 ml/l, COC 0.3% + bronopol 500 ppm, zantholin 2.0 mL/l significantly reduced the bacterial blight incidence (16.7%) caused by *Xanthomonas axonopodis* pv *punicae* and increased the yield of pomegranate (10.2 t/ha) as compared to high blight incidence of 64.8 per cent and low yield of 2.8 t/ha in untreated control plants.

Wilt caused by *Ceratocystis fimbriata* Ellis & Halst.

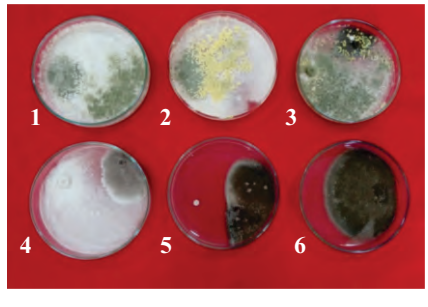
❖ *Ceratocystis fimbriata* isolates from wilt samples collected from Maharashtra and Karnataka were characterized based on morphological characters and molecular tools (ITS, tef1 genes). *C. fimbriata* specific primers were used to identify the mating type viz. MAT1 and MAT2. Isolates amplified with MAT2 primers were CF2, CF3, CFB, CFSP17, CF2 KAR and CFSP10. Isolates CF1 and CF4 and *C. Paradoxa* (used as outgroup) did not amplify.

Screening of carbandazim tolerant *Trichoderma* against *C. fimbriata*

❖ Three way screening method including *Trichoderma* – carbendazim – *Ceratocystis* was used to test the efficacy of *Trichoderma* isolates and carbendazim (500 ppm) against *Ceratocystis*. Three *Trichoderma* isolates *viz*., GJ16B, TH10, TN2A obtained from NBAIR, Bengaluru were used. *Ceratocystis* was inbibited by carbendazim (500 ppm). All three *Trichoderma* isolates inhibited *Ceratocystis* but TN2A was sensitive to carbendazim. *T. harzianum* isolate GJ16B was very effective in restricting the growth of *C. fimbriata* besides showing tolerance to carbendazim.

Identification of volatile compounds from *C. fimbriata* that affect spread by shot hole borers

❖ Based on the hypothesis that volatiles from *C. fimbriata* or infected wood are involved in attracting shot hole borer, the production of volatile compounds by *Ceratocystis* was studied using GCMS. If compounds are identified, it will be easy to trap and stop spread (in orchards older than 3 years). CFSP 17 isolate of *C.*



Three way interaction among *Ceratocystis fimbriata*, carbendazim and *Trichoderma harzianum* (1. Th GJ16B 2. Th GJ16B + *C. fimbriata* 3. Th GJ16B + Carbendazim + *C. fimbriata* 4. Th TN2A + *C. fimbriata* 5. Carbendazim + *C. fimbriata* 6. *C. fimbriata*)

fimbriata was used in the study. *Ceratocystis* was inoculated on different substrates for the comparison of volatile compound produced along with control. The different substrates used were PDA, PDB, pomegranate wood pieces and wood pieces from sources (wastage from saw mills). Few unique compounds *viz.* hexyl tiglate, 4-phenylheptan-4-ol, trans-edulan and ethyl-5-hydroxypentanethioate were present only in *C. fimbriata* inoculated wood pieces of pomegranate wood.

Sapota

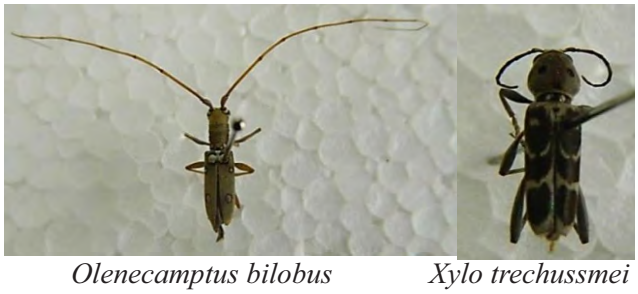
❖ For management of borer complex including bud borer (*Anarsia achrasella*), seed borer (*Trymalitis margaroius*) spraying of Bt @ 1 mL/l was as efficient as deltamethrin, profenophos and cyopermethrin.

Jackfruit

❖ Shoot and fruit borer (*Diaphania caesalis*) was the major pest with the peak incidence (32-45%) during October–November. Occurrence of scale (*Megapul venarea maxima*) was recorded in severe form (8-10 ovisacs and 10-25 adults /leaf) during November - December in sporadic trees. However, the scale population was effectively brought down by the predator (*Cryptolaemus montrouzieri*).

Fig

❖ Incidence of stem borer was recorded in two varieties *viz.*, Deanna and Poona. Deanna suffered severe infestation (65%) while it was very low (< 10%) in Poona. Three species of Cerambycidae *viz*., *Xylo trechussmei* (Laporte de Castelnua & Gory), *Olenecamptus bilobus* (Fabricius) and *Xystrocera globosa* (Olivier) were recorded from stems.



Olenecamptus bilobus *Xylo trechussmei*

Aonla

❖ Infestation of shoot gall psylla was recorded up to 37 % from Mayurbhanj region, while it was insignificant in Koraput region

Aonla shoot gall damage

Parasitoid for fruit fly management

❖ At CHES, Chettalli, fruit fly infested fruits of sapota, avocado, Malayan apple, egg fruit, west Indian cherry and wild fruits like *Spondiadulcis* were collected to rear the fruit fly species. *Diashamimorpha* sp. (Hymenoptera: Braconidae: Opiinae) was reared from *B. carayeae* infesting the wild host *Spondia dulcis* (Pickle weed). It was observed that there was 100% parasitism on *B. caryeae* pupae in the month of April but there was no parasitism in May. *Diashamimorpha* sp. is confirmed to be larvi-pupal parasitoid that deposits eggs on the larvae and emerges from the pupae because the infested fruits contained only larval stages and not the pupae.

Other minor pests

❖ At CHES, Bhubaneswar, infestation of *Cryptophelbia* was recorded on bael and tamarind ranged from 2.32 to 15% in bael and 1.24 to 1.58% in tamarind.

3.4.2. Vegetable Crops

Survey for incidence of virus diseases

❖ Survey conducted on cowpea, cucurbits, and okra in Raipur, Chhattisgarh, has indicated the incidence of 33.7% mungbean yellow mosaic virus, 11.5% cowpea aphid borne virus, 10.5% groundnut bud necrosis virus on cowpea, 70.5% bitter gourd leaf curl, 56.8% cucumber yellow mosaic and 12.7% papaya ring spot – W strain, 7.5% tobacco streak virus on cucurbits; 13.8% okra yellow vein mosaic and 47.5% okra enation leaf curl virus on okra.

Detection of seed borne tobamoviruses

❖ Tobamoviruses viz. cucumber green mottle mosaic virus (CGMMV), pepper mild mottle mosaic virus (PMMV) and tomato mosaic virus (ToMV) are frequently encountered in protected cultivation. Seeds collected from infected plants of cucumber, capsicum and tomato were tested

for seed born nature by ELISA and RT-PCR. There was externally seed borne infection of CGMMV (8%), PMMV (12%) and ToMV (14%) and none of the viruses were detected in embryo and cotyledon indicating absence of internal seed transmission of CGMMV, PMMV and ToMV in the seeds collected from virus infected fruits.

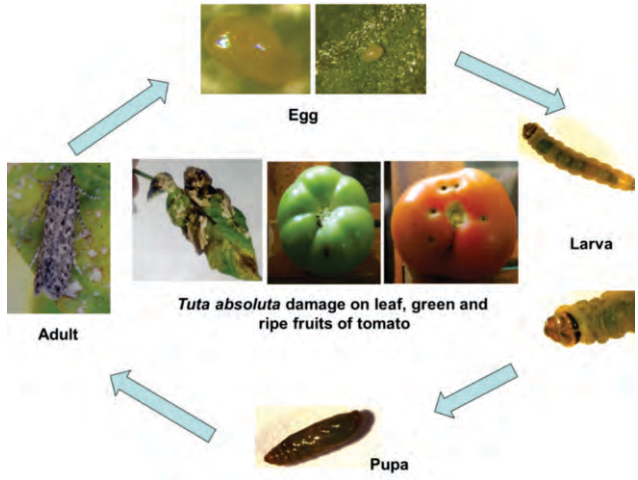
Detection of tobamo viruses in seeds of cucumber, capsicum and tomato

Crop	Seed source	No of seeds tested	No of seeds tested positive	
			ELISA	RT-PCR
Cucumber	Immature fruits	27	26	26
	Whole seed	175	14	13
	Seed coat	137	5	7
	Cotyledon	127	0	0
	Axis/embryo	127	0	0
Capsicum	Immature fruits	17	17	17
	Whole seed	125	15	15
	Seed coat	77	11	11
	Cotyledon	77	0	0
	Axis/embryo	77	0	0
Tomato	Immature fruits	11	10	10
	Whole seed	75	11	9
	Seed coat	50	17	18
	Cotyledon	50	0	0
	Axis/embryo	25	0	0

Tomato

Tuta absoluta: a new invasive pest

❖ The incidence of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) known as South American tomato leaf miner or tomato moth has been documented on tomato fields in around Bengaluru and this is the first record of the pest in India. Explorative surveys carried out in the districts of Bengaluru (Rural & Urban), Kolar, Chikkaballapur, Ramanagara and Tumakuru indicated its presence. In some fields there was up to 87% infestation. The species identification was confirmed by both morphometric and molecular methods. It is an oligophagous pest on solanaceous plants and its incidence has also been recorded on potato. Larvae were generally leaf feeders, creating blotch like leaf mines visible on both sides of the leaf. The mines had dark frass (excrement) visible inside, and over time the mined areas turned brown and dried. The larvae also mined apical buds and stalks and attacked fruits also. The affected fruits had distinct holes mainly in the upper half of the fruit towards fruit stalk usually covered with faecal mass. The infestation of *T. absoluta* ranged from low to high in different tomato fields surveyed (up to 15 mines/plant).



Life stages and damage symptoms of T. absoluta on tomato

Management of early blight using bioagents

❖ Bioagents *viz. Trichoderma harzianum* (Th), *Bacillus subtilis* isolates G2b and V10b were evaluated under field conditions against early blight of tomato caused by *Alternaria solani* during *kharif*. A PDI of 30.21 was recorded with V10b application followed by 33.54 and 38.32 in G2b and Th treated plots as against 32 in Mancozeb and 50.55 in untreated control. Maximum yield of 35.19 t/ha was recorded with G2b followed by 34.65 and 31.19 in V10b and Th as against 32.91 t/ha in Mancozeb and 24.69 t/ha untreated control. The sequential application modules were developed by alternating Mancozeb with Th, V10b and G2b. It was evaluated in comparison with Mancozeb and untreated control. The module Mz-V10b showed a PDI of 24.33 and a highest yield of 56.07 t/ha as against a PDI of 20.32 and yield of 54.33 t/ha in Mancozeb and a PDI of 28.22 and yield of 50.62 t/ha in untreated control. In the *rabi* season the module Mz-V10b showed a PDI of 24.33 and a highest yield of 87.17 t/ha as against a PDI of 20.32 and yield of 89.35 t/ha in Mancozeb and a PDI of 28.22 and yield of 52.79 t/ha in untreated control.

❖ Liquid formulations of 1% glycerol, castor oil, groundnut oil and kerosene were evaluated for

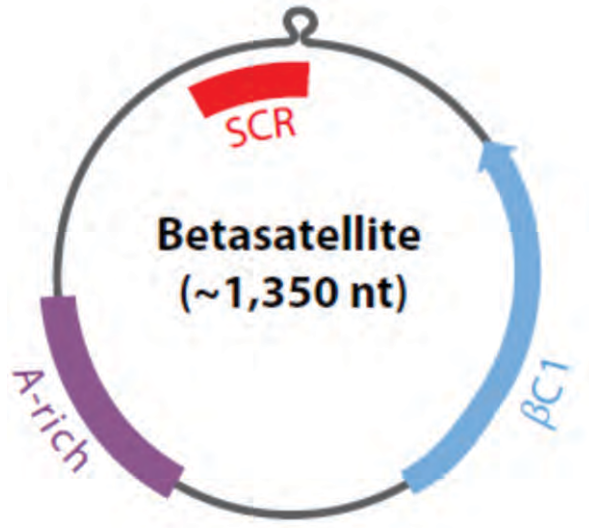
both *B. subtilis* S2b and *B. licheniformis* S3b. Formulations based on castor oil and glycerol survived even after 3 months. S2b and S3b had 6.2 x 10^8 and 6.3 x 10^8 CFU/ml in castor oil formulation while in glycerol it was 5.0 x 10^8 and 5.4 x 10^8 CFU/ml.

Chilli

Molecular characterization of Begomoviruses and associated Beta satellites

❖ For molecular characterization of viruses and strains associated with chilli leaf curl disease, plants showing symptoms *viz*., leaves with upward severe curling, boat shaped, inter veinal chlorosis and enation were collected from Guntur (CHL528, CHL537, CHL550) Andhra Pradesh, Sansawad (CHL477, CHL479, CHL485, CHL486, CHL492) in Madhya Pradesh and Jalana (CHL434, CHL435, CHL439, CHL464, CHL467, CHL470) from Maharashtra. The complete nucleotide sequences of DNA-A of 13 begomovirus isolates has been determined and sequence analysis indicated each of the DNA-A sequences contain the same arrangement of ORFs which is that typical for whitefly transmitted Begomoviruses, with 2 ORFs (AV1 and AV2) in virion sense DNA and four (AC1, replicase; AC2, AC3 and AC4) in complimentary sense DNA. Comparison of full-length sequences have indicated that Chilli leaf curl virus (ChLCV) associated with chilli leaf curl disease, based on DNA-A sequence nucleotide identity of 89.5 to 98.5% with the above six viruses. Twenty two betasatellite isolates collected on Chilli leaf curl were molecularly characterized and complete genome sequence was determined. PASC analysis showed that two beta satellites were associated with ChLCD, which includes chilli leaf curl betasatellite (88.1 -92.0%) and tomato leaf curl Bangladesh betasatllites (84 – 88.9%).

Chilli leaf curl symptoms



Genome organization of Chilli leaf curl beta satellite

Interaction of chilli veinal mottle virus

❖ Plant disease resistance genes (R genes) are important components of the genetic resistance mechanism in plants. Candidate TIR-NBS-LRR CaRGAs were identified in pepper using two approaches, PCR amplification with degenerate primers and database mining. Sequence identity analysis indicated that three RGA sequences have sequence homology of 83.7 to 92.5% with known R proteins of Tobamovirus resistance and phytophthora resistance.

Capsicum

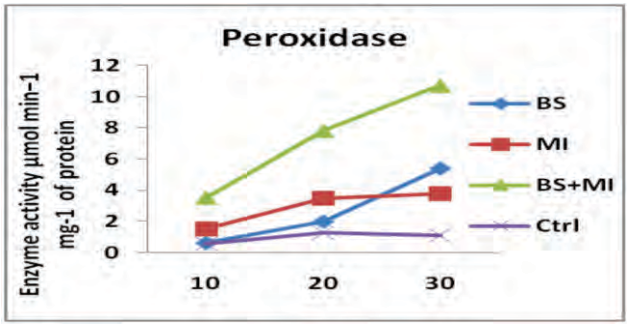
❖ Sanitation in and around the polyhouse and spraying of the formulation of *Metarhizium anisopliae* formulation developed at IIHR at five days interval intercepted with a spray of an acaricide at 90 and 140 DAP recorded significant reduction in thrips and other sucking pests under protected cultivation.

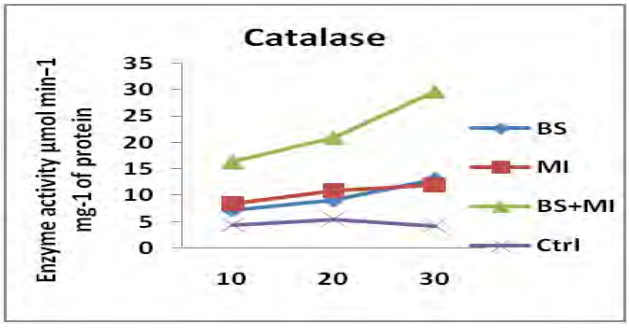
❖ Among different treatments application of thiabendazole (0.1%) and chitosan (0.1%) completely checked the fruit rot in capsicum var. Orbella whereas thiabendazole (0.1%) and chitosan (0.1%) resulted in 2.77% and 1.27 % fruit rot in Capsicum var. Bombay red. No residues of thiabendazole could be detected in capsicum samples at harvest.

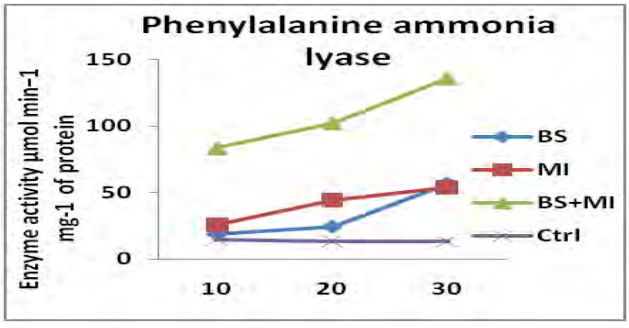
❖ Application of FYM enriched with *Bacillus subtilis, Trichoderma harzianum* and

Paecilomyes lilacinus recorded maximum yield (56.66 t/ha) and minimum nematode population (15/5 g root; 91/100g soil).

❖ **Biochemical changes induced in capsicum by bioagent *Bacillus subtilis* against root-knot nematodes:** Induction of systemic resistance was established in *Bacillus subtilis* treated capsicum against root knot nematodes through enhanced activities of defense enzymes like peroxidase, catalase and phenylalanine ammonia lyase.







Enzyme activities expressed in B. subtilis treated capsicum against root knot nematodes [BS – B. subtilis alone; MI – Meloidogyne incognita alone; BS+MI - B. subtilis challenged with M. incognita; Ctrl - control]

Brinjal

❖ Liquid and granular formulations of *Bt* toxins of Cry1I, Cry3A, CM, MD and AU from native *Bt* strains were developed and tested against adults of brinjal ash weevil, *Myllocerus subfasciatus*.

❖ Bacterial wilt was managed effectively by the integration of farm yard manure, green manure (sunhemp), *Pseudomonas fluorescens* as seed treatment as well as soil drench and application of copper oxychloride. The combined treatment recorded low disease incidence of 9.36 per cent and high yield of 40.60 t/ha as compared to high disease incidence of 64.0 per cent and low yield of 8.6 t/ha in untreated control.

❖ At CHES, Bhubaneswar, 47 germplasm lines were screened by artificial inoculation technique using virulent isolate of pathogen *Ralstonia solanaciarum*. *In vitro* screening against bacterial wilt revealed that brinjal accessions CHBR-1, CHBR-23, CHBR-24, CHBR-27, CHBR-28, CHBR-34, CHBR-35, CHBR-37, CHBR-2, CHBR-10, CHBR-15, CHBR-22, CHBR-18, CHBR-7, CHBR-8, CHBR-30, CHBR-31, CHBR-32 showed partial wilting while accessions CHBR-4, CHBR-5, CHBR-6 showed no wilting.

Bottle gourd

Molecular characterization of tobamovirus

❖ Based on electron microscopic observation, ELISA and indicator host inoculations, virus causing mosaic disease was identified as a cucumber green mottle mosaic virus (CGMMV) belonging to genus *Tobamovirus*. The complete nucleotide sequence of the RNA genome of a CGMMV was determined. The RNA genome consists of 6324 nucleotides and contains four open reading frames, ORF1 encodes a 128.4 kDa protein and ORF2 encodes 186.4 kDa proteins and both are involved in viral replication, gene expression, and movement. ORF 3 codes for the 28.8 kDa protein assumed to be involved in cell to cell spread of the virus and ORF4 encodesfor 157 amino acids (17.4 kDa) of the coat protein (CP).

Genome organization of Cucumber green mottle mosaic virus infecting bottle gourd

Management of downy mildew of cucurbits

❖ Thirty germplasm lines of bitter gourd were screened against downy mildew and all were highly susceptible to downy mildew. Bitter gourd plants of variety Nakara local were best protected by Allicin (garlic juice) and Mancozeb against downy mildew. Dispirin having acetyl salicylic acid as *a.i.* could also provide affordable level of downy mildew control. Detached leaf assay was carried out on cv. Nakhara Local for testing the efficacy of fungicides on *Pseudoperonospora cubensis* for seven days. Allicin, Mancozeb and Dispirin could check further progress of the disease. Biochemical changes induced in bitter gourd on application of the treatments have been studied in respect to accumulation of cell wall-bound (CWB) phenolic compounds. Five phenolic compounds (4-hydroxybenzoic acid, caffeic acid, 4-hydroxybenzaldehyde, 4-coumaric acid and ferulic acid) were identified using chromatography.

Onion

Biocontrol management of *Alternaria* blight

❖ Field evaluation of bioagents viz., *Trichoderma harzianum* (Th)**,** *Bacillus subtilis* (isolates G2b and V10b), and *Chaetomium* sp. revealed that the PDI with application of G2b, Th, *Chaetomium* and V10b was 23.14, 28.13, 29.15 and 30.11 respectively as against 24.28 in Mancozeb and 45.55 in untreated control. Maximum yield of 25.12 t/ha was recorded in G2b followed by 22.67, 21.16, 20.00 t/ha in Chaetomium, Th and V10b respectively as against 22.44t/ha in Mancozeb and 16.98t/ha in untreated control.

❖ The sequential application module was developed by alternating Mancozeb with Th, V10b, G2b and *Chaetomium* and evaluated in comparison with Mancozeb alone and with untreated control. The module with Th or G2B recorded a PDI of 25.17 and 33.83 as against 23.33 and 40.44 in Mancozeb and untreated control. The maximum yield of 28.33t/ha and 23.67t/ha were recorded in module 1 and 3 as against 22.18t/ha in Mancozeb and 19.72t/ha in untreated control.

Bio-prospecting of agriculturally important microorganisms

❖ At CHES, Bhubaneswar, plant growth promotion activity of the selected isolates was evaluated on tomato and brinjal. The selected isolates were screened against fungal pathogens (*Sclerotinia sclerotiorum* isolated from capsicum; *Colletotrichum* spp. isolated from ripe and unripe mango, *Colletotrichum* spp. from Guava and unidentified fungal pathogen from Fruit rot symptoms of mango). All the three antagonistic isolates (An15, AnX and 10C) showed inhibition of all fungal pathogens while *Trichoderma* sp. overgrew the fungal pathogens showing mycoparasitic activities. Different substrates were evaluated as carriers in formulation of the bacterial and fungal isolates, respectively. Finger millet grains and paddy husk supported the multiplication of *Trichoderma* isolates at standardized moisture level and can be used as cheaper base material. For developing consortium formulation, compatibility among the bacterial organisms has been established *in vitro* with all of the bacterial isolates showing compatibility with each other. However, the bacterial isolates were not compatible with two fungal isolates. Efficacy of cell free culture filtrate of antagonistic fungi has been established against fungal cultures *in vitro*.

3.4.3. Ornamental Crops

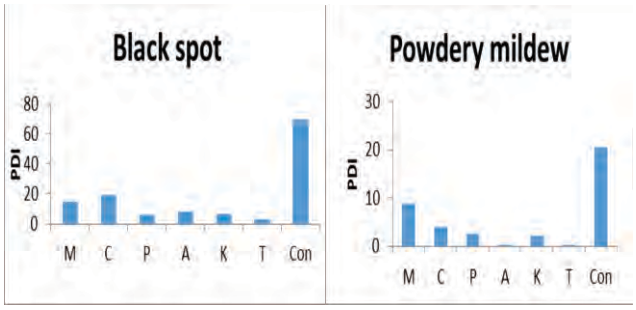
Rose

❖ Evaluation of sticky traps of different colours for the attraction of chilli thrips, *Scirtothrips dorsalis* revealed that blue coloured ones attracted maximum number of thrips followed by yellow and pink colours both in chilli and rose.

Evaluation of sticky colour traps for S. dorsalis attraction on rose

Fungicides for the management of black spot and powdery mildew

❖ Fungicides were screened under field condition against black spot caused by *Diplocarpan rosae* Wolf. and powdery mildew caused by *Podosphaera pannosa* (Wallr.) de Bary. For the black spot management, trifloxystrobin and propiconazole at 0.1% as foliar sprays were effective. For powdery mildew azoxystrobin and trifloxystrobin at 0.1% as foliar sprays were effective.



Effect of fungicides on black spot and powdery mildew incidence in rose.M- Mancozeb 0.2%; C-Carbendazim 0.1%; P- Propiconazole 0.1%; A-Azoxistrobin 0.1%; K- Kresoxin-methyl 0.1% ;T-Trifloxystrobin 0.1%; Con-Control. (PDI values for Black spot in Nov'14 and Powdery mildew in Feb'15)

Tuberose

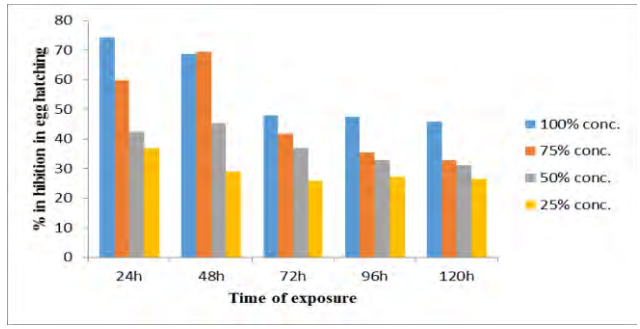
❖ Molecular characterization of blight pathogen was done by PCR amplification of ribosomal RNA gene namely LSU (Large subunit) and SSU (Small subunit). The sequence similarity search showed that the pathogen belonged to *Phoma* species.

Gerbera

❖ Whiteflies have been observed to oviposit heavily on gerbera. Densities of immature and adults were significantly higher from the 3rd week of releases and reached the peak in 9th week (September-October). *Encarsia transvena* could effect upto 38% parasitism on gerbera whiteflies in polyhouse.

Marigold

❖ **Evaluation of marigold in nematode management:** Root exudates of cv. Arka Bangara caused 46 to 74% inhibition in hatching of root knot nematode egg masses and 100% inhibition in nematode penetration.



Effect of marigold root exudates on root knot nematode egg hatching

3.4.4. Medicinal Crops

Aloe vera

Alternaria leaf spot

❖ Twenty five accessions were screened for resistance to *Alternaria* leaf spot. Accession No. 25 recorded the least disease incidence (5 spots per plant) followed by accessions No. 7, 17, 21, 23 and 29 (6 to 8 spots per plant). Accessions Nos. 2, 4, 9 and 34 had more disease incidence (30-40 spots per plant).

3.4.5. General aspects

Anti-fungal compounds

❖ The methanol extractive of *Andrographis paniculata* which had shown antifungal activity against the mycelial growth of *Fusarium solani*. The methanol extractive and andrographolide present in it exhibited activity against the spore germination of *Alternaria solani*. Quantitative estimation of andrographolide by HPLC revealed that the methanol extractive had 6.8% of andrographolide in it. Hexane, ethyl aceteate and methanol extractives of *Coleus forskohlii* roots also were further investigated. All the three extractives and pure forskolin present in the plant exhibited activity against the spore germination in *A. solani*. Quantitative estimation of forskolin in the extractives by HPLC revealed that hexane extractive had 3.9% of forskolin and ethyl acetate extractive had 4.6% of forskolin in them. This clearly showed that forskolin is only one of the antifungal compounds present in the *C. forskohlii.*

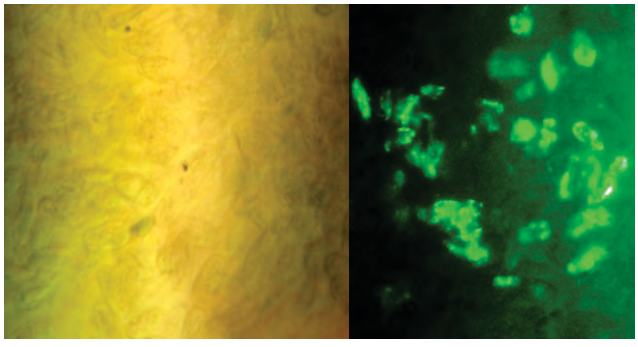
Bioformulations for thrips management

❖ Two formulations of *M. anisopliae* (oil and liquid) and a talc based formulation of *Baeuveria bassiana* with a shelf life of more than 10 months were developed for the

management of thrips on other crops like rose, mango, grapes etc. and hoppers on mango, tea mosquito bug on guava.

Biological management of root knot nematodes

❖ *Trichoderma viride* chitinase (*chi18-5*) gene expression pattern proved its excellent bio-control characteristics against *M. incognita.* The pathogen acted by rupturing the egg shells and thus involved in direct nematode egg parasitism. This was clearly visualized through the FISH probes by which the *T. viride* parasitism was established in the eggs.



T. viride hyphal attachment on M. incognita eggs using FISH probes

Identification of insect species through DNA barcoding

❖ DNA barcoding using CO-I gene was employed for discriminating 151 species of thrips for the first time. Analyses of the intra-specific and intra-generic distances of the CO-I sequences ranged from 0.0 to 7.91% and 8.65% to 31.15% respectively. Study revealed the existence of cryptic species in *Thrips hawaiiensis* (Morgan) and *Scirtothrips perseae* Nakahara (Thysanoptera: Thripidae) for the first time, along with previously reported cryptic species such as *Thrips palmi* Karny, *T. Tabaci* Lindeman, *Frankliniella occidentalis* (Pergande) and *Scirtothrips dorsalis* Hood. There is a feasibility of hosting an independent integrated taxonomy library for thrips and can serve as an effective system for species identification. *Thrips palmi* has been proved to be a vector of watermelon bud necrosis virus by transmission assay. The relative replication from nymph to adult was 60 fold. CO-I was employed for discriminating 142 individuals representing 32 species of aphids from India. Sequence analyses revealed that the intra-specific and inter-specific distances ranged from zero to 3.8% and 2.31 to 18.9%, respectively. In addition, the study also showed for the first time the prevalence of three cryptic species, namely *Brevicoryne brassicae* (Linnaeus), *Hyperomyzus carduellinus* (Theobald) and *Brachycaudus helichrysi* (Kaltenbach) from India. DNA barcoding is an efficient and accurate method for identification of aphid species (including cryptic species).

RNAi or Gene silencing technology

❖ RNAi constructs were made for actin gene and also for vATPase gene isolated from *H. antonii.* Delivery of cognate dsRNA through sponge mimicking the cashew stem elicited feeding by the adults. The effect of RNAi was validated using RT-qPCR, which showed a 50% down regulation of these target genes. vATPase subunit H and juvenile hormone binding proteins were tested for their susceptibility to the application of cognate dsRNA (500 bp) through sucrose diet. Silencing of OBP2 has resulted in delayed host recognition based on the Electro Antenno Gram readings. Similarly, silencing of both vATPase and JHBP genes resulted in mortality (80%) of treated aphids at 12.5 ug.

3.5. Crop Utilization and Farm Mechanization

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

Mango

Fruit coatings to extend the storage life

❖ Pectin coating (1%) alone or MA packing of non-coated fruits in micro-perforated (0.0125%) cryovac film could alleviate CI and extend the storage life of Alphonso mangoes upto 4 weeks at 8°C followed by 1 week (including ripening) under ambient conditions (27.0 - 34.3°C). Integration of both the treatments had no additional beneficial effect.

Innovative mango products

❖ In an experiment conducted to develop low sugar osmo-dried ripe mango slices of Alphonso, a process was standardized using ripe fruits slices and the final product had 7% less sugars compared to the normal osmo-dried slices. The final yield of the product was in the range of 15.3 – 28.2% and moisture content was 13.26 - 26.25% based on the treatments.

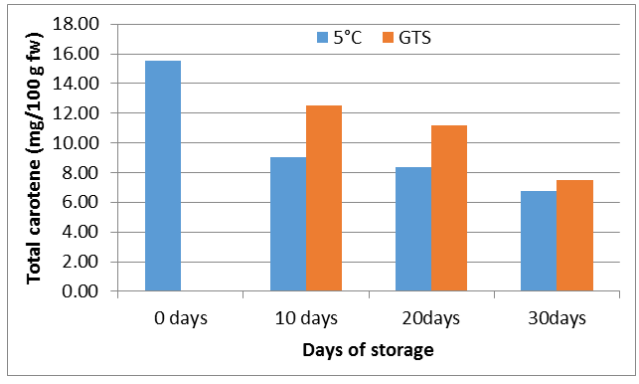
❖ A preliminary trial was conducted to develop a snack food using shredded raw (Totapuri and Banganapalli) and ripe (Alphonso) mango fruits. The finalized product was a dry, highly palatable and a storable snack. Further studies on quality parameters are under progress.

Effect of gradient temperature conditioning storage on fatty acid unsaturation, reactive oxygen species, antioxid- ant enzymes and chilling injury in Alphonso mango

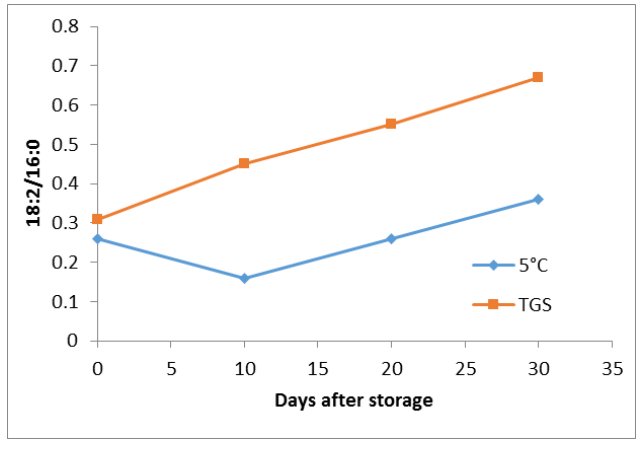
❖ Matured Alphonso fruits were stored at 5°C with or without gradient temperature conditioning (20 to 8° C over duration of 15 days). Visible chilling injury was completely absent in gradient temperature conditioning treatment at the end of 30 days of storage. However at 5°C storage, 30% of fruits showed the visible chilling injury symptoms. Total carotenoids and fatty acid unsaturation were more and production of reactive oxygen species was less in gradient temperature stored fruits compared to direct storage at 5°C.

Per cent affected fruits		
Days of storage	5°C	Gradient temperature storage
10	0	0
20	25	0
30	30	0

Percent fruits showing visible chilling injury symptoms at 5°C and gradient temperature conditioning storage treatments for different durations.



Total carotene content of ripened fruits after storage at 5°C and gradient temperature storage conditions (GTS).



Ratio of unsaturated (18:2) to saturated (16:0) fatty acids in unripe fruits after storage at 5°C and gradient temperature storage conditions (GTS).

Low cost ripening technique for mango

❖ The low cost mango ripening method standardized by IIHR has been modified by CHES, Bhubaneswar. An airtight room of dimension 3mx3mx3m was used as a ripening chamber accommodating 6-8 q of fruits in plastic trays. Ethrel (10 ml) and caustic soda (2g) were dissolved in 5-6 litres of water and kept inside the chamber in a tub. Fruits are kept inside the chamber for 16-20 hours to initiate the ripening, and then taken out and kept at normal room temperature for 3-4 days to complete the ripening process. The method was effectively used by the TSP beneficiaries for mango ripening at Kashipur, Rayagada.

Papaya

Fruit coatings to extend the storage life

❖ Pectin coating was not useful in extending the stoage life of papaya fruits (Red Lady) either under ambient conditions (23.5 – 30.7°C; 28-57% RH) or at low temperature (18°C; 83-88% RH).

Design and fabrication of customised corrugated fibre board (CFB) box for papaya

❖ Customised CFB box of size 450 x 300 x 150mm, 5 ply rate thickness, 20 kg/cm² bursting strength with in-built cushioning was designed which withstood vibration and drop test and was found suitable for packaging and storage of papaya both at low temperature and ambient temperature. The fruits packed in these boxes had a shelf life of 12 days at low temperature (18°C, RH 80%) with a weight loss of 3.43%. The quality in terms of total carotenoids and total sugar content were 1.67 mg/g and 5.58% respectively. The shelf life of papaya stored in these boxes under ambient conditions (26-29°C, RH 45%) was 5 days with a weight loss of 5.16%. The total carotenoids and total sugars content were 1.13 mg/g and 5.88% respectively.

Guava

Fruit coatings to extend the storage life

❖ Pectin coating was neither found to be beneficial in reducing physiological loss in weight (PLW) nor delaying the ripening during storage of guava (Allahabad Safeda) either at low temperature (12°C; 82-85% RH) or under ambient conditions (26.7°- 34.8°C).

Hurdle processing

❖ Ripe guava fruits were preserved using hurdle technology comprising of blanching followed by dipping in $CaCl_2$ solution for 30 minutes and subjecting to osmosis in 60°B syrup containing 0.3% citric acid and 700 ppm potassium metabisulphite or 300 ppm sodium benzoate. The yield of prepared product was 60.24% based on cut slices and 24.5% based on the whole fruit. The moisture content in the final product was 20 -23.0% and the product could be stored for 4 months without any microbial spoilage.

Karonda

Screening of karonda lines for processing

❖ Eight karonda lines provided by the Fruit Crops Division were screened for pickle making. TSS of the lines varied between 6.2 to 9.0° Brix with acidity level of 3.6 to 6.0% (Line 5/4).The sour karonda line 5/4 was promising for pickling with higher TSS and acidity.

Aonla

Innovative blended beverages

❖ Blending of aonla (Amla) juice with other vegetables like bottle gourd and ash gourd were attempted with various combinations ranging from 30-50% by keeping other additives constant. The blend consisting of 70% amla and 30% bottle gourd was judged the best.

Capsicum

Shrink wrapping of CFB boxes to extend the shelf life

❖ Green capsicum (cv. Indra) packed in 40 x 30 x10 cm size CFB boxes and over wrapped using semi-permeable films could be stored for 4 weeks at 8°C with a weight loss of only 4% as compared to 8% in non-shrink wrapped CFB boxes. At room temperature (23.5-30.6° C, 23-51% RH) these treatments could be stored for 10 days with a weight loss of only 5% and 15% respectively.

Shrink wrapped CFB boxes

Muskmelon

❖ In a study to develop osmo-dried and osmo-dehydrofrozen musk melon products, cubes/slices of green and yellow fleshed musk melon (procured from market) were subjected to various osmotic treatments using sugar syrup (40, 50 & 60 °Brix) and final product was preserved as dried and osmo-dehydrofrozen slices. In the final osmo-dried product, yield ranged from 33.15 to 66.09%, while in case of osmo-dehydro frozen products, yield ranged from 80.70 to 90.90%. Sensory quality of fruit custard made using osmo-treated musk melon cubes/slices had very high acceptability. Studies on their quality are in progress.

Beet root

❖ A process was developed for making osmotically dehydrated beet root sticks using 40 & 50 °Brix sugar syrup. Moisture content in dried samples ranged from 6.03- 18.93%, while the water activity(a_w) ranged from 0.446 to 0.580. The proudct yield of osmo-dried samples ranged from 32.08 to 35.42% while the yield was only 6.60% in the untreated (control) samples. Omsotically dehydrated samples were found to be highly acceptable with a total sensory score of 74.60/100 , as against total sensory score of 35.60/100 in the untreated samples.

Carrot

Effect of edible coatings on storage life of minimally processed carrots

❖ Among different edible coatings like methyl cellulose (0.75 & 1.5%), polyvinyl alcohol (2 & 4%), CMC (0.75 & 1.5%), pectin (0.75 & 1.5%) and chitosan (0.5 & 1.0%), evaluated along with modified atmosphere packaging, it was found that pectin 0.75% helped in extending the marketability of minimally processed carrots to 21 days at 8°C. The treated samples showed low cut-end whitening and other sensory changes as well as better retention of carotenoids and antioxidants. Rise in levels of phenolic acids such as ferullic, vanillic and syringic acids was also noticed in the treated samples compared to fresh carrot.

Radish

Minimal processing protocols

❖ Minimal processing protocol for radish was standardized. Among the various edible coatings used, poly vinyl alcohol and modified atmosphere helped in extending the shelf life of fresh cut radish up to 7 days at 8°C storage.

Screening of LAB isolates for antimicrobial activity

❖ 25 isolates of lactic acid bacteria with antagonistic activity against *Salmonella* and *Listeria* were isolated from vegetable samples (bean, brinjal, carrot, green leafy vegetables, etc.) obtained from market. Out of the 25 isolates, 4 isolates were confirmed to be antimicrobial peptide producers.

Tomato

Usage of processing wastes for value added products

❖ A protocol involving enzymatic extraction of lycopene from tomato peels (processing waste) was standardized and the extracted lycopene was used for fortification of fruit/vegetable beverages. Fortified tomato juice and soup exhibited higher nutritional values in terms of proteins, ascorbic acid, phenols and antioxidant activity. After two months of storage at ambient temperature (28.72 to 35.58°C) these lycopene enriched beverages retained its nutritional content significantly. The value of their antioxidant activity ranged from 9.72 to 12.53 mg AAE/100g, ascorbic acid from 3.85 to 4.48 mg/100g, proteins from 6.15 to 8.71%, and total lycopene from 2.51 to 18.17 mg%. The sensory quality of the products after storage for two months was acceptable.

Green Leafy Vegetables

High humidity storage box for vendors

❖ The high humidity storage box designed for push cart vendors was found suitable for retaining the freshness and marketability of the palak and fenugreek leafy vegetables up to 2

Palak leaves after 2 days of storage *Fenugreek leaves after 2 days of storage*

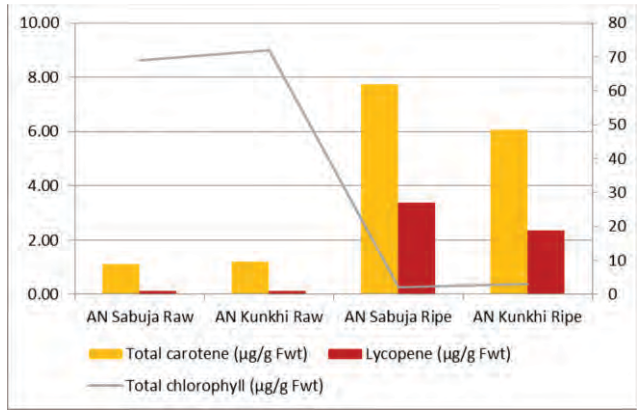
days compared to only for one day with traditional practice.

Under Utilized Fruits & Vegetables

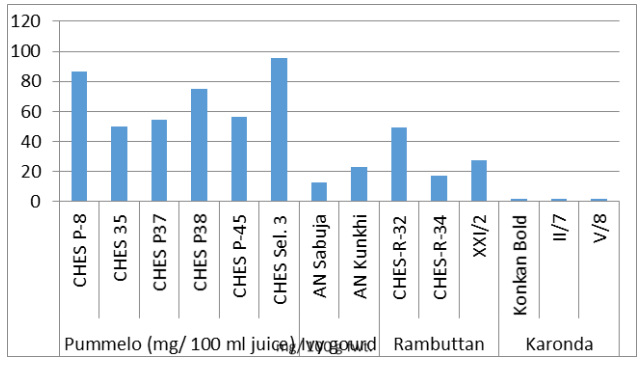
Nutritional profiling

❖ The nutritional profiling and estimation of antioxidant potential of pummelo (*Citrus grandis*) - collections (CHES P-8, CHES P-35, CHES P37, CHES P38, CHES P-45 and CHES Selection 3); rambutan *(Nephelium lappaceum)* - collections (CHES-R-32, CHES-R-34 and XXI/2); ivy gourd (*Coccinia indica*) - varieties Arka Neelachal Sabuja and Arka Neelachal Kunkhi; avocado (*Persea americana*) - collections (PA-IV-5, PA-VII-1, PA-II-1 and PA-II-4); and of karonda (*Carissa carandas*) - collections (Konkan Bold, II/7 and V/8) revealed significant variations.

❖ Among the five future fruits, rambutan, karonda, pummelo, rambutan and avocado contained higher concentrations of protein. Juice of pummelo (CHES-P38, P-48 and Selection 3) had highest soluble sugars while rambutan and karonda had the highest starch content compared to the remaining crops. Karonda had higher phenols, flavanoids and anthocyanin than the other crops. Skin and seed of avocado had high phenol and flavanoid contents, while anthocyanin was found only in the skin of avocado. These constituents contributed to higher antioxidant activity (DPPH, FRAP activity). The phenol profile varied significantly in different fruits and parts of fruits: notably greater quantities of protocatechuic acid, gentisic acid, salicylic acid, vanillic acid, *p*-hydroxy benzoic acid, gallic acid in rambutan pulp; caffeic, *p*-coumaric acid and ferulic acid in pummelo. Ivy gourd on ripening, showed increased contents of carotene and lycopene; whereas, total chlorophyll (a + b) decreased. The pink fleshed collections of pummelo - CHES 35, CHES P37, CHES P38 and CHES P-45 had higher carotene and lycopene content, while vitamin C content was high in yellow pummelo collections - CHES P-8 and CHES Selection 3.



Changes in pigment content in ivy gourd with ripening



Vitamin C content in future fruits and vegetables

Survey on harvest & post-harvest losses and unmarketable wastage in flowers

❖ Survey of flower farms in Tumakuru district of Karnataka and Salem district Tamil Nadu showed no wastages or losses at harvest stage. However, the survey of markets in Salem, Erode, Hosur, Bengaluru and Mangaluru showed that during marketing at short distance (50-60 km from the production centres), the wastage / loss were in the range of 2.1 to 4.5% at commission agents-cum-whole sellers level in flowers like chrysanthemum, rose and marigold. While at retailers level, the loss was in

Harvesting of chrysanthemum

the range of 1.0 to 4.5%, with an aggregate of 3.1 to 4.5%. In distant markets (300-500 kms from production centres) the losses at commission agents-cum-whole sellers level was the highest (20.8 to 25.70%) followed by retailer's level (in the range of 10.70 to 13.04%). Soiling, drying, petal drop and discoloration were responsible for wastages / losses in flowers.

Cut foliage

Packaging and storage

❖ Packaging and storage of cut foliage viz. maleluca, fern, cordyline, asparagus and dracaena revealed that wrapping with polyethylene 100 gauge and packaging in CFB box reduced 6-8% of weight loss at RT(temp.26°±2°C & RH 45-55%) over control (22-28%). Among these five cut foliage evaluated, maximum vase life of 90 days was obtained with cordyline while, asparagus had the least vase life (8 days).

Rose

Stage of harvest for maximum shelf and vase life

❖ Optimum harvest stage for longer shelf life and vase life was determined in six varieties of rose cut flowers. Cut flowers harvested at tight bud stage had longer vase life of 9.5 days in rose var. Carvette compared to other varieties (7.5 -9.2 days).

Vase solutions for increasing vase life of cut rose

❖ Vase solution of 250 ppm of patchouli essential oil + 1.5% sucrose extended the vase life of rose var. Carvette cut flowers by two days over the control and other essential oils (9.5-12 days). Optimum concentration of patchouli essential oil was 300 ppm for chrysanthemum and tuberose cut flowers.

Dried flowers

Product Development

❖ Various dried flower products, such as photo frames, mementoes, tea coaster, table mat, floders, gift bags, etc have been prepared and evaluated.

Mushrooms

❖ A recipe for mushroom fortified chutney powder was standardized to enhance the nutritional quality of the daily diet. The fortified chutney powder was found to contain 2.75% higher protein content 2.39% higher fibers and 2.52% less fat compared to control.

Harvest stages of rose var. Corvette cut flower
S_1: Tight bud stage; S_2: Two petals opened stage; S_3: Four petals opened stage

3.5.2. Farm Mechanization

Improvement of animal drawn onion seed drill: The animal drawn onion seed drill was improved by reducing overall weight and wheel type for better traction. Metallic seed chambers were replaced with plastic and the support frame was redesigned to reduce the weight of the machine. It was tested in the farmer's field at Dibburahalli, Chintamani (Tk.) during kharif season using Arka Bindhu variety of onion. The plant population was 180 – 220 seedlings/m^2 and average plant to plant distance was 6 – 8 cm. The improved onion seeder had a field capacity of 3 ha/day.

Improvement of manual drawn onion seeder: The manual drawn onion seeder was improved with metal wheels instead of plastic wheels to have better traction and increased width for more field capacity. The operating width is 1.2 m and field capacity was 0.2 ha/h.

Manual drawn onion seeder with metal wheels

Tractor drawn bed former cum onion seeder: Tractor drawn bed former-cum-onion seeder consisted of bed former, seeder and seed closures attached to it. The bed former forms a

broad bed of 90 cm width and 15-22.5 cm height while seeds are sown by seeder on the bed. Six onion seed chambers of size 150 mm dia. and 50 mm width made of plastic were mounted on a shaft and the shaft was driven by a ground wheel. Holes of 3.5 mm diameter were drilled along the circumference of the chamber at a radial pitch distance of 50 mm. Onion seeds were filled in the chamber to half its volume. The seeds were dropped at a distance of 8 – 12 cm row to row and 8 – 10 cm plant to plant and seed closures covered the seed with soil on the bed. The seedling population was 65 – 75 per square meter after seed germination. The field capacity was 0.2 ha/h.

Tractor drawn bed former-cum-onion seeder

Motorized bulb breaker for garlic planting material production: A garlic bulb breaker to break and separate cloves from the whole garlic bulb was designed and developed for planting material production. The garlic bulb breaker consisted of feeding chute, two rubber padded rollers for each stage (two stages – top and bottom), blower, outlets for cloves and skins, main frame and power transmission system. The garlic bulb breaker was evaluated with three types of rubber padding material (plain – plain ; button – button; and corrugated – corrugated), four clearances between the rollers (15, 18, 21 and 24 mm) and three peripheral speeds of roller (25.92, 34.56 and 43.2 m/min). Germination experiments were conducted to study the quality of garlic cloves separated by the machine and planted. Highest breaking efficiency of 75 per cent was obtained with corrugated type rubber padding material at an optimum clearance of 18 – 21 mm between rollers and at 43.2 m/min peripheral speed of rollers. Minimum damage of 0 to 0.7 per cent and clove loss of 1.08 per cent were observed at optimized parameters. The garlic cloves separated by the developed machine had 100 per cent germination. The breaking capacity of machine was 400 kg/h. The operating cost of the machine was Rs. 0.3/kg against Rs. 2.25 /kg by manual clove separation.

Motorized Garlic bulb breaker

Outdoor unit for growing mushroom: An evaporative cooling type outdoor growing unit of size 1m x 1m x 2m for mushroom was designed and fabricated to grow mushrooms for small scale growers. The outdoor frame of the growing chamber is made up of PVC and GI pipes, nylon mesh, plastic mesh covers to avoid insect entry and water absorbing cloth as outside cover to maintain RH and temperature. It contains a water tub on portable frame from where the water is pumped on to the cloth for wetting, using a pump and drip pipe line with holes. Due to evaporative cooling the temperature reduced and relative humidity raised inside the chamber. Initial testing during 2nd fortnight of March 2015 showed the temperature in the range of 19-41°C (average 25.5°C) and humidity 19-82% (average (55%). Nylon rope and rings were used to hang bags inside the chamber from the top frame of the chamber. The water was recycled by collecting it at the bottom water tub. It accommodates 25–30 Nos. of 1kg bags to grow mushroom.

Outdoor unit for growing mushroom

Testing of Integrated system for cleaning, conveying and storage of grain: Integrated system for grain cleaning, conveying to the storage bin and to the boiler was tested. The motorized bucket elevator system was developed and adopted to combine the three activities of grain cleaning, conveying to storage bins and conveying to grain boiler could be done simultaneously saving both time and manpower by 50%.

Conveyor system for grain storage and grain boiler

FERTREE Drill

❖ An efficient and cost effective power tiller mounted prototype for fertilizer application in fruit crops has been developed at CHES, Bhubaneswar (CHES FERTREE Drill) to reduce the cost of fertilizer application and to address the problem of labour shortage during application period. It can be attached with the power tiller and deliver fertilizer effectively in the feeder root zone. The implement has three units: storage, transmission and delivery unit. Storage unit has fertilizer carrying capacity of 20 kg. There are separate chambers for granular fertilizer (Urea, DAP, MoP) and powder form of fertilizer (SSP) in the fertilizer box. Agitator (non-screw type) has been attached at the base of the box to ensure continuous flow of fertilizer. The transmission unit has two PVC delivery pipe (5 mm dia.) which receives fertilizer from box and transmit to the delivery unit. The delivery unit has a funnel shaped collection box (20 x 20 x20 cm) without valve wherein delivery pipe (4 cm dia.) is attached. The delivery pipe is attached with tyne and furrow opener.

Specifications, cost and labour efficiency of FERTREE drill

Fertilizer carrying capacity	20 kg
Number of furrow opener	1
Width of furrow	50 mm
Depth control - 20-30 cm	20-30 cm
Fertilizer Delivery system	Adjustable
Delivery rate	4-10 kg/min.
Coverage area/day (6-7 hrs)	1 ha (400 plants) 2 ha (100 plants)
Cost of fertilizer application	Rs. 1800/day (Labour 3 + Fuel)
Cost effectiveness (FERTREE DRILL: Manual (16 labour))	Rs. 1800: 4000 (222%)
Labour efficiency (in compare to manual)	533% (3: 16)
Cost of the FERTREE drill	Rs. 20000-25000

A view of FERTREE drill

Mechanical peeling of jackfruit for culinary purpose

❖ CHES, Bhubaneswar developed a mechanical peeler for minimal processing of tender jackfruits. The mechanical peeling reduced the drudgery and saved time. Further, dipping of pieces in solution containing citric acid (1.0%) and ascorbic acid (1.0%) enhanced the shelf life jackfruit by one week when packed in polyethylene bags. This model of minimal processing of tender jackfruit and packing in RTC packets was taken up as one of the interventions under Tribal Sub Plan in tribal villages Mohna block of Gajapati district and is highly successful. The tribal women are able to process more quantities of jackfruits and market in the nearby towns.

Modification of existing mango harvester to improve the efficiency

❖ The load of the harvested fruits held in the net in the existing model puts heavy strain on the shoulders and upper arms of the person harvesting the mangoes. In Odisha traditionally mango harvesting is done by shaking the trees or manually plucking them which has a lot of disadvantages especially the high drudgery, fruit damage due to falling on ground and contamination with soil and debris. Looking into these difficulties, CHES, Bhubaneswar has improvised the mango harvester with an aim to reduce drudgery, avoiding injuries to the fruits

and increasing the harvesting efficiency in terms of number of fruits harvested per unit time. The major modification of the harvester included replacing the net-bag with a soft cloth/ shade net stitched into funnel like structure (approx 15 ft. long), replacing the harvester frame with galvanized iron wire, and removing the upper portion of the handle . Replacing net with soft cloth/ shade net funnel has reduced the requirement of frequent raising and lowering of the harvester with load of fruits. This modification has reduced the strain on the shoulders of the person harvesting the fruits, thus increasing harvest efficiency from 1.5 kg/min to 3.5 kg/ min. Further, the funnel with long pipe assisted the harvested fruits to slide slowly down to the ground or to a container placed below the tree. This completely avoided fruit injury due to falling on the ground or getting dirty or contaminated. Replacing the iron frame with galvanized iron wire has further reduced the weight of the structure by 250 gm. Removal of the upper portion of the handle has provided more space for latching on the fruits and reduced the instances of the fruits bumping and falling down.

Existing mango harvester

Modified mango harvester

Modified mango harvester with transmission hose

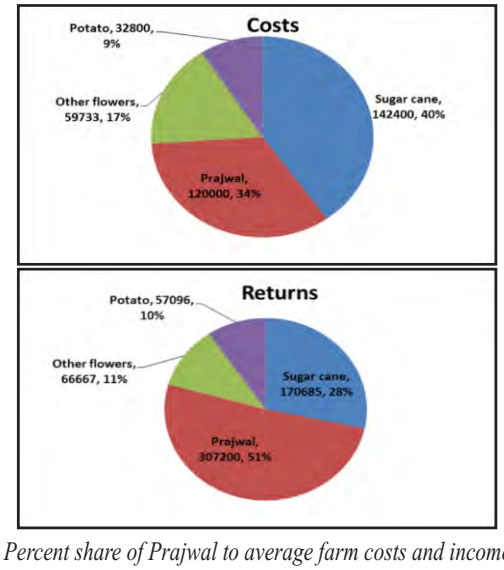
3.6. Economics of Production, Statistical Research and Computer Application

3.6.1. Economics of Production, Marketing and Trade

Assessing the economic impact of adoption of tuberose hybrid, Prajwal

- Tuberose hybrid, Prajwal, released by IIHR is widely adopted in Dharmapuri in Tamil Nadu and Meerut in UP regions. Economic assessment based on a sample of 28 growers from each region suggested distinct variations in crop production practices. The crop is grown on a three year cycle including two year ratooning in Dharmapuri, while it is grown as an annual crop in Meerut. The third year crop, though gives good return, often found to get high nematode infestation, making it impossible to grow the crop again in the same field in Dharmapuri. Sale of lose flowers by weight is more common in Dharmapuri, while cut flowers of 24 spikes is popular in Meerut. The per hectare cost of cultivation worked out to Rs.3.5 lakh in Dharmapuri and Rs.4.41 lakh in Meerut with net returns of Rs.5.34 lakh and Rs.5.30 lakh and BCR of 2.52 and 2.34 respectively.

- The cultivation of Prajwal in Meerut is considered important as the crop is taken up in small area of around an acre for obtaining a daily ready cash of around Rs 1000 for meeting the household expenses. Though hardly 15 % of the average farm area is allotted towards tuberose in Meerut, the crop accounts for 34% costs and contributes to more than 51% of the average annual farm income thereby signifying its preference for the farmers.



Percent share of Prajwal to average farm costs and income

Impact of technology and efficiency on tuberose cultivation

- Frontier production function and decomposition model was applied for the pooled sample of 58 for estimating the technological impact on efficiency of tuberose Prajwal cultivation. Results indicated that the contribution of technology towards gross revenue and production is lower in Dharmapuri than in Meerut. Though the efficiency of production did not show significant difference, higher input use by Dharmapuri farmers resulted in higher overall returns.

Export performance of processed fruit and vegetable products

- **Mango pulp:** The export of mango pulp from India recorded a growth of 7.2% in quantity and 11.76% in value. Saudi Arabia, UAE, Netherlands, Kuwait, Yemen, USA, UK, Germany and Canada are the major importers of mango pulp. All the major importing countries registered positive and significant growth. Saudi Arabia continues to be the major importer of mango pulp from India. The share of Netherlands, UK, Yemen, and Canada increased during TE 2012-13 while that of USA and Kuwait decreased.

- **Dried and preserved vegetables:** The export of dried and preserved vegetables recorded negative and non-significant growth during the last decade. USA was the major importer (14.06%) followed by Spain (10.63%), France (10.15%), Russia (8.33%), Belgium (8.11%) and Germany (6.5%). Except France (9.18% in quantity and 14.97% in value), other countries registered negative growth in import of dried and preserved vegetables. The shares of all the major importing countries except Bangladesh and Nepal increased during TE 2012-13. Maximum increase was observed in France, Russia, Spain, Netherlands and Australia.

- **Export performance of gherkin:** Gherkin from India is exported in three forms *viz.,* fresh/chilled, provisionally preserved and prepared/preserved by vinegar/acetic acid. The export of gherkin (total) from 1987-88 to 2012-13 increased from 1978 MT to 2,39146 MT with a compound growth rate of 40.69% in quantity while the export earnings increased from Rs 338 lakhs to Rs 85541 lakh with a compound growth rate of 44.34%. Regarding composition of

exports during 2012-13, provisionally preserved gherkins accounted for 73 per cent followed by prepared/preserved (27%) and fresh (1%). The share in the exports of provisionally preserved gherkins increased from 60 per cent during 1990-91 to nearly 73% during 2012-13. India ranks first in the trade of gherkin in the international market, accounting for about 31.35% of 677 thousand MT of World Trade and 27.63% of value of World trade of 655 million US $ during 2012. The other major countries doing trade in the international markets are Germany (17% of value), Turkey (11%), USA (9%) and The Netherlands (5.5%). India increased it's per ton value realization from US $ 494 to US $846.5 suggesting improvement in its export standards as well as the advantageous position in the international market. The major destinations of exports of fresh gherkin from India are UAE, Nepal, Oman, Pakistan and Singapore which together account for nearly 78% of exports during 2012-13 in value terms. Similarly the major destinations of exports of preserved cucumbers & gherkins from India are Russia, Belgium, Spain, United States and France together accounting for 82% of exports during 2012-13 in value terms. The major destinations of exports of preserved cucumbers & gherkins from India are Russia, United States, France, Belgium and Canada which together accounting for nearly 66% of exports during 2012-13 in value terms. The volume of international trade in cucumber and gherkin (MT) and the exchange rate (Rs/US$) are the important factors influencing the exports.

Economics of production of papaya

❖ The estimation of economics of papaya was taken up in Mandya, Mysore and Malavalli areas of southern Karnataka. The average size of holding was 0.46 ha and Red Lady was the most popular variety cultivated. With spacing of 8x8, 8x7, 8x6 feet, the average planting density was 1860 plants/ha and farmers applied 32 t of FYM and 570 kg of N, 953 kg of $P_2O_5$and 1024 kg of K_2O/ha. Papaya cultivation employed 202 days of men labour and 403 days of women labour. It was observed that the majority of men labour employed were from their own family while women labourers are mostly hired from outside. The total cost of cultivation worked out to Rs.3,72,643/ha. The major costs were on inorganic fertilizers (24.6% of total costs) and the human labour input (24.7%). Farmers realized a yield of 110.09 t /ha against the potential yield of about 200. There existed large variability in yield across farmers (CV=73 %). The cost of production worked out to Rs. 3.38/kg and the average price realization was Rs. 8.73/kg. The average gross return was Rs. 9, 48,473/ha and the net return was Rs. 5,75, 830/ha. The distribution of net profit or loss revealed that nearly 15% of farmers realized net return as high as Rs. 10 lakh and 19% of farmers incurred loss in cultivation of papaya. However, nearly 57% of farmers earned net income of more than Rs 7 lakh/ha. The BC ratio for papaya cultivation was 2.55.

3.6.2. Statistical Research

Studies on influence of outliers in designed horticultural crop experiment

❖ Outliers are likely to occur in the data generated from a designed horticultural crop experiment due to various reasons such as disease and/or insect attack on some particular plot of the experiment and mistakes creep in while recording data. Carrying our regular ANOVA with outliers data in any of the replications, may result in non-significant results among the treatments under comparison. In order to identify aberrant data in a general complete block design, three different measures namely studentized residual; cook's distance and modified cook statistic were computed. Measures were tested to study the influence of outliers on treatment effects in a designed experimental data in brinjal and the results indicated that the probability of type I error decreased from 7.22% to 2.51%, after correction for outliers, which clearly indicates the influence of outliers on treatment effects.

Optimum sample size required for developing crop logging models in banana and papaya using bootstrapping

❖ Bootstrapping is a resampling procedure wherein samples of different sizes were generated to arrive at the optimum sample size required for crop yield estimation. Original sample (size of n=100) corresponding to various crop specific traits were utilized to generate samples of various sizes starting from n=50 till n=500 (increment of 10). Every time, using the sample size generated models were fitted and mean square errors were computed. Finally, a model having minimum MSE (hence high R^2)

and the corresponding sample size were identified as optimum. Accordingly, a sample of size 150 for Banana and 200 for Papaya would be the optimum for developing biometrical models with least error in prediction. Effect of six outliers identified using Cook's measure, when corrected increased the prediction power of crop logging models by 7% and 16% for the respective crops.

3.6.3. Computer applications

Database development

Database on IIHR varieties and hybrids for web based retrieval system

❖ Database on varieties/hybrids of earlier releases of IIHR, with salient features comprising more than 100 varieties/hybrids were uploaded to retrieval system. Web pages were developed to display the data of old varieties and hybrids as images. By clicking on image its description and salient features displayed as pop up window, news page for latest developments on variety releases are also designed and developed.

Development of database on disease and disorders of tomato crop for development of crop management module for DSS

❖ Database on Tomato diseases *viz.,* fungal, viral, bacterial and other disease along with detailed images and diagnostic procedures were developed for disease management modules. Data base on various abiotic disorders of tomato were developed with images and control measures for disorder management. This data was uploaded to the knowledge base of DSS to derive solutions from inference provided in the knowledge base of DSS.

Development of national database on mango

❖ A DBT funded project is under operation at CHES, Bhubaneswar. The project aims to develop a National database on mango by collecting information from different districts of the states like Odisha, Chhattisgarh and Jharkhand. The information is also obtained from those farmers who are cultivating more than 10 mango varieties. The data on cultivation practices; pest and disease incidences, utilization of mango *etc.,* have been recorded. Fifteen districts of Odisha have been covered.

Software Development

Expert system development for tomato

❖ An 'Expert System on tomato' has been developed as interactive modules can provide on-line information on different crop management issues like disease management, disorder management and general features such as planting system, propagation, irrigation, harvesting, cultural practices.

Portal of expert system on tomato

Disease diagnosis module

❖ Interactive disease diagnostic modules were developed for the users to identify the type of disease observed in their field. This module has four sub groups *viz.,* fungal, viral, bacterial and others. The users have options to choose the type of infection. Each module is displayed as scrolling images. If the disease symptoms appear similar to the problems observed in farmer's field then by clicking the particular image a solution page is displayed in a new window with the details of disease along with its control measures. If the symptoms do not match with the images displayed, then it is redirected to another set of disease modules for choosing the similar type of infection based on images till the conclusions arrived.

Disorder management module

❖ Tomato plants can develop several abiotic disorders that distort plants and blemish fruits. In this module tomato disorders, with their description are added to the DSS for the users to identify the type of disorder. If the disorder symptoms are observed similar in nature then by clicking on the image, expert system provides the details of disorder and its curative control measures using the inference available in the system.

Expert system development for mango

❖ The expert system on mango has been developed as interactive modules comprising general features such as planting system, propagation, irrigation, harvesting and cultural practices under crop profile.

Portal of expert system on mango

Disorder management module in mango

❖ Many physiological disorders in fruit affect both quality and storage life of mango in all growing regions of the world. The disorder management module in mango provides solution for several fruit disorders in mango.

In this interactive module, the mango disorder with its description and dynamic images are available in DSS for the users to identify the type of disorder complexity. By clicking the scroll buttons on the image, the image keeps changing till the symptoms are matched with disorder in field. Once the disorder looks similar to the user's problem then by clicking the image a solution page is displayed in a new window.

Disease diagnosis modules

❖ In this module, the images of different fungal diseases are displayed by clicking the scroll buttons. If the disease symptoms appear similar to the problems observed in farmer's field then by clicking the particular image a solution page is displayed in a new window as symptoms and control measures of the disease from the knowledge base of expert systems else it will be redirected to other modules.

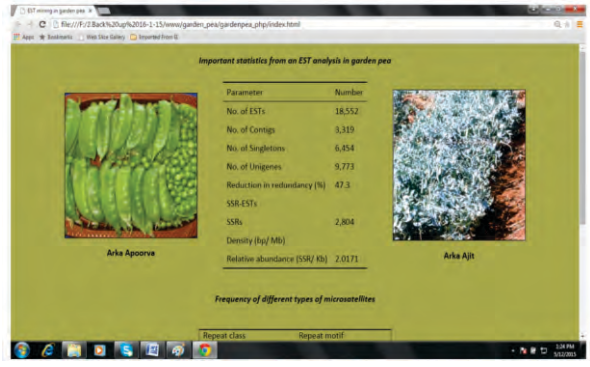
Development of AICRP (Fruits) information system

❖ The website for AICRP information system was developed using Microsoft Web expression applications. The Home page consists of flash objects with scrolling crop images. The navigation menu and sub menu hierarchy comprising Home, About AICRP, Centers, Varieties, Achievements, Genetic resources on crops with center details, Technologies developed, Contact information were developed. The content of web based information system for AICRP (Fruits) is available at http://pcfruits.wix.com/aicrp.

Bioinformatics

Web based interfaces for EST-SSR databases

❖ Web based interfaces have been developed in WAMP server web development environment for retrieving information from the EST-SSR databases of watermelon, muskmelon, garden pea, *Brassica Oleraceae*, *Araceae* and *Myrtaceae*. The databases have been created in MySQL RDBMS for Windows while the retrieval system has been created using PHP scripting language. The web based user interface allows for querying the database based on SSR motif, SSR length, SNP type *etc.*



Web based interfaces portal for EST-SSR database

Classification model for the identification of hsp100 proteins

❖ A Multi-Layer Perceptron (MLP) neural network model has been developed for the identification of hsp100 proteins from non-hsp100 proteins, based on the features - amino acid compositions and length of the protein sequences. The important features were selected using Correlation Based Feature Selection (CBFS) method. K-fold cross validation has been used for the generation of training and testing sets. An accuracy of 97.7 % was obtained by this model. The performance of this model was found to be superior to the models based on the decision tree J48 and nearest neighbour. A program has been written for computing the amino acid compositions and di-peptide compositions of a set of protein sequences.

3.7. Extension Research

3.7.1 Identification of Research and Extension Gaps for Varieties and Technologies Developed by IIHR, Bengaluru through PRA

In order to identify the research and extension gaps pertaining to "Protected cultivation of vegetables with bio-intensive management of pests and diseases", Participatory Rural Appraisal (PRA) was conducted in Karnataka, Andhra Pradesh, Tamil Nadu and Kerala with more than 650 stakeholders as respondents *viz.,* farmers, officials of developmental departments, research personnel of corporate companies, marketing agencies, processing as well as seed industry, subject matter specialists (SMS) of KVKs and a few exporters from India, Singapore, Malaysia.

Research gaps in protected cultivation of vegetable crops

- Identification of root stocks for grafting and development of hybrids resistance to foliar and soil borne diseases in capsicum, tomato, parthenocarpic cucumber and cherry tomato.
- Appropriate scheduling of silver based H_2O_2 and its effect on soil microbial population, growth, quality and yield of vegetables in protected environment
- Integrated approach in management of soil borne pests and diseases to produce export quality produce
- Fertigation schedule for Melons, high value Herbs and leafy vegetables like Lettuce, Broccoli and Celery
- Appropriate scheduling of commercial fungicides and insecticides and their compatibility with botanicals and bio-pesticides used in polyhouse cultivation.
- Validation of application of bio-pesticides through *Jeevamrutha* and *Panchagavya* used by farmers and their impact on soil-borne pests and diseases in protected cultivation

Extension gaps in protected cultivation of vegetable crops

- Production package for bio-intensive management of Phytopthora, bacterial wilt and nematodes in different vegetable crops under protected environment
- Application of microbial consortium for enhancing growth, yield and quality of vegetable crops under protected conditions
- Production package for Cherry Tomato, Jordanian Tomato and Leafy Vegetables
- Use of different colour shade nets and their impact on growth, yield and quality of vegetables under protected environment
- Integrated water and nutrient management including fertigation for vegetable crops in protected cultivation
- Cropping sequence/pattern in vegetables for commercial polyhouse cultivation under varied micro-climatic situations.

SWOT analysis of protected cultivation of vegetable crops

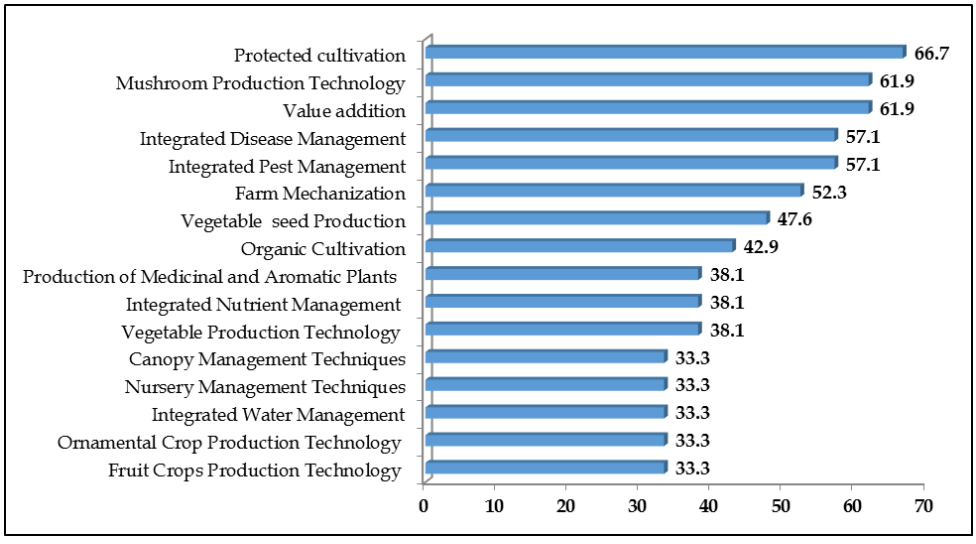
- A SWOT analysis was undertaken on "Protected cultivation of vegetable crops" with the active participation of 330 stakeholders such as farmers, officials of developmental departments, representatives from Input Agencies/Corporate Companies, Banks and Market. The results throw adequate light on research, development and policy strategies to promote protected cultivation of vegetables.

3.7.2. Impact of Capacity Building of Trainees on the Adoption of ICAR-IIHR Technologies including Identification of Future Training Needs

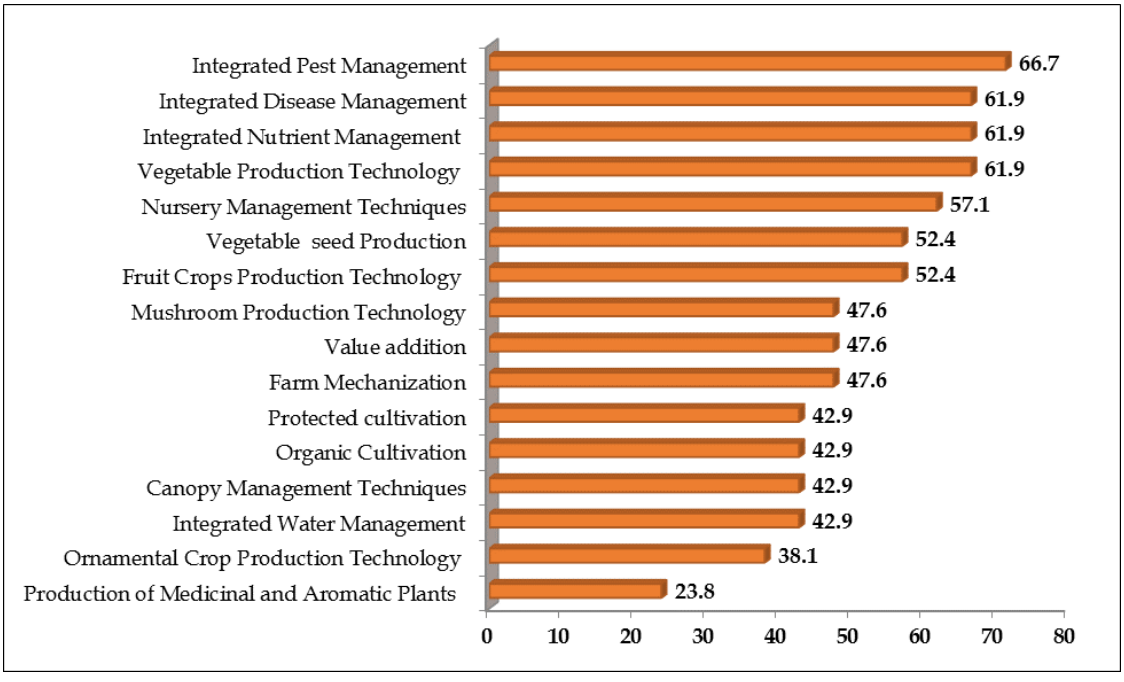
- The reaction and learning level impact of ICAR-IIHR training programmes were assessed for selected training programmes. It was found that the training programmes were significantly effective in imparting knowledge. The training needs of extension personnel of KVKs and farmers of North East Hill Region (NEHR) were assessed. Protected cultivation, mushroom production technology, value addition, integrated disease management, integrated pest management, farm mechanization and vegetable seed production were the major training needs of KVK personnel of NEHR. Integrated pest management, integrated disease management, integrated nutrient management, nursery management techniques, vegetable seed production technology and fruit crops production technology were the training needs of farmers of NEHR as felt by extension personnel of KVKs.

Effectiveness of training programmes

Training Theme	Participants	Average Knowledge Score		t value
		Before	After	
Rejuvenation and Management of Important Fruit crops (16-20, December 2014)	Farmers (23)	116	239	10.66**
Organic Cultivation of Selected Vegetable and Fruit Crops (5-9, January 2015)	Officers (25)	45	53	2.89**
Organic Cultivation of Selected Vegetable and Fruit Crops (27- 31, January 2015)	Farmers (12)	33	67	8.66**
Integrated Pest and Diseases management in Horticulture (19- 24 January 2015)	Officers (25)	39	70	11.41**
Integrated Pest and Diseases management in Horticulture (16 - 21 February 2015)	Farmers (14)	24	45	2.89**



Training needs of extension personnel of KVKs of NEHR (N=22 KVKs)



Training needs of farmers of NEHR as felt by KVKs personnel (N=22 KVKs)

3.7.3. Assessment and Refinement of ICAR-IIHR Technologies through Farmers' Participatory Demonstrations

❖ Field demonstrations on ICAR-IIHR techonolgies were organized under real farm situations in collaboration with KVKs and progressive farmers. The productivity potentials and profitability of ICAR-IIHR technologies under real farm situations are given below.

Productivity potentials of ICAR-IIHR technologies under real farm situations

Technology	Centre/ Location	Yield (t/ha)		% yield increase
		IT*	FP*	
Tomato				
Arka Rakshak vs Private	KVK Hirehalli, Karnataka	70.0	52.0	25.7
Arka Rakshak vs Private	KVK Doddaballapura, Karnataka	68.1	57.4	15.7
Arka Rakshak vs Private	KVK Mysore, Karnataka	72.0	51.0	29.1
Arka Rakshak vs Private	Seethakempanahalli, Karnataka	85.0	64.8	23.7
Arka Rakshak vs Private	KVK Krishna	64.0	55.0	14.0
French Bean				
Arka Suvidha vs Local	KVK Hirehalli, Karnataka	9.8	6.8	30.6
Arka Suvidha vs Local	KVK Krishnagiri, Tamil Nadu	14.6	12.0	17.8
Arka Anup vs Local	KVK Krishnagiri, Tamil Nadu	15.5	12.0	22.5
Hot Pepper				
Arka Kyati vs Private	KVK Chamrajanagar, Karnataka	29.3	23.0	22.7
Arka Kyati vs Private	KVK, Krishna, Andhra Pradesh	26.0	20.0	23.0
Dolichos				
Arka Amogh vs Local	KVK Hirehalli, Karnataka	15.2	11.4	25.0
Marigold				
Arka Bangara vs Local	KVK Hirehalli, Karnataka	10.6	7.4	30.1
Climate Resilient Technology Package				
Onion (Before vs After)	Kadur Taluk, Karnataka	25.3	16.4	35.1
Tomato (Before vs After)	Kadur Taluk, Karnataka	45.3	32.2	28.9

*(*IT-IIHR Technology; FP-Farmers Practice)*

3.7.4. Application of Innovative Extension, Information and Communication Methodologies for Transfer of Technology in Horticulture

❖ A Farmers Interest Group (FIG) was formed at Hosahalli village, Doddaballpura taluk. The purpose was to demonstrate the impact of group approach in dissemination of improved horticultural production technology. The baseline survey in the village indicated that 67% of the farmers grow banana, tomato, French bean and chillies. Based on the baseline survey, ICAR-IIHR technologies such as integrated nutrient management package for vegetables, application of microbial consortia for enhancing growth of vegetables and banana, foliar application of banana special, bunch feeding of nutrients etc., were demonstrated in the field of members of FIG. As a result, there was 100% adoption of micro-nutrient application along with recommended fertilizers in banana and vegetables crops. It was also found that as a result of demonstration, 86 % and 96% of the farmers adopted integrated pest management technology in vegetables and bunch feeding in

IIHR Interventions demonstration among FIG members

banana respectively. The demonstration of bunch feeding of nutrients resulted in 22% increase in bunch weight of banana in demonstration plots (13.80 kg) than the control plots (10.82 kg).

3.7.5. Demonstrations and Technology Interventions

Demonstration of Climate Resilient Technologies (CRTs) of IIHR, Bengaluru through Technology Demonstration Component (TDC) of National Initiative on Climate Resilient Agriculture (NICRA)

❖ Under the NICRA project, demonstration of CRT package in onion crop was organized in NICRA adopted villages (4) in 40 acres. Bullock and tractor drawn onion drum seeder were refined based on the felt needs of farmers and their use was demonstrated in 50 acres in NICRA adopted villages. Manually operated onion grader, tractor drawn onion digger and seed extractor were introduced in NICRA adopted villages. Disease resistant, high yielding onion variety (Arka Kalyan) and hybrid (Arka Lalima) were demonstrated along with CRT package such as raised bed cultivation, providing good slope and drainage, use of bullock drawn and tractor driven onion drum seeder, foliar nutrition (Vegetable Special) and IPM/IDM practices in 120 acres in NICRA adopted villages, which resulted in enhanced plant health, higher yields, enhanced bulb quality and shelf life. ICAR-IIHR tomato hybrids, Arka Rakshak and Arka Samrat (Triple disease resistant) were demonstrated in 15 acres of NICRA adopted villages.

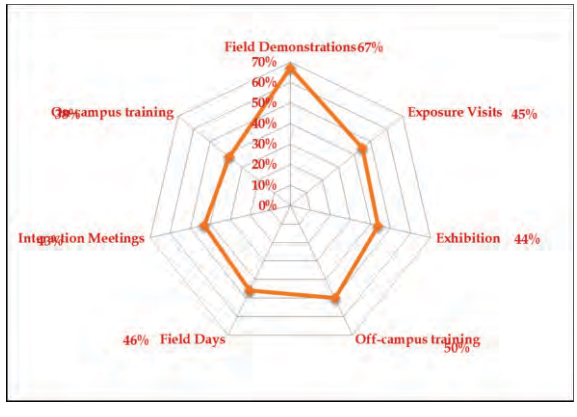
Demonstration of bullock-drawn onion drum seeder

Demonstration of bio-control of pests and diseases and integrated crop management practices in protected cultivation of vegetables and flowers

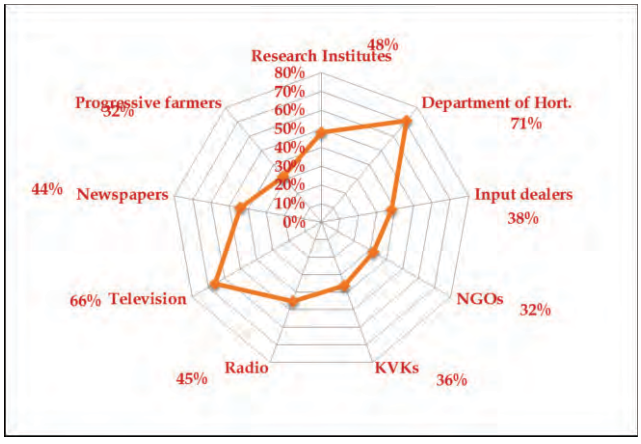
❖ Under the sponsored project of RKVY, Govt. of Karnataka, bio-intensive crop management of vegetables and flowers was demonstrated in 110 acres under poly house and net-house conditions. The crop management practices include varieties/ hybrids, bio-pesticides, botanical pesticides, training and pruning techniques, harvesting tools, post-harvest management practices, marketing management etc. developed by ICAR-IIHR. A portal for providing complete information about protected cultivation of vegetables and ornamental crops is being developed.

Preferences of horticulture farmers

❖ A National Farmers Meet (NFM) was organized by Indian Council of Agricultural Research (ICAR) and Tamil Nadu Agricultural University (TNAU) at Regional Research Station (RRS), Paiyur, Tamil Nadu on 14.3.2015. The purpose was to sensitize the farmers about improved horticultural production technologies and obtain first-hand information about problems of horticulture farmers of Karnataka, Tamil Nadu, Andhra Pradesh and Kerala. A brief survey was conducted at NFM with horticulture farmers as respondents (60) through a structured questionnaire. Analysis of the survey data indicated that mango, tomato and marigold are the major fruit, vegetable and ornamental crops cultivated respectively. Non-availability of critical inputs such as fertilizers, seeds/planting material and lack of remunerative market price are the major issues in contemporary horticulture, apart from unawareness towards improved horticulture production technologies. Field demonstrations and off-campus training programmes are the two major extension interventions preferred by the horticulture farmers whereas mass media channels are preferred as information sources apart from institutional sources such as development departments and research Institutes.



Preferences of horticulture farmers towards extension methods



Preferences of horticulture farmers towards sources of information

Bio-pesticide technology interventions for livelihood improvement of scheduled caste population in Vellore, Tamil Nadu (Sponsored by DST)

❖ Two training programs were organized on use of bio-pesticides at KVK, Vellore, Tamil Nadu to 200 SC/ST farmers on 25.11.2014 and 03.03.2015, during which bio-pesticides were distributed freely to the farmers to reduce their cost on plant protection and improve their livelihood through sustainable crop production. Method demonstrations were conducted on enrichment of vermi-compost/ FYM and neem cake mixture with bio-pesticides. Such enriched vermi-compost mixtures were distributed freely to 10 progressive farmers identified as techno-agents for raising disease free vegetable seedlings under shade net conditions.

Demonstration of enriching vermi-compost with bio-pesticides at KVK, Vellore

Transfer of patentable technology of bio-pesticide consortia among karnataka farmers for sustainable crop production (Sponsored by NABARD)

❖ Farmers training programmes were organized at Kolar, Hoskote and Malur in Karnataka, through which 110 farmers benefitted. A total of 220 kg of bio-pesticides worth of Rs. 93, 500/- were distributed to the farmers (2 kg/ farmer @ Rs. 425/kg). On-farm trials were conducted at Kolar and Malur to evaluate the bio-efficacy of bio-pesticides under real farm situations. At Kolar, significant reduction in root-knot index of nematode was observed in tomato (RKI-2.81 on 1-5 scale) with an yield increase of 14.8% over control. At Malur, significant nematode suppression was recorded (RKI-2.68 on 1-5 scale) over control (RKI- 4.13) in carrot, with an yield increase of 14.6%.

Farmers training program at Kolar

Popularization of bio-rational technology for management of mango inflorescence hoppers (Sponsored by NABARD)

❖ Oil formulation of *Metarhizium anisopliae* was supplied to farmers in Srinivasapura and Chintamani in Karnataka to demonstrate and disseminate the biological control technology of mango inflorescence hoppers.

Development, Dissemination of bio-intensive management of brinjal shoot and fruit borer, *Leucinodes orbonalis* in Karnataka and transfer of technology on mass production of *Trichogramma chilonis* (Sponsored by DST-SSTP)

❖ The technology was disseminated in 10 acres in Mysuru district of Karnataka. A field day was conducted in Bettadabeedu, Mysuru district. Eighteen participants were imparted training on mass production of *Trichogramma chilonis*.

Demonstration and impact of technologies on Coorg Mandarin

❖ A study conducted at CHES, Chettalli on impact of Coorg Mandarin production technology indicated that all the farmers had knowledge and well adopted Bordeaux mixture. About two-

third of them applied coffee cherry husk extract and half of them adopted vermi-compost. Nearly two-fourth of the farmers adopted lime application and *Trichoderma harzianum*. About one-fourth of them adopted Methyl Eugenol pheromone traps and remarked that it is effective in trapping fruit flies. About 25% of the growers indicated that it was difficult to identify between rootstock and graft under field conditions, 12.5% of farmers indicated that grafted plant fruits are of not good taste and requires more irrigation, whereas 12.5% of growers indicated that grafts are having advantage of uniform flowering, vigorous growth, less pest and disease incidence, good bearing of fruits, better fruit size and early fruiting. In case of seedlings, 25% growers reported better taste and 12.5% farmers indicated that requires less irrigation.

❖ About two-fourth of the farmers gave 4 to 5 irrigations and blossom showers, whereas one-fourth of them gave 3 irrigations, followed by one-tenth of them gave 10 irrigations. About three-fourth of them got yield of less than 300 fruits/plant, whereas one-fourth got 300 to 600 fruits /plant. About half of the farmers used oranges for home consumption and distribution to relatives and friends, while nearly two-fourth of them marketed through pre-harvest contractors. One-fourth of the farmers adopted direct marketing, while one-fifth of them involved in growers processing and wine preparation. About 75% of farmers reported *Phytophtora,* CGB and CTV diseases as major constraints, while 50% of farmers indicated seasonal non-availability of labourers, lack of marketing knowledge and elephant problem, 37.5% of growers expressed lack of awareness about Coorg mandarin cultivation and 12.5% growers expressed lack of interest in Coorg mandarin cultivation as other constraints.

4. All India Coordinated Research Projects

4.1. AICRP on Fruits

The project aimed at identification, release of varieties/hybrids through multilocation testing (MLT); maintaining safety duplicates besides evaluation and augmentation of germplasm with NAGS; evaluation of input-use-efficient technologies and assessment of plant health management technologies under different agro-climatic zones. This project has also been mandated for assessment of post-harvest losses of banana and mango in major hot-spots.

4.1.1. Crop Genetic Resources

Papaya: At IIHR, Bengaluru, twenty two varieties evaluated, plant height was least at first flowering and number of nodes to first flower was also less (15.50) in variety Pusa Nanha. The fruit weight was maximum in 'Tainung 1' (1.75 kg) and the fruit cavity index was least in 'Red Indian' (25.38%). The TSS was found to be maximum in 'Washington' (12.4°Brix).

4.1.2. Crop Improvement

Acid lime: Clone 2 has been released from Akola as PDKV Bahar for cultivation in Maharashtra for higher yield (22%) over the existing varieties. In addition, Thornless and seedless genotype identified at Akola and released as PDKV-Chakradhar.

Grape: Hybrid ARI-516 (*V. labrusca* var. Catawba x *V. vinifera* var. Beauty Seedless) found promising for bluish black berry with rudimentary soft seeds, pleasant aroma and high juice recovery (70%) suitable for processing.

Litchi: Cultivar Rose Scented performed superior with respect to tree vigour, fruit yield and quality at Pantnagar.

Mango: Dashehari-35 continues to be superior for yield at Pantnagar and Sangareddy.

Sapota: DHS-2/1, a clonal selection, found superior for yield (20%) over DHS-1 at Arabhavi.

Guava: At IIHR, Bengaluru, promising hybrids/selections were evaluated; variety Arka Mridula recorded maximum fruit weight (178 g) and TSS (11.8°B) with minimum titrable acidity (0.15%) and seed hardiness (9 kg/cm^2). In another trial, the fruit weight was higher (165 g) in SG 10-3 and the pulp colour was pink. The seed hardiness was lower (9.4 kg/cm^2) in SG 10-3 and higher (13.1 kg/cm^2) in SG 10-1.

4.1.3. Crop Production

Banana: In macro-propagation studies revealed that the sawdust + *Trichoderma viride* (30 g) responded better with minimum days (30.13 days) for primary bud initiation for variety Ney Poovan (AB) at Arabhavi. However, at Jalgaon, sawdust + BAP (4 ml) + *Bacillus subtilis* (30 g) took 18 days for varieties Grand Naine and Srimanthi and at Jorhat for cv. Jahaji. Studies for chemical manipulation of banana for higher yield (83.7 t/ha) and quality revealed that bunch spray of 2,4-D (10 ppm) along with 250:90:250 g N:P_2O_5:K_2O/plant/crop, respectively was found beneficial in cv. Grand Naine (16% higher yield) under Gujarat conditions. In organic production trial, combination of FYM (10 kg/plant) + neem cake (1.2 kg/plant) + vermicompost (5 kg/plant) and wood ash (1.75 kg/plant) + triple green manuring with sunhemp (at Coimbatore) or Diancha (at Jorhat) + double intercropping of cowpea+bio-fertilizers, *viz.,* Vesicular Arbuscular Mycorrhizae (25 g/plant), *Azospirillum* (50 g/plant), phosphate solubilizing bacteria (50 g/plant) and *Trichoderma harzianum* (50 g/plant) was effective in registering the higher bunch weight. In variety Nendran, split application of 80% RDF at 3, 5, 7 and 9 MAP is equally effective as 100% in terms of yield and B:C ratio, resulting in the saving of 20% of fertilizers at Kannara. Micronutrient spray ($ZnSO_4$ at 0.5%+ $FeSO_4$ at 0.5%) with a surfactant at 3rd, 5th and 7th months after planting (MAP) has increased bunch yield (14.08 kg) (22% increased yield) with higher returns (BC ratio of 2.25) in cv. Rasthali at Kannara.

Citrus: VAM (500 g) + PSB (100 g) + *Azospirillum* (100 g) + *Trichoderma harzianum* (100 g) per plant has resulted in requirement of inorganics to 75% RDF at Tirupati (sweet orange) and recorded better growth, yield and quality.

Litchi: Studies on substrate dynamics cv. Rose Scented resulted that application of ½ recommended dose of fertilizers + 50 kg FYM + 5 kg vermicompost improved fruit yield (55.58 kg/tree), fruit weight (22.42 g), TSS (21.16 ^{O}B), ascorbic acid (30.20 mg/100g pulp), aril content (16.52 g) as well as for reduced fruit drop (49.33%) and reduced fruit cracking

(7.07%) at Pantnagar. Pruning trial in cv. Rose Scented revealed that harvesting with 50 cm long branch was found effective for increased growth rate of new emerging shoots (40.15 cm) with maximum panicle emergence (67.13 %), panicle length (34.73 cm), reduced fruit drop (59.45%) and fruit cracking (12.7%) as well as improved yield (67.87 kg/tree) and pulp content (67.01%) at Pantnagar. Foliar spray of K_2HPO_4 (1%) + KNO_3 (1%) was found to induce flowering 6 days earlier than the control at Bhagalpur.

Mango: The double hedge row system of planting in mango proved effective for higher yield of fruits at Pantnagar (11.99 t/ha as against 6.46 t/ha in square system of planting). Substrate dynamics studies resulted in maximum TSS (19 °B) with the application of 50% RDF + FYM (50 kg) + vermicompost (50 kg) at Sangareddy. Annual pruning of mango tree by heading back of 10 cm terminal shoots immediately after harvest and application of paclobutrazol in September was found better for higher yield and good fruit quality at Pantnagar. Studies on pre harvest sprays for improving post-harvest shelf life in cv. Banganpalli revealed that maximum storage life (12 days) was recorded in trees sprayed with $CaCl_2.6H_2O$ (6%) along with mulching over 10 days in control at Sangareddy. Preliminary trial on post-harvest loss (PHL) assessment at Kovvur recorded a total loss of 29.9% which included 1.9% due to physical injury, 9.28% due to insect damage, 1.29% due to diseases, 4.29% at assembly markets and 17.43% during ripening and retailing.

Sapota: Plant spacing of 8 m x 4 m at Arabhavi recorded higher yield (12.85 t/ha) as against 5.96 t/ha in 10 m x 10 m (8 years) cv. Kalipatti. Studies on effect of organic and inorganic fertilizers, combination of vermicompost (10 kg) + 750:300:400 g N, P_2O_5, K_2O per tree, respectively recorded higher fruit yield at Periyakulam.

4.1.4. Crop Protection

Banana: Bud injection of imidacloprid 17.8 SL (0.06%) @ 1 ml/bud and azadirachtin 1% (5 ml/l water) @ 2 ml/bud was found to be most effective treatment in minimizing the per cent fruit infestations by red rust thrips at Gandevi. Three sprays of propiconazole (0.05%)+petroleum based mineral oil (1%) effectively controlled the *Eumusae* leaf spot (Sigatoka leaf spot) disease for cv. Grand Naine at Arabhavi and at Coimbatore whereas, difenconazole (0.1%)+petroleum based mineral oil was effective at Kannara. For the management of *Fusarium* wilt of banana, dipping of suckers in carbendazim (0.2%) for 30 minutes+drenching carbendazim (0.2%)+2% carbendazim injection (3 ml) at 3rd, 5th, 7th MAP has recorded least incidence of *Fusarium* wilt (18.5%) as compared to control (80.4%) at Coimbatore, same trend also observed at Jorhat and Pusa. Reduced rhizome rot was recorded with the use of healthy suckers+drenching with streptocyclin (500 ppm) @ 1L/plant (15 days, 2nd, 4th MAP)+growing sunhemp in the interspace till 6 month after planting at Gandevi and Arabhavi.

Citrus: Foliar application of novaluron 10EC (0.005%) @ 0.5 ml/l or azadirachtin (1%) @ 4 ml/l or petroleum oil spray (5 ml/l) twice at 15 days interval was effective against Citrus psylla up to 14 days in sweet orange (Mosambi at Rahuri and Sathgudi at Tirupati). For effective control of Citrus mites, two sprays of ethion 50 EC (0.05%) or propargite 57EC (0.057%) or abamectin 1.9 EC (0.0007%) or neem oil (5%) first at initiation of the pest infestation and second after 15 days thereafter, are recommended. At Tirupati, the foliar application of *Bacillus thuringiensis* (0.1%) at pest initiation stage was found effective for management of lemon butterfly up to 14 days after and is comparable with the chemical check (carbaryl); however, at Tinsukia, carbaryl (0.1%) was only found superior.

Grapes: Soil drenching with imidacloprid 70 WG @ 0.45 g/l/vine twice at 20 and 40 days after forward pruning was found effective against thrips, jassids and mealy bug at Rahuri and Rajendrangar.

Guava: Hanging of glass wide mouth bottle traps containing methyl eugenol (0.1 %) and DDVP (0.1 %) @ 10 traps per hectare was cost effective for managing fruit flies at Sangareddy.

Litchi: Application of trichocards, followed by two sprays of *Bt* at 7 days interval starting from colour break stage has been recommended for the management of fruit borer.

Mango: For management of hoppers, module-IV [First spray of spinosad (0.004%) at panicle emergence stage followed by second spray (21 days after first spray) with thiamethoxam (0.008%) and third need-based spray of neemazal (10000 ppm @ 3 ml/l of water)] was found effective. For the management of foliar anthracnose disease in mango, three sprays of carbendazim (12%) + mancozeb (63%) @ 0.2% (2 g/l) or carbendazim @ 0.1% (1 g/l) starting from appearance of initial symptoms on new flush at 10 days interval are effective. Two sprays of carbendazim (12%) + mancozeb (63%) @ 0.2% (2 g/l) starting at flowering stage at an interval of 10 days are effective against blossom blight of mango.

Papaya: Raising of papaya seedlings under nylon net (40-60 mesh) and spraying of acephate (0.15%), 3 days before planting with use of two rows of border crop of maize (sown 15 days before planting) as well as application of neem oil (1%)+acephate (0.15%) at 15 days interval was found superior for management of PRSV at Gandevi. Profenofos 50 EC (0.075%) @ 1.5 ml/l and novaluron 10 EC (0.005%) @ 0.5 ml/l showed superiority in reducing the seed borer infestation (4%) as against acephate (0.15%) with 13-14% infestation in sapota at Gandevi and Palghar.

4.2. AICRP on Arid Zone Fruits

Pomegranate: At IIHR, Bengaluru, fourteen genotypes collected from sub Himalayan region were evaluated for resistance to *Xanthomonas,* recorded two genotypes to be tolerant to bacterial blight. Twenty eight lines were identified for various characters from mutagenic population.

Annona: At IIHR, Bengaluru, nine varieties were evaluated after five years, Arka Sahan excelled in yield (45.76 kg / plant) and quality.

4.3. AICRP on Vegetables

4.3.1. Crop Improvement

Tomato: Under ToLCV (AVT-I), out of 11 entries evaluated, three entries ToLCV4 (577 q/ha), ToLCV3 (570 q/ha) and ToLCV 7 (565q/ha) were out yielded. Susceptible check Punjab Chhuara expressed 58% ToLCV incidence. Out of eight determinate hybrid trial (IET), Hyb-5 (51 t/ha) recorded the highest yield followed by Hyb-4 (45 t/ha) and Hyb-1 (42 t/ha).

Hyb 5

Hyb 4

Brinjal: Under AVT-I eight entries were evaluated, 13/BRBWRES-2 (490q/ha and 13/BRBWRES-4 (435 q/ha) performing better for yield and bacterial wilt resistance over the checks. Under AVT-II, seven entries were evaluated, 12/BRBWRES-4 (415q/ha) and 10/BRBWRES-3 (410q/ha) performing better for yield and bacterial wilt resistance over the checks.

Okra: In Hybrid trial (IET), 10 hybrids were evaluated, 2014-OKHYB-1 recorded highest fruit yield (17.36 t/ha). Its fruits are tender, lush green, medium length and girth. In hybrid trial (AVT-I), 12 hybrids were evaluated, hybrids 2013-OKHYB-8 recorded highest fruit yield (17.90 t/ha). Its fruits are tender, lush green, medium length and girth. In hybrid trial (AVT-II), 14 hybrids were evaluated, 12-OKHYB-12 recorded highest fruit yield (17.06 t/ha). Its fruits are tender, lush green, medium length and girth.

French bean: In bush type IET, four entries were evaluated, 2014/FBB VAR 2 recorded maximum pod yield (17.8 t/ha) followed by check Arka Suvidha (16.7 t/ha). In AVT I, four entries were evaluated, 2013/FBB VAR 3 recorded maximum pod yield (15.5 t/ha) followed by 2013/ FBBVAR-1 (14.8 t/ha), check Arka Suvidha recorded pod yield (15.0 t/ha).

Cowpea: In bush varietal trial (AVT II), five entries were evaluated, none was found to be superior to both the checks, Arka Garima (17.8 t/ha) and Kashi Kanchan (17.2 t/ha). Out of the six entries in Bush varietal trial (IET), 2014/ COPBVAR2 recorded maximum pod yield (18.0 t/ha) followed by Arka Garima (Check) (17.8 t/ha).

Peas and Dolichos: In pea varietal trial early IET, out of five entries tested, AP 3 (check) and VRP 6 (check) recorded maximum pod yield (7.3 t/ha). In mid-season AVT I, 2012/PEVAR-4 recorded maximum pod yield (86.31 q/ha) followed by 2012/PEVAR-1 (81.25 q/ha.). In mid-season powdery mildew resistant trial (AVT I), 2012/PMPM-5 recorded maximum pod yield (11.2 t/ha) followed by Arka Ajit (Check) (9.5 t/ha) and in AVT II, 2011/PMPM-3 recorded maximum pod yield (11.1 t/ha). In dolichos pole type varietal trial, 13/DOLPVAR-3 ranked first with pod yield (22.7 t/ha) followed by 13/DOLPVAR-1 (21.1 t/ha).

Amaranth: In varietal trail AVT II, seven varieties were evaluated, 2012/AMVAR-06 (205.2 q/ha) recorded maximum leaf yield followed by 2012/AMVAR-01 (201.9 q/ha) and 2012/AMVAR-05 (200.9 q/ha).

Bitter gourd: In hybrid (IET) trial, five hybrids were evaluated, 2013/BIGHYB-07 (186.6 q/ha) out yielded the check hybrids. In hybrid (AVT-I) trial, six hybrids were evaluated, 2012/BIGHYB-06 (237.1q/ha) followed by 2012/BIGHYB-02 (232.2 q/ha) out yielded the check varieties. In hybrid (AVT-II) trial, five hybrids were evaluated, 2011/BIGHYB-04 (242.3 q/ha) out yielded the check hybrids.

Ridge gourd: Out of five varieties evaluated (AVT I), 12/RIGVAR-3 (424.8 q/ha) followed by 12/RIGVAR-2 (374.8 q/ha) out yielded the check. In AVT-II, three out of seven entries namely, 11/RIGVAR-04 (386.2 q/ha) followed by 11/RIGVAR-03 (296.3 q/ha) and 11/RIGVAR-07 (270.8 q/ha) out yielded the check. In IET, three out of four entries namely, 2013/RIDHYB-06 (452.7 q/ha) 2013/RIDHYB-02 (423.0 q/ha) and 2013/RIDHYB-05 (332.9 q/ha) out yielded the check.

4.3.2. Crop Production

Organic farming in amaranth: During *kharif* season, yield obtained ranged from 21.14 t/ha to 24.9 t/ha from three cuttings in different organic treatments, which was on par with conventional treatment.

Micronutrient studies in hybrid tomato: In hybrid Arka Rakshak, mixture of six micronutrient recorded significantly higher yield (101.9 t/ha) compared to control (89.1 t/ha).

Drip fertigation in chilli: Hybrid Arka Meghana tested during *kharif* for different fertigation schedules, highest dry yield (4.1 t/ha) was recorded with WSF fertigation, which was significantly superior to soil application (3.29 t/ha).

Okra seed production: In hybrid seed production, a simplified pollination was developed, simultaneous emasculation at yellow bud stage (on the day of anthesis) and pollination with fresh pollen resulted in highest fruit set (27.74%) which was on par with the conventional method of crossing and emasculation (25.34%). This technology saves 50% time and improved the crossing efficiency.

Pumpkin seed production: Physiological maturity and longevity of pumpkin seeds in relation to fruit age and duration of *in situ* storage was studied. The stage of harvesting and pre-harvest duration influenced the seed set and seed quality in pumpkin. The total number of filled seeds/fruit was highest in 45 days of harvest and immediate seed extraction. The number of empty seeds decreased with increase in harvest time and pre storage duration. The test weight was highest in 45 days of harvesting after anthesis and 30 days of pre storage duration. There was a definite trend in seed recovery due to harvest stage and pre-storage duration.

4.3.3. Crop Protection

Insect-pest management

Management of *Meloidogyne incognita* with biocontrol agents in okra: Seed treatment with *Pseudomonas fluorescens* 1% W.P. (cfu-2 x 10^8) @ 20 g/kg seed and application of 5 tons of FYM enriched with *Paecilomyces lilacinus* (2x10^6 cfu/g) @ 2.5 kg+*Pseudomonas fluorescens* (2x10^8 cfu/g) @ 2.5 kg/ha significantly reduced final population of *M. incognita* and significantly increased yield by 17.54%.

Evaluation of bio-efficacy of liquid formulation of *Bacillus pumilus* 1% A.S. in the management of *Meloidogyne incognita* infecting okra: Seed treated with *Bacillus pumilus* 1% A.S. @ 10 ml/kg seed and application of 5 tons of FYM enriched with *B. pumilus* @ 5 l/ha recorded significantly lower *M. incognita* population (64.16%) and higher yield (30.36%).

Evaluation of bio-efficacy of liquid formulation of *Pseudomonas putida* 1% A.S. in the management of *Meloidogyne incognita* infecting okra: Seed treated with *Pseudomonas putida* 1% A.S. @ 10 ml/kg seed and application of 5 tons of FYM enriched with *P. putida* @ 5 l/ha significantly suppressed the hatching of root knot nematode eggs (65.53%) and final nematode population (61.95%) compared to control, significantly increased the yield by 29.61%.

Bio-efficacy of liquid formulation of *Bacillus subtilis*-1% A.S. in the management of *Meloidogyne incognita* infecting tomato: Substrate treatment with *B. subtilis* @ 5 ml/kg cocopeat in pro-trays and soil application of 5 tons of FYM/2 ton of vermicompost enriched with *B. subtilis* @ 5 l/ha recorded significantly highest yield (26.28%) and lowest nematode population in soil and roots of tomato (60.37%).

Evaluation of bio-efficacy of liquid formulation of *Bacillus amyloliquefaciens*-1% A.S. in the management of *Meloidogyne incognita* infecting tomato: Substrate treatment with *B. amyloliquefaciens* @ 5 ml/kg cocopeat in pro-trays and soil application of 5 tons of FYM/2 ton of vermicompost enriched with *B. amyloliquefaciens* @ 5 l/ha recorded significantly highest yield (28.45%) and lowest nematode population in soil and roots of tomato (61.82%)

Disease management

Survey and surveillance of diseases of important vegetable crops in the farmers' field at periodical intervals: Survey for virus incidence has indicated incidence of ChiVMV (25.4%) and CMV (21.5%) in chilli, CGMMV (2.5%) and ZYMV (9.5%) in cucurbits. In tomato, highest incidence of Tomato leaf curl Bangalore virus (ToLCBV) (67.5%), followed by spotted wilt disease caused by Groundnut bud necrosis virus (GBNV) (11.8%), and potyvirus (11.5%).

Survey and distribution of yellow vein mosaic

disease causing begomoviruses in wild and cultivated species of okra: Seventy seven wild accessions of okra comprising of *A. angulosus var. grandiflorus*, A. *angulosus* var. *purpuries,* A. *manihot, A. moschatus, A. caillei*, *A. moschatus* var. *tuberosus*, *A. tetraphyllus,* and *A. tuberculatus,* collected from Kerala, Odisha, Rajasthan and Uttar Pradesh and some of the species were showed incidence of YVMV in their native locations.

Assessment of genetic diversity of okra yellow vein mosaic virus: Seventy six begomovirus isolates collected from Andhra Pradesh, Delhi, Gujarat, Haryana, Karnataka, Kerala, Odisha, Punjab, Rajasthan and Uttar Pradesh molecularly characterized and complete DNA-A genome sequence determined. 112 beta satellite and 114 alpha satellite isolates collected molecularly characterized and complete genome sequence determined.

4.4. AICRP on Floriculture

4.4.1. Crop Genetic Resources

Rose: Nine new accessions were added. Varieties with good seed germination ability were identified.

Carnation: Fifteen carnation accessions have been added. All the 82 germplasm accessions were maintained under naturally ventilated polyhouse.

Heliconia: Twenty three accessions have been maintained as germplasm. New germplasm block has been established.

4.4.2. Crop Improvement

Tuberose: Hybrid Arka Nirantara at different centres has shown consistently superior performance. A total of 16 genotypes as reference collection were evaluated as per UPOV guidelines. The draft guideline was finalized.

Gladiolus: A total of eight genotypes were evaluated for different vegetative and floral traits. In Purple group 'Arka Naveen' and in red group IIHRG-11 was found to be promising for cut flower purpose.

Rose: The genotypes Berries N Cream for thrips resistance; Pushkar Pink and Pushkar Red for fragrance; Pusa Virangana for powdery mildew, Vivaldi and Diplomat for cut flower; Suma, Crifty Duty, Lili Marlene for loose flower; Cyclamen, Easy Going, Doris Tystermann, Carefree Beauty, IIHR 11 for black spot resistance as seed parent identified for targeted breeding.

Carnation: Germplasm was characterized for 58 traits resulted in identification of example varieties for 102 states.

Gerbera: Ten genotypes were evaluated for quality traits under naturally ventilated polyhouse. Genotype Vilassar recorded maximum flower stalk length followed by Kyllian. Maximum flower diameter was recorded in Kyllian, whereas Pasto recorded maximum stalk diameter. The genotypes Kyllian and Vilassar were found promising and recommended for flower quality.

Chrysanthemum: Eight genotypes were evaluated under open field condition. Maximum number of branches/plant was recorded in Usha Kiran. Earliest bud appearance was recorded in PAU-B-43, whereas, Local Yellow Semi-double recorded late. Maximum number of flowers/plant was recorded in Arka Pink Star followed by 'Local Yellow Semi-double' and PAU-B-107. Maximum flower diameter was recorded in 'PAU-B-43', whereas, genotype Kirti recorded maximum duration of flowering followed by Arka Pink Star.

China aster: Five genotypes were evaluated for cut flower and loose flower. The genotype Arka Archana produced maximum number of flowers per plant, followed by Arka Aadya and Kamini. Maximum flower diameter was recorded in Poornima followed by Kamini. A total of 20 genotypes were evaluated for various morphological traits. The DUS test draft guidelines was finalized and submitted to the PPV & FRA, New Delhi.

Marigold: Nine lines were evaluated, IIHRFm-1, IIHR Mo-2 and IIHR Mo4 found to be ideal for landscape. Bm-1, Bm-2 and Bm-3 were found to be having compact flowers. VTIC of ICAR-IIHR, Bangaluru has identified IIHRMGYP-1 with the name Arka Bangara. It is resulted from crossing between germplasm lines MG-87 and MG-32. The variety comes to flowering by 40-45 days and continues to flower for next 65-70 days. Flowers are medium in size (5-6.5 cm). Yield potential of the variety is 10 tons/acre in winter and 5 tons/acre in summer. It has petaloid sterile flowers and ability to multiply by vegetative propagation. Flowers are of yellow gold colour (RHS colour 12-A, yellow group).

Arka Bangara

Two marigold hybrid selections *viz.,* Arka Agni and Arka Alankara were found to be high yielding and identified by VTIC. Arka Agni is developed from hybridization between IIHRMGYP-1 and 9-2. It is a petaloid male sterile line multiplied by vegetative propagation. It has medium plant height (80-85 cm), flower colour is orange (RHS colour N25C, orange group), petaloid male sterile flowers. Flowers are compact, large (7.5-8 cm), high yielding (7-7.5 tons/acre). Flowering starts 40-45 days after planting and continues to flower for 60 days. It is a vegetatively propagated. Arka Alankara is developed from hybridization between IIHRMGYP-1 and 9-2. It is petaloid male sterile line multiplied by vegetative propagation. It has medium height plant (75-80 cm). Flower colour is gold yellow (RHS colour 9A, yellow group). It has petaloid male sterile flowers. Flowers are compact and large (7-7.5 cm), high yielding with 6-6.5 tons/acre. Flowering starts 40-45 days after planting and continues to flower for 60 days. It is vegetatively propagated.

Arka Agni *Arka Alankara*

Turf grass: Among six grass species evaluated, the adaption was limited to Kentucky blue grass (*Poa pratensis* L), *Lolium perene* L. and *Agrostis palustris* L. Initial two years these three grass species performed well, however, during summer months (April and May 2014) these three species could not survive. Grass species *Eragrostis curvula, Paspalum notatum* Flugge and *Argentine bahia* were found suitable for Bangalore conditions.

Ornamental flowering shrubs: All the thirty ornamental flowering shrubs (*Pachystychus lutea, Mynea erecta, Hibiscus hawaiin, Calliandra brewipes, Eranthemum reticulate, Gardenia jasminoids, Hamelia patens, Cassia biflora, Nyctanthus arboria, Magnolia mutabilis, Hibiscus, Plembago capensis, Euphorbia, Megacapasma erithroclamus, Hibiscus mutabilis, Cestrum diurnum, Russelia junceae, Strelitzia reginea, Plumeria pudica, Callistemon lanceolatus, Murraya exotica, Lemonia spectabilis, Jasmine samabac, Bougainvillea, Ixora singaporensis, Tecoma gaudichoudi, Lagerstromia indica, Galphimia gracilis and Jatropha pandurifolia.*) have been established and observations on season, nature and colour of flowers, shape of silhouette, branching pattern, size, texture, density, hardiness and resistance to insects and diseases were recorded.

4.4.3. Crop Protection

Disease diagnostics in bulbous ornamentals: Survey for incidence of viruses in ornamental bulbous crops in Karnataka has indicated incidence of CMV 22.5%, CYMV 10.5% on canna, LMV 14.5% on lilium, CMV 7.8%, BYMV 13.5%, TSV 2.7% and *Phytoplasma* 1.5% on gladiolus, whereas, tuberose mild mottle virus incidence up to 41.5 to 90.5% was recorded in different places.

4.5. AICRP on Medicinal and Aromatic Plants and Betelvine

4.5.1. Crop Genetic Resource

Five land races were collected and maintained at CHES, Hirehalli. A total of 109 germplasm are maintained including three *Piper* species namely *Piper colubrinum*, *P. hamiltonii* and *P. longum*. Flowering was recorded in 50 female clones and 8 male clones, flowering was not observed in *Meetha Pan* and *Kakair*. Among hybrids, flowering was recorded in four hybrids IIHR Hy8-43, IIHR Hy08-64, IIHR Hy07-1 and IIHR Hy08-62 which produced female inflorescence.

4.5.2. Crop Improvement

Twelve female clones, three male clones, six hybrids (female) and four male hybrids were used in the crossing programme. Ten inter varietal crosses, five crosses between varieties and hybrids and five inter-hybrid crosses were carried out. Hybrid seedlings are established in polyhouse. Out of eight hybrids and four parental lines evaluated under areca nut garden, five hybrids performed well over three years. Hy06-4 consistently recorded higher leaf yield followed by Hy06-1, Hy06-8 and Hy06-9. Nine promising hybrids with desirable plant vigour and leaf traits over two years were evaluated. The hybrids Hy07-37, Hy07-36 followed by Hy08-20 showed consistently higher leaf yields in both the years.

Interspecific hybridization between *P. betle* and *P. colubrinum* (*Phytophthora* resistant) was carried out. Fruit set, seeds/fruit and establishment of seedlings was very low. The interspecific hybrids raised in previous year (Mysore Local/*P. colubrinum*, Bangla Nagaram/*P. colubrinum,* IIHR BV 96/*P. colubrinum* and Simurali Babna/*P. colubrinum*) were established under shade net. The interspecific hybrids from Mysore Local/*P. colubrinum* have recorded good vigour.

4.5.3. Crop Production

Twenty three hybrids under shade net house (simulating bareja conditions) were evaluated for growth and yield. Higher leaf vine was recorded in Hy08-52 (145.50), Hy06-4 (107.08), Hy06-1 (105.17) and Hy06-11 (100.67). In another trial, thirty six hybrids evaluated for growth and yield traits under shade net conditions. Leaf yield/vine varied from 26 to 96. Hy 07-25 and Hy 07-36 recorded higher leaf yield per vine (96 and 88 leaves/vine respectively) followed by Hy08-58 (78.25), Hy07-37(77.25), Hy07-24 (63.75) and Hy07-41 (63.35). The hybrids evaluation trial hybrids Hy 06-4 recorded higher leaves/vine (242) and male clone Swarna Kapoori (255). Hy 06-1 and 06-11 are at par within the female clone Hirehalli local.

Eight high yielding clones along with local check (Hirehalli Local) were also evaluated in Areca nut garden. Maximum leaf yield was recorded in IIHR BV 67 (93.87 lakh leaves/ha) followed by Sirugamani 1 and Mysore Local (64.22 and 59.45 lakh leaves/ha, respectively). Hirehalli Local recorded lowest leaf yield (19.99 lakhs/ha) after fifth year of planting.

At IIHR there was no significant difference for vine length between the entries. Hybrid Hy 06-4 recorded 242 leaves/vine, while, male clone Swarna Kapoori recorded 255. Hy 06-1 and 06-11 are at par within the female clone Hirehalli Local.

4.6. All India Network Research Project on Onion and Garlic (AINRPOG)

Onion: Nine lines were evaluated in *kharif* varietal/hybrid IET trial, three lines namely OSK1312 (364.67 q/ha), OSK1310 (347.17 q/ha) and OSK 1320 (293.28 q/ha); AVT-1, out of 13 lines, three lines namely ASKO1203 (373.33 q/ha), ASKO1201 (373.11 q/ha) and ASKO1237 (366.45 q/ha); AVT-II, out of 13 lines, three lines namely BSKO 1256 (355.56 q/ha), BSKO1233 (331.11 q/ha) and BSKO1231 (263.40 q/ha); hybrid IET trail, out of 7 lines three lines namely OSK 1337 (364.20 q/ha), OSK1327 (344.37 q/ha and OSK (334.45 q/ha) and in hybrid AVT 1, among 11 hybrids ASKO1217 (477.63 q/ha), ASKO1220 (466.00 q/ha) and ASKO 1285 (440.43 q/ha) recorded significantly higher bulb yield and its attributing traits.

In *rabi* IET trail, 9 lines evaluated, three lines namely OSR1357 (466.34q /ha) , OSR1354 (448.84 q/ha) and OSR1364 (407.60q/ha); AVT-1, 12 lines evaluated, three lines namely ASRO1201 (558.45q/ha), ASRO1203 (497.67q/ha) and ASRO 1207 (466.45q/ha); AVT II, 12 lines evaluated, BSRO1275 (458.33 q/ha), BSRO1259 (455.56 q/ha) and BSRO1227 (437.78 q//ha); IET hybrids, 7 lines evaluated, three lines namely OSR1374 (493.83 q/ha), OSR1370 (455.37 q/ha) and OSR1370 (357.22 q/ha) and in hybrid AVT 1, 11 lines evaluated, three lines namely ASRO1217 (504.44 q/ha), ASRO1220 (488.89 q/ha) and ASRO 1222 (458.89 q/ha) were recorded significantly high bulb yield and its attributing traits.

Garlic: Under the garlic varietal trial (IET) in *rabi* season 7 lines evaluated, three lines namely GRS 1328 (61.25 q/ha), GRS 1330 (51.75 q/ha) and GRS1332 (49.25 q/ha) and AVT II, 7 lines evaluated, three lines namely BGSD1228 (53.25 q/ha), BGSD1219 (52.25 q/ha) and BGSD (45.00 q/ha) were recorded significantly high bulb yield and its attributing traits.

4.7. All India Network Project on Pesticide Residues

4.7.1. Residue study of acephate, profenofos and chlorpyrifos in brinjal

Acephate treatments were given to brinjal at standard and double dose of 560 g a.i./ha and 1120 g a.i./ha, respectively. Initial residues of acephate and its metabolite methamidofos on brinjal from treatment at 560 g a.i. /ha were 8.611 and 0.165 mg/kg, respectively. Initial residues of acephate and methamidofos on brinjal from treatment 1120 g a.i. /ha were 13.629 and 0.289 mg/kg. The residues of methamidofos increased from 0 day to 5th day and decreased thereafter. The total residue levels of acephate and its metabolite in field soil collected on 15th day were below detectable limit (BDL) of 0.1 mg/kg.

Profenofos treatments were given to brinjal at standard and double dose of 500 g a.i. /ha and 1000 g a.i. /ha, respectively. Initial residues of profenofos on brinjal from treatments at 500 and 1000 g a.i/ha were 5.121 and 11.113 mg/kg. The residues persisted for 20 and 25 days and dissipated with the half-life of 3.2 days from standard and double the standard dose treatments respectively. The residue levels of profenofos in field soil collected on the 15th day were below detectable limit (BDL) of 0.05 mg/kg from both the treatments.

The application of the chlorpyrifos 20 EC in Brinjal @ 3 ml/L resulted in residues of 0.13 µg g-1, respectively, one hour after application. The level declined with time and reached below determination level of 0.01 µg g-1 on 7th day from treatment with a half-life of 1.76 days. No residues of chlorpyrifos was detected in

untreated capsicum samples. Also, no residues of chlorpyrifos was found in the soil at harvest at 20 days after application of insecticide.

4.7.2. Residue study of triazofos and chlorpyrifos on capsicum

Triazofos treatment was given to capsicum at standard of 500 g a.i. /ha. Initial residues of triazofos on capsicum from treatment at 500 g a.i. /ha was 5.223 mg/kg. The residues persisted for 15 days and dissipated with the half-life of 3.7 days. The residue levels of triazofos in field soil collected on the 15th day was below detectable limit (BDL) of 0.05 mg/kg.

Application of the chlorpyrifos 20 EC in capsicum @ 3 ml/L resulted in residues of 0.33 μgg^{-1}, respectively, one hour after application. The level declined with time and reached below determination level of 0.01 μgg^{-1} on 15th day from treatment with a half-life of 2.2 days.

4.7.3. Residue study of fluopicolide and propamocarb hydrochloride on cucumber

The residues of fluopicolide and propamocarb hydrochloride were analysed in cucumber from treatments at recommended and double doses of 93.75+937.5 g a.i./ha and 187.5+1875 g a.i./ha, respectively. Initial residues of fluopicolide on cucumber from treatments recommended and double doses were 0.303 and 0.554 mg/kg. The residues persisted for 10 day and 15 days and dissipated with the half-life of 4.2 and 4.4 days from the recommended and double dose treatments. Initial residues of propamocarb on cucumber from treatments at recommended and double doses were 2.430 and 4.487 mg/kg. The residues persisted for 10 day and 15 days and dissipated with the half-life of 4.3 and 4.4 days.

4.7.4. Residue study of chlorpyrifos, ethion, sprotetramat, profenofos, quinalfos and triazofos on okra

Chlorpyrifos residues were analysed in okra from treatment at standard dose of 300 g a.i. /ha. Initial residues of chlorpyrifos on okra from the treatment at 300 g a.i. /ha was 0.765 mg/kg. The residues persisted for 7 days and dissipated with the half-life of 1.3 days from the treatment, respectively.

Ethion residues were analysed in okra from treatment at standard dose of 500 g a.i. /ha. Initial residue of ethion on okra from treatment at 500 g a.i. /ha was 6.107 mg/kg. The residues remained on okra for 10 days and reached below the limit of quantification on the 15th day. The residues dissipated with the half-life of 1.6 days.

Profenofos residues of were analysed in okra from treatment at standard dose of 500 g a.i. /ha. Initial residues of profenofos on okra at 500 g a.i. /ha was 10.19 mg/kg. The residues persisted for 7 days and dissipated with the half-life of 1.2 days. The residue levels of profenofos in field soil collected on the 15th day was below detectable limit (BDL) of 0.05 mg/kg.

Quinalfos residues were analysed in okra from treatment at standard dose of 250 g a.i. /ha. Initial residues of quinalfos on okra from the treatment at 250 g a.i. /ha was 2.574 mg/kg, respectively. The residues persisted for 3 days and dissipated with the half-life of 0.53 days from the recommended dose treatment. The limit of quantification of the method was 0.05 mg/kg.

Triazofos residues were analysed in okra from treatment at standard of 500 g a.i. /ha. Initial residues of triazofos on okra from treatment at 500 g a.i. /ha was 9.046 mg/kg. The residues persisted for 15 days and dissipated with the half-life of 2 days. The residue levels of triazofos in field soil collected on the 15th day was below detectable limit (BDL) of 0.05 mg/kg.

Spirotetramat residues of were analysed in okra from treatments at the standard and double doses of 90 g and 180 g a.i. /ha, respectively. Initial residues of spirotetramat on okra from treatments at 90 and 180 g a.i. /ha were 0.746 and 1.009 mg/kg. The residues persisted for 7 days and 10 days and dissipated with the half-life of 1.8 and 2.7 days from the recommended and double dose treatments, respectively. The residue of the major metabolite spirotetramat-enol was below detectable limit (BDL) on all days.

4.7.5. Residue study of cypermethrin, profenofos and triazofos on tomato

Cypermethrin residues of were analyzed in tomato from treatment at standard dose of 50 g a.i. /ha. Initial residues of cypermethrin on tomato from the treatment at 50 g a.i. /ha was 0.72 mg/kg. The residues persisted for 15 days and dissipated with the half-life of 4.3 days from the recommended dose treatment.

Profenofos residues of were analyzed in tomato from treatments at standard and double doses of 500 g a.i. /ha and 1000 g a.i. /ha, respectively. Initial residues of profenofos on tomato from treatments at 500 and 1000 g a.i. /ha were 3.618 and 9.708 mg/kg. The residues persisted for 15 day and 20 days and dissipated with the half-life of 2.6 days from the recommended and double dose treatments.

Triazofos residues of were analyzed in tomato from treatment at standard dose of 500 g a.i. /ha. Initial residues of triazofos on tomato from the treatment at

500 g a.i. /ha was 9.575 mg/kg. The residues persisted for 25 days and dissipated with the half-life of 3.6 days from the recommended dose treatment.

4.7.6. Residue studies of acephate in cabbage

Application of the acephate 50% in cabbage @ 1.5 g/L resulted in residues of 0.33 µg g^{-1}, respectively, one hour after application. The level declined with time and reached below determination level of 0.01 µg g^{-1} on 15th day from treatment with a half-life of 2.5 days.

4.7.7. Residue studies of acephate in cauliflower

The application of the acephate (Megastar 75% SP) in Cauliflower @ 1.5 g/L resulted in residues of 0.33 µg g-1, respectively, one hour after application. The level declined with time and reached below determination level of 0.01 µg g-1 on 15 day from treatment with a half-life of 2.5 days.

4.7.8. Residue study of chlorpyrifos and ethion on curry leaves

Chlorpyrifos residues were analysed in curry leaves from treatment at standard dose of 300 g a.i. /ha. Initial residues of chlorpyrifos on curry leaves from the treatment at 300 g a.i. /ha were 5.626 mg/kg. The residues persisted for 90 days and dissipated with the half life of 8 days from the recommended dose treatment.

Ethion residues were analysed in curry leaves from treatment at standard dose of 500 g a.i. /ha. Initial residues of ethion on curry leaves from the treatment at 500 g a.i./ha were 14.613 mg/kg. The residues persisted for 120 days and dissipated with the half-life of 15.2 days from the recommended dose treatment.

4.7.9. Residue study of chlorpyrifos and profenofos on chilli

Application of the chlorpyrifos 20EC in chilli @ 3 mL/L resulted in residues of 0.33 µg g^{1}, respectively, one hour after application. The level declined with time and reached below determination level of 0.01 µg g^{-1} on 15th day from treatment with a half-life of 2.5 days.

Application of the profenofos (Curacron 50% EC) in chilli @ 1.0mL/L and 2.0mL/L resulted in residues of 4.27µg g^{-1} and 9.15 µg g^{-1}, respectively, one hour after application. The level declined with time and reached below determination level of 0.01 µg g^{-1} on 15th day for T1 and on 20th day for T2 from treatment with a half-life of 3.8 days and 2.6 days.

4.7.10. Residue study of oxadiargyl (80WP) and deltamethrin (10EC) in onion

The application of the oxadiargyl 80 WP @ 160 and 320 g a.i./ha, resulted in residues of 0.06 and 0.38 µg g-1, respectively, in immature onion one hour after application. The level declined quickly and reached below determination level of 0.01 µg g-1 on 10th day with a half-life of 1.2 days following treatment at recommended dose of application whereas at double the recommended dose, the residues reached below determination level on 15th day with a half-life of 2.1 days.

In case of deltamethrin, Deltamethrin (Decis Forte 10 EC) residues of 0.97 and 1.14 mg kg-1, from the lower and higher dose treatments, respectively, gradually declined and residues reached below quantification level (< 0.05 mg kg-1) on 15th day from application at recommended dose and on 20th day from that at double the recommended dose with a half-life of 2.3 to 4.0 days. Mature onion and soil samples were collected on 30th day after last application were found to be free from residues of deltamethrin.

4.8. ORP on Fungal Foliar Diseases

4.8.1. Integrated disease management of early blight of tomato

An integrated disease management trial with 10 treatments including *Trichoderma harzianum* OTPB3 spores using NS 501 variety. Fenamidione –mancozeb (0.3%) significantly reduced early blight incidence. Alternate spray of *T. harzanum* OTPB3 followed by copper hydroxide also reduced the early blight incidence with good yield.

Integrated management of early blight of tomato

Treatment	PDI	Yield/ton/ha
Mancozeb (0.2%)	32.64 (34.50)	57.31
Chlorothalonil (0.2%)	30.72 (35.69)	58.02
Copper hydroxide (0.2%)	29.55 (28.06)	57.10
Metiram (0.3%)	34.60 (33.55)	52.60
Metalaxyl+Mancozeb (0.2%)	30.06 (34.50)	72.40
Dimethomorph + Mancozeb (0.1% + 0.2%)	29.55 (42.54)	96.70
Fenamidione mancozeb (0.3%)	25.60 (53.67)	97.50
Fosteyl – Al + Propineb (0.2%)	26.2 (52.60)	73.51
Cymoxanil + Mancozeb (0.2%)	28.60 (49.70)	70.66
OTPB3 (2%) + Copper hydroxide (0.2%)	31.21 (31.12)	62.31
Control	78.50 (62.50)	31.54
SEM	0.60	1.78
CD at 5%	1.90	5.62

Total of 29 isolates of *Phytophthora infestans* were obtained from tomato late blight. All 29 isolates from tomato exhibited the same indistinct colony pattern with cotton woolly like aerial mycelium. The colony

growth rates varied from 3.92 to 8.14 mm/day. Sporangia were formed on compound sympodial sporangiophores with a small characteristic swelling just below the sporangium. Isolates had caducous and semi-papillate sporangia. Sporangia were predominantly ellipsoid, limoniform or ovoid, tapering at the base. The mean length of sporangia ranged from 29.34 to 33.60 mm and mean breadth from 16.64 to 19.81mm. L/B ratios of sporangia ranged from 1.68 to 1.98. Pedicel lengths were <3 mm. The mating type assay with A1 and A2 tester isolates indicated that all the 19 isolates were of the A2 mating type.

4.8.2. Protein profiling in *Phytophthora capsici* and *P. boehmeriae in* chillies and capsicum

Protein profile of *P. capsici* and *P. boehmeriae* that infect chillies and capsicum was carried out The banding patterns of native proteins were recorded between the range of 20-205 kDa. The unique protein profile obtained for both *P. capsici* and *P. boehmeriae*s pecies. The *P. capsici* share the total of eight protein mass, among six protein masses such as 174.87, 118.92, 84.67, 70.24, 60.48 and 25.00 kDa are recognized as species-specific. *P. boehmeriae* share the total of nine protein mass, among seven protein masses such as 170.57, 95.70, 80.43, 67.70, 58.64, 32.18 and 26.60 kDa are recognized as species-specific. The protein mass of 39.40 and 34.52 kDa are identified both in *P. capsici* and *P. boehmeriae* species. However, isolates within a species had identical protein patterns.

4.8.3. Onion

The combined multilocus sequence analysis with phenotypic characters revealed the presence of two species from two *Colletotrichum* species complex on onion. *Colletotrichum siamense* (27 isolates) from *C. gloeosporioides* complex and *C. truncatum* (10 isolates) from *C. truncatum* complex were identified. Pathogenecity of both species has been confirmed and both species are sensitive to carbendazim.

4.9. Centre of Excellence on Betelvine

4.9.1. Plant Genetic Resources

Field Gene Bank of Betel vine was established. Standard crop of *Sesbania* has been raised and 60 germplasm lines and 20 hybrids have been multiplied.

4.9.2. Crop Improvement

Sixty lines (45 germplasm and 15 hybrids) were evaluated for three major nutrients (N,P,K) and seven micro elements (Ca, Mg, S, Fe, Mn, Zn, Cu). Crude protein content varied from 1.25 to 17.47%. Higher protein content was recorded in Meetha pan, IIHR BV 68-1, *Piper colubrinum* and inter-specific hybrid. Calcium varied from 0.28 to 3.51%. Iron content varied significantly among the lines from 24.49 to 124.68 ppm whereas Manganese content showed a variation from 20 to 62.93 ppm. Hybrids recorded higher crude protein, K, Ca, Mg and S. In general, hybrids have recorded higher Fe content over the germplasm and parents.

Phytochemical analysis of betel leaf extract of five different groups of cultivars showed the presence of different compounds like flavanoids, terpenoids, steroids, tanins, phenols Saponins and Proteins. Presence of Alkaloids was recorded only in Kapoori group. Quantitative analysis of Phenols and tannins showed that the groups differ significantly for their presence. Bangla cultivars recorded higher phenol content (105 µg/ml), whereas, Kapoori cultivars contained lower phenol content (62.1 µg/ml).

Significant differences were recorded for stomata length, breadth, density and type of stomata among the germplasm, hybrids and parents. The stomata density varied from 148 (Bangla, M.P.) to 246/mm^2 (IIHR BV76). IIHR BV71 recorded bigger size stomata with 32.83µm length and 18.5 µm width. In general, Bangla clones recorded bigger sized stomata whereas Kapoori clones had smaller stomata.

4.9.3. Crop Production

For evaluation standards, Gall wasp tolerant *Erythrina subumbrans*, *Melia dubia*, *Gliricidia sepium*, *Sesbania grandiflora*, *Oroxylum indicum*, *Moringa oleofera, Ceiba pentandra* and *Grevellia robusta* planting material were procured. Meetha pan was procured from East Midanapur area of West Bengal and established under polyhouse.

4.9.4. Post-harvest Technology

Betel vine leaves cv. Hesaraghatta harvested at two stages (light green and dark green) were stored at room temperature (28.6 to 34.8°C), 12°C, 8°C and 5°C to revealed that Betel vine leaves stored for a week at 5°C recorded least moisture loss and retention of green colour, phenols, flavonoids and antioxidants.

5. Transfer of Technology

The Institute has multi-dimensional approach in extension for effective transfer of technologies to various stakeholders which has been the mandate of extension research and education across the country. Accordingly the Division of Extension and Training, 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' meets, 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 IIHR Regional Stations at Chettalli and Hirehalli in Karnataka, Bhubaneswar in Odisha and KVKs at Hirehalli in Tumkur dist. and Gonikoppal in Kodagu dist. The details are given below.

5.1 Training Programs

5.1.1. IIHR – Hesaraghatta

The Division of Extension and Training organized 21 On campus and 15 Off campus trainings on various technologies with the active participation of scientists of other divisions. A total of 1215 trainees across the country underwent training programs and got benefited. The details of the training are given below;

On Campus

Sl. No.	Title	Date(s)	Number of participants
1.	Production technology of custard apple var. Arka Sahan.	April 22-26	14
2.	Improved vegetable production technology for farmers and officers of Chikkaballapur.	May 20-21 June 24-25 June 27-28	30 29 28
3.	Post-harvest handling and processing of fruits and vegetables for the farmers of Manipur.	June 17-22	25
4.	Importance of vegetable and fruit crops for the farmers of Jalgaon, Maharashtra State.	Sept. 02-06	20
5.	Use of improved machineries for PHM in onion.	Oct. 09	10
6.	Improved cultivation and PHM of onion.	Oct. 18	08
7.	Advances in production technology of horticultural crops for the farmers of Ranchi, Bihar.	Oct. 20-23	21
8.	Post-harvest technology in horticultural crops for the farmers of Kerala.	Nov. 24-29	25
9.	Advances in production technology of horticultural crops for the officers of Kerala.	Dec. 01-07	22
10.	Post-harvest management of horticultural crops for the officers of Kerala.	Dec. 08-13	21
11.	Rejuvenation of important fruit crops.	Dec. 16-20	20
12.	Organic cultivation of selected vegetable and fruit crops for the officers of Kerala.	Jan. 05-09	24
13.	Protected cultivation of high value vegetable and ornamental crops for the officers of Kerala.	Jan. 12-17 Feb. 09-14	25 22
14	Integrated management of pests and diseases in horticultural crops.	Jan. 19-23	25
15	Organic cultivation of selected vegetable and fruit crops.	Jan. 27-31	20
16	Integrated and bio-intensive management of pest and disease in horticultural crops.	Feb. 16-21	16
17	Training cum business strategy meet on horticulture for the officers of NABARD.	Feb. 25-27	30
18	Tropical mushroom production technology for the farmers of Kerala.	Mar. 03-07	15

Off Campus

Sl. No.	Title	Date(s)	Number of participants
1.	Pomegranate production technology in farmer's field in and around Belagur and Kolar.	March 27 Oct. 17	28 24
2.	Refresher program on mushroom cultivation at Rajanukunte.	April 10	94
3.	Problems in production and export of rose onion at Sadli village Sidlaghatta taluk, Chikaballapur.	May 07	40
4.	Cultivation practices for fruits at Sonda, Sirsi Uttara Kannada.	May 13	48
5.	Improved cultivation of onion and other vegetable crops for the farmers at Narasipura.	June 19	46
6.	Improved onion cultivation and grafting technology in tomato, for farmers of Giriyapura and Hirenallur.	Sept. 12	14
7.	Use of IIHR Bio-pesticides for sustainable management of vegetable crops at Malur in collaboration with NABARD.	Sept.26	35
8.	Management of pomegranate gardens and use of IIHR bio-pesticides at Hosadurga.	Oct. 27- 28	55
9.	ICM in protected cultivation of vegetable crops and flowers at RUDSETI, Chikkaballapura.	Oct. 29	45
10.	Production of quality mangoes for export from Kolar and Chikkaballapur districts at Mango Development Centre Hogalagere, Kolar.	Oct. 30	56
11.	Improved production practices for rose onion using- Arka Bindu at Chinnakayalapalli of Chikkaballapur.	Nov.11	35
12.	Use of bio-pesticides for SC/ST farmers at KVK, Vellore, Tamil Nadu.	Nov. 25 March 03	100 100
13.	Improved production practices for Rose onion using- Arka Bindu at S. Guttahalli, Chintamani.	Dec.12	45

5.1.2. CHES Chettalli, Kodagu

The Station organized three On campus and seventeen Off campus trainings as given below benefiting 420 trainees.

On Campus

Sl. No.	Title	Date(s)	Number of participants
1.	Integrated nematode management in fruit and vegetable crops.	May 15	15
2.	Pepper nursery management for tribal farmers.	Nov. 05	20
3.	Nursery management for tribal farmers.	Nov. 08	20

Off Campus

Sl.No.	Title	Date(s)	Number of participants
1.	Commercial nursery raising in coffee at Balagundi tribal village, Somvarpet, Madikeri.	Mar. 09	25 30
2.	Commercial nursery raising in vegetables and Balagundi tribal village, Somwarpet, Madikeri.	Mar. 16-17	25 20
3.	Commercial nursery raising in coffee and pepper.	Mar. 17	40
4.	Fruits and vegetables preservation.	Jan. 23	20
5.	Production technologies of horticultural crops at tribal villages.	Jan. 19-29 Feb. 03 Feb. 09 Feb. 25 Mar. 02-03 Mar. 09 -10 Mar. 16-17 Mar.23	20 20 40 40 40 20 25 20
6.	Fruits and vegetables preservation at Hoskote village, in collaboration with the Dept. of Horticulture.	Feb. 14	25

5.1.3. CHES, Bhubaneswar

The Station organized five On campus and three Off campus trainings to the different stakeholders. In all 284 participants benefited.

On Campus

Sl. No.	Title	Date(s)	Number of participants
1.	One year apprentice training on horticulture.	April - March	16
2.	Commercial vegetable cultivation.	April 23-25	25
3.	Canopy management and INM in mango.	Sep. 01	30
4.	Nursery production and management of fruits and vegetable crops.	Sep. 04-06	30
5.	Mango production technology under tribal sub-plan.	March 12	30

Off Campus

Sl. No.	Title	Date(s)	Number of participants
1.	Horticultural interventions for enhancing tribal livelihood in Mohna block of Gajapati dist. (Odisha).	Dec. 29	88
2.	Minimal processing of raw jackfruits for vegetable purpose for the tribal farm women of different SHGs of Mohna block of Gajapati dist. (Odisha).	Feb. 13	30
3.	Backyard kitchen gardening and commercial cultivation of cucurbits for the tribal farmers of different villages of Mohna block of Gajapati dist. (Odisha.)	Mar. 09	35

5.1.4. KVK, Hirehalli, Tumkur

The Krishi Vigyan Kendra organized 84 trainings on various technologies in the fields of horticulture and allied subjects.

Sl. No.	Type of Training	No.	No. of Participants		Total
			Male	Female	
1.	On campus	32	452	422	874
2.	Off campus	45	820	980	1800
3.	Vocational	05	62	10	72
4.	Extension personnel	02	74	15	89
	Total	**84**	**1408**	**1427**	**2835**

5.1.5. KVK, Gonikoppal, Kodagu

The Krishi Vigyan Kendra organized the following 69 trainings as per the mandate of KVKs benefiting 2744 trainees.

Sl. No.	Type of Training	No.	No. of Participants		Total
			Male	Female	
1.	On campus	23	352	476	828
2.	Off campus	42	800	956	1756
3.	Vocational	02	72	07	79
4.	Extension personnel	02	70	11	81
	Total	69	1294	1450	2744

5.2. Field Demonstrations

5.2.1. IIHR, Hesaraghatta

The Division of Extension and Training in collaboration with other divisions of the Institute organized 137 field demonstrations of various technologies in different locations which detailed below;

Sl. No.	Type of Training	Locations	No. of Demostration
1.	A model demonstration block showing improved/ hybrid vegetable- 36 varieties including 10 hybrids.	IIHR, Hesaraghatta during *kharif*	01
2.	A model demonstration block showing improved/ hybrid vegetable- 34 varieties including nine hybrids.	IIHR, Hesaraghatta during *rabi*	01
3.	Arka Rakshak tomato hybrid and CRT's in tomato cultivation.	Six locations in Kolar, Chikkaballapura and Bengaluru rural	06 10
4.	IPM in vegetable crops.	Bengaluru rural, Kolar and Chikkaballapura	02
5.	IPM in brinjal.	Hosahallipalya, Agrahara	
6.	IPM in bhendi.	Hosahallipalya, Agrahara	02

Sl. No.	Type of Training	Locations	No. of Demostration
7.	Use of microbial consortium in onion, papaya and capsicum under polyhouse.	Bengaluru urban and rural, Ramanagara, Mysore and Chamarajnagar	26 06
8.	Bio-control of pests and disease under protected cultivation of vegetables.	Bengaluru urban and rural dist.	05
9.	Use of improved seed and production technologies in rose onion and use of bullock drawn drum seeder.	Dibburahalli village, Sidlaghatta, Chikkaballapur	
10.	Improved onion variety-Arka Bindu and production technologies.	Sahukar Guttahalli of Chintamani, Chikkaballapur	03
11.	Improved onion hybrid Arka Kirthiman and production technologies.	Gollahalli of Nelamangala	03
12.	Horticultural practices in China aster.	Pemmanahalli and Gollara Hatti villages of Hirehalli, Bengaluru.	06
13.	Effect of bio-pesticides in management of nematodes in capsicum under protected cultivation.	Agralagurki of Chikkaballapur	04
14.	Effect of Basillus Spp. bio-pesticides for sustainable management of nematodes in tomato and chilli.	Thammarasanahalli village Bengaluru urban	02
15.	Improved French bean varieties - Arka Anup and Arka Suvidha.	Ammanghatta, Varadenahalli, of Gubbi taluk of Tumakuru.	18
16.	Improved French bean varieties - Arka Anup and Arka Suvidha.	Singanahalli and M.T.Pallya of Tumkuru	04
17.	Improved variety of chilli – Arka Suphal.	Singanahalli and Bommanahalli villages of Tumkuru	06
18.	Hybrid chilli – Arka Meghana.	Vadekal village of Tumkuru.	12
19.	Amaranthus variety-Arka Suguna.	Vadekal, Singanahalli and MT pallya villages of Tumkuru	14
20.	Prevention of spongy tissues in Alphonso mango by using Arka Saka Nivarak in farmers orchards.	Nippani, Dharwad, Karvar, Hunsure, Doddaballapur and Gouribidanure	06
		Total	**137**

5.2.2. KVK, Hirehalli, Tumakuru

Demonstrations on various technologies in agriculture, horticulture, homes science and allied fields through On Farm Testing (OFT) and Front- Line Demonstration (FLD) programs were under taken in different villages in Tumkuru district. Accordingly four OFTs for 18 farmers of five villages and 17 FLDs covering 150 farmers of twelve cluster villages were covered.

5.2.3. KVK, Gonikoppal, Kodagu

A total of three On- Farm Testing (OFT) covering 15 farmers in ten different villages and also nine Front –Line Demonstrations (FLD) covering 150 beneficiaries on agriculture, horticulture and allied fields in 12 different villages of Kodagu district have been organized.

5.3. Field Days

5.3.1. IIHR, Hesaraghatta, Bengaluru

Sl. No.	TITLE	Date & Place
1	Arka Rakshak tomato hybrid.	02.07.2014, Hennagara village of Anekal Bengaluru urban.
2	Ridge gourd-IIHR technologies.	22.08.2014, Silvepura village of Bengaluru North
3	IIHR field day for ASRT delegates.	11.09.2014, IIHR, Bengaluru
4	Field days on vegetable varieties /hybrids grown with advanced production technology.	16.09.2014, IIHR, Bengaluru
5	Nematode management in protected cultivation.	27.09.2014, Agalaguraki village of Chikkaballapur
6	Vegetable hybrids with improved production technology.	10-11.1.2015, IIHR, Bengaluru.
7	Bio-control of nematodes in capsicum and tomato.	08.12.2014, Thammarasanahalli village, Bengaluru North.
8	Vegetable field day.	24.01.2015, IIHR, Bengaluru

5.3.2. KVK, Hirehalli

The KVK organized one field day on Amla production technologies at D. Nagenahalli, Koratagere Tumakuru on September 22, 2014 in which about 200 farmers participated.

5.3.3. KVK Gonikoppal, Kodagu

The KVK conducted three field days on different technologies covering 130 participants

Sl. No.	TITLE	Date & Place
1	Use of Arka microbial consortium in black pepper.	19.9.2014, Gonikoppal, Virajpet Kodagu
2	Integrated nutrient management in banana.	17.12.2014, Shirangala village of Somwarpet
3	Vegetable crops.	13.01.2015, KVK, Gonikoppal

5.4. Farmers – Scientists- Interfaces/ Meetings

For effective dissemination of IIHR technologies 16 different interface meetings were organized. The details are given below.

5.4.1. IIHR, Hesaraghatta, Bengaluru

Sl. No.	Title	Date(s)	Place	Number of participants
1	Interface with farmers, officials of KVK and scientists on mango production technologies.	June 03	IIHR,Bengaluru	138
2	Interface on IIHR technologies for farmers on the occasion - ICAR Foundation day.	July 16	IIHR, Bengaluru	120
3	Interaction meeting with officers of NABARD, Dept. of Horticulture, GoK, NHB on promotion of protected cultivation of vegetable crops in cluster mode.	July 22	Department of Horticulture, Bengaluru	20
4	Livelihood security of farm women through appropriate horticultural interventions.	Aug.28	Bommanahalli and Singanahalli, Tumkuru	32
5	Interface meeting with input companies, exporters, bankers and marketers of high value vegetables and flowers at BIEC on for promotion of protected cultivation.	Aug.30	Bengaluru	40
6	IIHR Foundation Day - Interface meeting.	Sept.05	IIHR, Bengaluru	
7	Interaction meetings with farmers at Hodekal, Mydala, Singenahalli.	Sept. 18-19	Chikkaballapur	32
8	Interface meeting with Druv Technology Solutions and Rijk Zwaan Seeds India Pvt. Ltd., Bengaluru on development of portals on protected cultivation of vegetable crops.	Sept. 20	Bengaluru	10
9	Farmers interactive meeting on transfer of technology aspect of IIHR.	Dec. 10	Amanaghatta, Gubbi, Tumkuru	24
10	Farmers interactive meeting on transfer of technology aspect of IIHR.	Dec. 22	Vardanahalli, Gubbi Tumkuru	22

Five off campus need based training programmes for farmers for promotion of varieties and technologies of the Institute were organized for 62 farmers/ entrepreneurs of Kadur taluk, Chikamagaluru district of Karnataka on various aspects of horticulture as given below.

Sl. No.	Name of the programme	Date	Number of participants
1	Farmers-Scientists interaction on improved cultivation of onion	01.07.2014	12
2	Farmers-Scientists interaction meeting on refinement of onion sowing machines.	05.07.2014	09
3	Farmers-Scientists interaction meeting on IPM, IDM in onion and use of onion digger and grader.	07.07.2014	25
4	Farmers-Scientists interaction meeting on improvement of onion digger and grader.	09.10.2014	06
5	Farmers-Scientists interaction meeting on onion de-topper, grader and other machineries.	21.10.2014	10

5.4.2. KVK, Gonikoppal

Sl. No.	TITLE	Date	Places
1	Animal health campaigns	Sept. 02, 08, 16, 22 and 27	Badagarakeri, Harihara, Parakatageri, Birunani and Teralu
2	Soil health campaign	N0v.26	K. Badaga

5.5. Exhibitions

5.5.1. IIHR, Bengaluru

Sl.No.	Event / Occasion	Venue	Period
1	Mango Diversity Fair.	IIHR, Bengaluru	June 03
2	Mega Field Day and Farmers Interface on Tomato- Arka Rakshak.	Hennagara, Anekal	July 02
3	86th ICAR- Foundation day.	IIHR, Bengaluru	July 16
4	Inauguration of PG School in Horticulture Sciences.	IIHR, Bengaluru	Aug 16
5	Hasiru Santhe- Mela Organized by BBMP & Min of Agri. GoK.	Vidhyarannyapura, Bengaluru	Aug 24
6	XXII Group Meeting of AICRP on MAP & Betel vine.	IIHR, Bengaluru	Sep 18 -19
7	Krishi Mela 2014 of UAHS Shivamoga.	UAHS, Shivamoga	Oct. 18-20
8	National Krishi Mela - 2014.	UAS, GKVK, Bengaluru	Nov 19-21
9	Southern Regional Agril. Fair-2015.	TNAU, Coimbatore	Jan 06 -09
10	Kisan -2015.	IIHR, Bengaluru	Jan 09-10
11	National Meet on Distant Hybridization.	IIHR, Bengaluru	Jan 22 -23
12	Parliamentary Committee Visit to IIHR.	IIHR, Bengaluru	Feb 03
13	National Seminar on Oil Palm Cultivation.	Oil Palm Research Station, Pedavegi	Feb.05-06
14	Eastern Zone Agricultural Fair.	CPRS Patna, Bihar	Feb.19-21
15	Annual Pusa Krishi Vigyan Mela.	IARI, New Delhi	March 10-12
16	National Horti. Farmers Meet organized by ICAR and TNAU.	RRS(TNAU), Paiyur	Mar 14

5.5.2. CHES, Bhubaneswar

Sl. No.	Event / Occasion	Venue	Period
1	State Level Fruit Festival- 2014	Adivasi Ground, Bhubaneswar	May 24-26
2	ICAR Institutes-SAUs and State Departments Interface Meet	CRRI, Cuttack	Oct 21-22
3	Regional Agriculture Fair-Odisha	Balasore, Odisha	Oct 28-30
4	Regional Krishi Mahostava-Government of Odisha	Berhampur, Odisha	Dec 28-30
5	Eastern Zone Regional Agriculture Fair, ICAR-CPRI & Indian Potato Association	CPRI, Shimla	Feb 19-21

5.5.3. KVK, Hirehalli

The KVK, Hirehalli participated in 10th International Agriculture and Horticultural Expo at Pragathi Maidan, New Delhi during July 25-27, 2014.

5.5.4. KVK, Gonikoppal

Sl. No.	Event / Occasion	Venue	Period
1	Krishi Mela – ARS Ponnampet	Ponnampet	Nov. 30
2	Golden Jubilee of Cardamom Research Centre	CRC(IISR), Appangala	Dec.20-22
3	Protection of Plant Varieties & Farmers Rights Act	CHES Chettalli	Feb. 27
4	Krishi Uthsava	Bilugunda	Mar. 18

5.6. TV and Radio Programs

Scientists of the Institute gave 15 radio and 39 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
Precision farming in vegetable crops	11.06.2014	AIR, Bengaluru
Advances in production technologies for onion crop	14.06.2014	AIR, Bengaluru
Role of KVK in addressing climate change in agriculture and horticulture	17.06.2014	AIR, Bengaluru
Advanced production technology and improved varieties of chilli	19.06.2014	AIR, Bengaluru
Leafy vegetable varieties released by IIHR and their production technology	20.06.2014	AIR, Bengaluru
Tuberose cultivation	30.06.2014	AIR, Bengaluru
Bonsai cultivation	12.07.2014	AIR, Madikeri
Oyster mushroom cultivation	22.07.2014	AIR, Madikeri
Organic farming and its importance	21.08.2014	AIR, Bengaluru
Advances in production technologies for rose onion crop for export	02.09.2014	AIR,Bengaluru
Buffalo management in summer	11.10.2014	AIR, Madikeri
Pest and disease management in paddy	23.11.2014	AIR, Madikeri
Mixed farming technologies based on horticultural crops	01.01.2015	AIR, Bengaluru
Pest and disease management in areca nut	28.01.2015	AIR, Madikeri
Developmental strategies for enhancing vegetables and floriculture production in Chitradurga – Radio Kisan Divas 2015	12.03.2015	AIR,Chitradurga

5.6.2. Television Programs

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

Topic	Date	Station
Panel discussion on disease management in important horticulture crops	02.04.2014	DDK, Bengaluru
Use of mango harvesting technology	16 .04.2014	DDK, Bengaluru
Management of summer horticulture crops	23.04.2014	DDK, Bengaluru
Removal of rootstock sprouts, water shoots, crisscross & lower branches in sapota	07.05.2014	DDK, Bengaluru
Inter zonal cross learning visit to KVK Hirehalli & NICRA village	15 .05.2014	DDK, Bengaluru
Mango harvester and its usage	28.05.2014	DDK, Bengaluru
Onion cultivation through raised bed method	04.06.2014	DDK, Bengaluru
Mango low cost ripening chamber - IIHR technology	05.06.2014	DDK, Bengaluru
Recent advances in cultivation of black pepper	05.06.2014	Coorg Channel

Topic	Date	Station
Prevention of spongy tissue in Alphonso mango using – IIHR Arka Saka Nivarak.	05.06.2014	DDK, Bengaluru
Plant protection in pepper cultivation.	08.06.2014	Coorg Channel
Importance of vaccination for F&M - HS in animals.	12.06.2014	Coorg Channel
Horticultural cropping systems and hints to farmers.	11.07.2014	DDK, Bengaluru
Farmers- scientist- interface at IIHR.	16.07.2014	DDK, Bengaluru
Tomato variety Arka Rakshak.	18.07.2014	India TV
Tomato variety Arka Rakshak.	25.07.2014	NDTV
Importance of krishi melas and extension activities.	29.07.2014	DDK, Bengaluru
Improved onion varieties and production methods.	06.08.2014	DDK, Bengaluru
Recently developed improved vegetable varieties of IIHR.	13.08.2014	DDK, Bengaluru
ATIC in the service of farming community.	14.08.2014	DDK, Bengaluru
IIHR extension activities and importance of exhibitions.	16.08.2014	DDK, Bengaluru
Anti-oxidant rich amaranthus varieties, Arka Samraksha and Arka Varna.	18.08.2014	DDK, Bengaluru
Success story of ridge gourd farmer of Silvepura–field day coverage.	22.08.2014	DDK, Bengaluru
Field day coverage.	26.08.2014	DDK, Bengaluru
Soil and water conservation under NICRA at D.Nagenahalli.	05.09.2014	DDK, Bengaluru
Success story on scientific dairy farming.	05.09.2014	DDK, Bengaluru
Field day at IIHR.	18.09.2014	DDK, Bengaluru
Recent advances in quick wilt disease management in black pepper.	20.09.2014	DDK, Bengaluru
Preparation for rabi crops- hints to the farmers.	26.09.2014	DDK, Bengaluru
Field day on management of nematodes in protected cultivation in capsicum at Agalagurki.	27.09.2014	DDK, Bengaluru
Banana special for boosting banana yield.	09.10.2014	DDK, Bengaluru
Nendran banana cultivation.	25.10.2014	DDK, Bengaluru
Coriander variety, Arka Isha and palak variety, Arka Anupama released by IIHR, Bengaluru.	12.11.2014	DDK, Bengaluru
IIHR technologies for the farmers.	20.11.2014	DDK, Bengaluru
Field day on management of tomato and capsicum-field day coverage.	08.12.2014	DDK, Bengaluru
Panel discussion on management of pomegranate crop.	13.01.2015	DDK, Bengaluru
Panel discussion on plant protection in important fruit crops.	27.01.2015	DDK, Bengaluru
Tomato hybrids- Arka Rakshak and Arka Samrat.	25.03.2015	DD National
Video shoot of Vigyan Prasar to popularize science and technology behind the IT programme entitled 'Spices'	28.03.2015	M/S Beacon Television, Mumbai

5.7. Agricultural Technology Information Centre (ATIC)

The Division of Extension and Training houses an Agricultural Technology Information Centre (ATIC). Through its single window concept, ATIC has been extending services to the stakeholders by providing technological products of the Institute, publications, seed and planting materials, technical know–how and telephone messages. A total number of 2879 stakeholders visited ATIC and an amount of Rs. 74.2 lakhs has been realized as revenue through sale of products and publications.

Details of Field Days Organized

Mango Field Day

The CHES, Bhubaneswar organized a Field Day on Mango May 18, 2014 at its station with an objective of strengthening the public understanding on varietal diversity, fruit quality, marketing channel and related aspects. About 100 participants from ICAR (CRRI, CIFA, CTCRI, and DWM), state departments, mango growers, mango lovers, farm women and consumers participated in the program. Shri A. Chandra, Special Secretary, Govt. of Odisha was the Chief Guest and inaugurated the Field day. A Scientist's-Farmer's interaction meet was organized on the occasion in which resource persons from CHES, Bhubaneswar interacted with the farmers on various issues of mango production. An exhibition showcasing mango diversity in the region was also organized for the benefit of the participants.

Bio-Intensive Management of Brinjal Shoot and Fruit Borer

The Institute organized a field day on Bio- intensive management of brinjal shoot and fruit borer at HD Kote, Mysore on June 16, 2014 under the DST–SSTP project "Development and dissemination of bio-intensive management of brinjal shoot and fruit borer, *Leucinodes orbonalis* in Karnataka and transfer of technology on mass production of *Trichogramma chilons* at farmer's level.

Tomato Field Day

A Field Day on tomato hybrid Arka Rakshak was organized by IIHR, Bengaluru in collaboration with Department of Horticulture, GOK in the tomato field of Shri Babu at Hennagara village, Anekal, Bengaluru Urban district on July 02, 2014. Shri Ramalinga Reddy, Minister of Transport and In-charge Minister, Bangalore Urban district, Govt. of Karnataka inaugurated the Field day. Justice Nagamohan Das presided over the function. The tomato grower Mr.M. Babu, who had raised the tomato hybrid on his five acre of land shared his experience about the advantages of cultivating Arka Rakshak. He expressed that Arka Rakshak was high yielding with triple disease resistance with excellent fruit quality attributes like fruit firmness and good keeping and transport quality. He further said that the tomato fruits were exported to distant markets like Bangladesh and Port Blair besides, Ahmedabad, Mumbai and Kerala and urged the tomato growers to adopt Arka Rakshak. More than 250 farmers participated in the field day.

Sri Ramalinga Reddy addressing

Field Day on Importance of Arka Microbial Consortium in Capsicum

The Institute organized a field day on 'Importance of Arka Microbial Consortium in Capsicum' in the field of Mr. Yashwanth of Konnagattha village, Doddaballapura taluk, Bengaluru Rural district on September 23, 2014. About 60 vegetable farmers from in and around the village participated in the event. Dr. A. N. Ganeshamurthy, Head, Division of Soil Science and Agricultural Chemistry addressed the gathering

Farmers in the capsicum field

and informed about various microbial and micronutrient formulations developed by IIHR, Bengaluru and appealed to the farmers to take advantage of the novel technologies like Arka Microbial Consortium, Arka Fermented Cocopeat that have immense potential and can reduce the use of fertilizers. Dr. G. Selvakumar, Senior Scientist spoke on the importance of Arka Fermented Cocopeat for vegetable seedling production and Dr. P.

Panneerselvam, Scientist spoke on the significance of the Arka Microbial Consortium and its utility in boosting vegetable yields and soil health. Mr. Yashwanth, who has been using the product for the past two years shared his experiences with the Arka Microbial Consortium and its importance in capsicum crop production. A scientists-farmers interaction was also organized on the occasion.

Vegetable Field Day

The Institute organized Field Day on Improved Vegetable Varieties / F_1 Hybrids developed and Production Technologies standardized by the Institute in the vegetable demonstration block at its campus on September 16, 2014. High-yielding triple disease resistant tomato hybrids; Arka Rakshak and Arka Samrat, high-yielding disease resistant chilli hybrids; Arka Khyati, Arka Meghana & Arka Harita, bacterial wilt resistant brinjal hybrid, Arka Anand, onion varieties; Arka Vishwas, Arka Sona, Arka Swadista & Arka Ujjwal, onion hybrids; Arka Lalima & Arka Kirthiman and synthetic variety Arka Bheem, French bean varieties; Arka Komal, Arka Suvidha, Arka Anoop & Arka Sharath, dolichos varieties; Arka Amogh, Arka Sambhram & Arka Soumya, pea varieties; Arka Sampoorna, Arka Priya & Arka Pramod, multi-cut Amaranthus varieties; Arka Suguna & Arka Arunima, palak variety, Arka Anupama, coriander variety, Arka Isha, pumpkin varieties; Arka Suryamukhi & Arka Chandan, bush Ssquash variety, Patty Pan, ridge gourd variety, Arka Sujat and bottle gourd variety, Arka Bahar had been grown in the demonstration plots according to the recommended precision farming techniques including mulching, drip irrigation, fertigation *etc.* A field visit of the farmers was arranged to witness the crops grown in the demonstration block where the breeders explained the features of these varieties and clarified queries raised by farmers. Brochures on vegetable varieties released from IIHR and recommended cultivation practices were distributed to farmers. Seeds of these varieties were also made available for sale. Scientists –farmers, interactive meeting was arranged after the field visit.

Farmers interacting with scientists in the field

More than 200 farmers from Bengaluru, Mysoru, Chikballapur, Doddaballapur and Tumkuru districts of the Karnataka and Cuddapah district of Andhra Pradesh participated in the Field day.

Field Day cum Scientist-Farmer Interface Program on Arka Microbial Consortium

The KVK, Gonikoppal in association with Division of Soil Science, IIHR, Bengaluru organized a Field Day cum Scientists - Farmers Interface Program on Arka Microbial Consortium on September 19, 2014. More than 100 progressive planters, farmers, extension functionaries from different taluks of Kodagu participated in the program. Dr. A. N. Ganeshmurthy, Principal Scientist and Head, Division of Soil Science and Agricultural Chemistry, IIHR, Bengaluru inaugurated the field day. Dr. P. Paneer Selvam, Scientist, IIHR, Bengaluru explained in detail the role of Arka Microbial Consortium in producing healthy plants material which can guard against diseases and how to use this product. Dr. G. Selva Kumar, Senior Scientist, IIHR, Bengaluru spoke on the importance of Arka Coco-pith in the production of quality planting materials in vegetable/fruit crops and black pepper. Dr. Saju George, Program Coordinator, KVK, Gonikoppal requested the growers to acquaint with the latest technologies in consultation with the Subject Matter Specialists of KVK in enhancing the production and productivity in black pepper. Mr. Ayyappa, from Arvathoklu village of Virajpet taluk of Kodagu district who has been using Arka Microbial Consortium in black pepper since last one year shared his experiences of recovery of pepper vines by use of Arka Microbial Consortium with the guidance and monitoring from scientists of IIHR, Bengaluru and KVK, Gonikoppal.

Farmers in the field

Field Day on Ridge Gourd

A field day on Management of ridge gourd through improved IIHR technologies was organized in the ridge gourd field of Shri Antony, Silubepura village, Bengaluru Rural on August 22, 2014. About 48 vegetable growing farmers from in and around the

village participated in the event. Scientists of the Institute addressed the gathering and spoke about newly released technologies from IIHR and appealed to the farmers to take advantage of the newly released low cost technologies, importance of micro nutrients and significance and use of Arka Microbial Consortium for improved yield and soil enrichment. Shri Antony, progressive farmers addressing the gathered farmer said that ridge gourd has given better yield because of application of Boric acid, Arka Microbial Consortium and integrated management of fly.

Dr. Ganeshamurthy addressing

Field Day and Exhibition on IIHR Varieties and Technologies

The Institute at Hessaraghatta, Bengaluru organized a two-day Field day and Exhibition at its campus on January 09-10, 2015. The objectives of the event was to showcase high yielding varieties/hybrids and technologies developed by the Institute. The event was organized coinciding with KISAN-2015 organized at BIEC, Bengaluru for which IIHR was the Knowledge partner. Farmer interested in horticultural technologies were brought to the Institute from the International Exhibition Center, Bengaluru. Information related to new varieties of fruits, vegetables, ornamental and medicinal crops, technologies related to plant protection, soil science, plant physiology, biotechnology *etc.* were displayed at the exhibition, where scientists provided first hand information to farmers. KVK Hirehalli and CHES, Chethalli also displayed their technologies. Entrepreneurs who had benefitted from IIHR technologies also displayed their products for sale. More than 1400 farmers visited the exhibition stalls got benefitted.

Visitors in the IIHR exhibition stall

Field Day & Awareness Program on Protection of Plant Varieties and Farmers' Rights Act

A Field Day & Awareness Program on Protection of Plant Varieties and Farmers' Rights was organized at KVK demonstration farm at Athur on January 13, 2015. The highlight of the program was 'Vegetable Demonstration Block' developed with 16 different types of vegetables and their varieties from IIHR, Bengaluru. Dr. T. Manjunatha Rao, Director, IIHR, Bengaluru, Dr. P. C Tripathy, Head, CHES, Chettalli; Dr. S. J. Ankegwoda, Head, CRC, Appangala; Dr. A. T. Sadashiva, Head Vegetable crops, IIHR, Bengaluru and team of scientists from Vegetable Division of IIHR, Bengaluru and CHES, Chettali were present as resource persons. More than 250 farmers, representatives from Forestry College, Ponnampet; officials from Department of Agriculture, Horticulture, ATMA, Bhoochetana, NGO representatives working for agriculture, Press and media representatives from all the three talukas of Kodagu district participated in the program.

Mr. N. Bose Mandanna Progressive Grower and Former Vice Chairman, Coffee Board was the Chief Guest and inaugurated the Field day. The scientists from the Institute interacted with farmers on the\ varieties and hybrids of tomato, chilli, French beans, yard long bean, brinjal, radish, bhendi, peas, dolichos, corinader, palak, amaranthus from IIHR, Bengaluru and also cabbage, *Knol Khol,* beet root and carrot from other sources.

The Awareness Program on Protection of Plant Varieties and Farmers' Rights Act was inaugurated by Dr. T. Manjunatha Rao, Director, IIHR, Bengaluru. Dr. P. C. Tripathi, Dr. A. T. Sadashiva, Dr. T. S. Aghora, from IIHR, Bengaluru and Dr. S. J. Anke Gowda from CRC, Appangla explained about role and importance of Protection of Plant Varieties and Farmers' Rights Act (PPV&FRA), the farmer's rights and provisions for registering farmers varieties present in the act, DUS guidelines in various vegetables, cardamom, black pepper, turmeric and ginger *etc.* A compendium on PPV and FRA (in Kannada) brought out by KVK, Gonikoppal was released on the occasion. The growers actively interacted with the experts on different aspects of vegetable cultivation, coffee and pepper production, fertilizer and organic manuring requirements *etc.* An exhibition was arranged on the occasion to exhibit vegetable varieties from IIHR, Bengaluru. Farmers also exhibited their vegetables, black pepper and rice varieties.

6. Education, Training and Capacity Building

6.1. Post-Graduation Education

The Institute is offering courses/guidance to students of M.Sc. (Ag), M.Sc. (Hort), and Ph.D. degrees in collaboration with UAS, Bengaluru, UAS, Dharwad, UHS, Bagalkot, Dr. YSR Horticultural University, Andhra Pradesh, Sher-E-Kashmi University of Agricultural Sciences and Technology, Birla Institute of Technology, Pilani, Rajasthan, Allahabad Agricultural Institute, U.P., S.K. University, Ananthapur, JNTU, Hyderabad, TNAU, Coimbatore, Kuvempu University, Shimoga, Karnataka, Bangalore University, Bengaluru, Jain University, Bengaluru and Gandhigram Rural University, Gandhigram, Tamil Nadu. Scientists of the Institute have been recognized as faculty/guides by these universities and offering various courses and guiding students for their research work.

6.1.1. Initiation of the Post Graduate School in Horticultural Sciences

The problems faced by current day horticulture research requires multi-disciplinary research approach coupled with extended gap of available and required human resource, which calls for introduction of Ph.D. program in horticultural sciences at IIHR, Bengaluru. An MoU was signed between IARI, New Delhi and IIHR, Bengaluru for initiation of Ph.D. program as an Outreach Program of PG School, IARI, New Delhi.

Dr. S. Ayyappan, Hon'ble Secretary, DARE, Government of India and Director General, ICAR, New Delhi inaugurated the Post Graduate School of Horticultural Sciences, at ICAR-Indian Institute of Horticultural Research, Bengaluru, on August 16, 2014. Dr. N. K. Krishna Kumar, Deputy Director General (Hort. Sci.), ICAR, New Delhi and Dr. R. K. Jain, Dean and Joint Director, IARI, New Delhi were also present as Special Guests on the occasion. Inaugurating the PG School, Dr. Ayyappan said that the Indian Institute of Horticultural Research, Bengaluru has all the expertise in terms of human resources and advanced infrastructure facilities for conducting research and pursuing higher studies in horticultural sciences in the country. He called upon the students to make best use of these expertise and facilities to excel in their research studies. Vice Chancellor of UAS, Bengaluru, Directors and Heads of ICAR Institutes/Regional Stations situated in Bengaluru, former Directors, HODs and scientists of IIHR, all the staff of the Institute and the students of Ph.D. program attended the function. Dr. Ayyappan also laid the Foundation Stone for the "Arkavathi Student Hostel".

Dr. S. Ayyappan addressing after inaugurating Post Graduate School in Horticultural Sciences

Dr. S. Ayyappan laying the Foundation Stone of Arkavathi Student Guest House

Program for Academic Year 2014-15: The disciplines of Fruit Science, Vegetable Science, Floriculture & Landscape Architecture and Post Havest Technology have been finalized for the Ph. D. program. During the current academic year (2014-15), 16 students, three in Fruit Science, six in Vegetable Science and seven in Floriculture & Landscape Architecture have been admitted to pursue Ph.D. degree program. The PG program is in-house and all the basic facilities required for the students such as hostel, classroom, library, playground, recreation facilities *etc.* have been created at the Institute campus itself.

Creation of Board of Studies at IIHR, Bengaluru: The Board of Studies (BOS) for the academic activities of PG education, IIHR, Bengaluru was constituted. The BOS consists of Chairman –Dr. T. Manjunatha Rao, Director and Professor – Member (Ex-Officio), Head, Division of Fruit Crops – Member, Head, Division of Vegetable Crops – Member, Head, Division of Ornamental Crops – Member, Head, Division of Post-Harvest Technology – Member, Nominee from IARI, New Delhi, Members- Dr. T. Vasantha Kumar, Principal Scientist, Genetics – Member, Dr. H.S.Vageeshbabu, Senior Scientist - Member, Dr. Kanupriya, Scientist (SS) Fruit Crops – Member, Dr. P. Nandeesha, Scientist, MBB – Member, and Ms. Pratiksha Kumari, Student Representative – Member and Dr. M. Krishna Reddy, IIHR PG Education Coordinator – Member Secretary. The 1st meeting of the newly constituted BOS for the Academic Session 2014-15 was held on November 01, 2014 and the second meeting was held on March 30, 2015 under the chairmanship of Dr. T. Manjunatha Rao, Director and Professor, IIHR, Bengaluru.

Recognition of IIHR scientists as teaching faculty and research guides: The Academic Council of IARI has approved 85 Scientists as faculty of PG program at IIHR, Bengaluru in the disciplines of Agronomy, Agricultural Economics, Agricultural Entomology, Agricultural Extension, Agricultural Statistics, Agricultural Chemicals, Biochemistry, Genetics, Horticulture-Fruit Science and Technology, Horticulture-Vegetable Science, Horticulture-Floriculture and Landscape Architecture, Microbiology, Molecular Biology and Biotechnology, Nematology, Plant Genetic Resources, Plant Pathology, Plant Physiology, Post-harvest Technology, Seed Science and Technology and Soil Science and Agricultural Chemistry. The Academic Council approved 18 Scientists as Research Guides of PG program in the disciplines of Horticulture-Fruit Science and Technology, Horticulture-Vegetable Science, Horticulture-Floriculture and Landscape Architecture and Post-Harvest Technology.

PG Courses offered for Ph.D.program: The following courses were offered for the Ph. D. program in Horticultural Sciences.

Sl. No.	Course no.	Course title	Trimester	Course Leader
1	FSC602	National horticulture problems and fruit production (4+0)	I	Dr. Reju M. Kurian
2	VSC601	Hi-tech vegetable farming (3+1)	I	Dr. S.S. Hebbar
3	Hort 601	Export oriented horticulture (3+1)	I	Dr.D.V.Sudhakar Rao
4	PGS 503	Intellectual property and its management in agriculture (1+0)	I	Dr. S. Ganeshan
5	PGS 504	Basic statistical methods in agriculture (2+1)	I	Dr. R. Venugopalan
6	PGS 505	Agricultural research, research ethics and rural development programmes (1+0)	I	Dr. B. Balakrishna
7	PP 602	Responses of plants to a biotic stresses (2+1)	I	Dr. R.M.Bhatt
8	FSC 691	Seminar (1+0)	I, II	Dr. M.R.Dinesh
9	FLA 691	Seminar (1+0)	I, II	Dr. T.Manjunath Rao
10	VSC 691	Seminar (1+0)	II	Dr. A. T. Sadashiva
11	FSC 611	Breeding of fruit crops (4+1)	II	Dr. M. Sankaran
12	VSC 611	Breeding of Cross-pollinated vegetable crops (3+1)	II	Dr. R. Veere Gowda
13	FLA 611	Commercial Floriculture (3+1)	II	Dr. H.P. Sumangala
14	FLA 621	Advanced breeding of Ornamental crops (3+1)	II	Dr. C. Aswath
15	GP 643	Concepts in Heterosis Breeding	II	Dr. M. V. Dhananjaya
16	PL Path 604	Molecular basis of Host pathogen interaction (2+1)	II	Dr. M. Krishna Reddy
17	PL Path 607	Plant Health diagnostics and Management (2+2)	II	Dr. S. Sriram
18	PP 503	Global Climate Change and Agriculture	II	Dr. R.H. Laxman

6.1.2. Courses offered by IIHR Scientists to other Universities

The scientists of the Institute offered the following courses for the post graduate students

Sl. No.	Course no.	Course title	Degree	University	Course coordinator
1	FSC 505	Breeding of fruit crops (1+1)	M.Sc.	UHS	Dr. T. Sakthivel
2	FLA 601	Advances in flower production technology (2+1)	Ph.D.	UHS	Dr. Rajiv Kumar
3	CIB 606	Emerging trends in seed quality enhancement (2+1)	Ph.D.	UHS	Dr. Bhanu Prakash
4	HST 601	Applied regression analysis (2+1)	Ph.D.	UHS	Dr. R. Venugopalan

6.1.3. 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. Anuradha Sane – Chairperson, one M.Sc (Hort.) student and Member, Advisory Committee for two M.Sc and one Ph.D students, UHS, Bhagalkot.
- Dr. Chakravarthy, A. K. – Guide, University of Horticultural Sciences-Bagalkot, Jain University-Bengaluru, Kuvempu University-Shimoga, and Bangalore University, Bengaluru.
- Dr. Dhananjaya, M. V. – Chairman, Advisory Committee of one Ph.D. and one M.Sc. students and Member of Advisory Committee of 2 PhD and 3 M.Sc. students of UHS Bagalkot, Karnataka.
- Dr. Gajanana, T. M. - Chairperson for one M.Sc. (Agricultural Economics) student, UAS, Bengaluru.
- Dr. Hima Bindu. K. - Chairman for one M.Sc student, UHS, Bagalkot and Member Advisory Committee for two M..Sc. students of UHS, Bagalkot and UAHS, Shimoga
- Dr. Krishna Reddy, M. - Chairman for one Ph.D. student in Plant Pathology, Department of Plant Pathology, UAS, Bengaluru.
- Dr. Madhavi Reddy, K. - Chairperson for one M. Sc. (Hort.), UHS Bagalkot, PG Centre Campus, Bengaluru and Co-chairperson for one M. Sc. student, Department of Crop Improvement & Biotechnology, College of Horticulture, Mudigere
- Dr. Padmini, K. - Guide for one M. Sc. Vegetable Science student, UHS, Bagalkot.
- Dr. Panneerselvam, P. - Co-guide for one Ph. D student of Gandhigram Rural Institute-Deemed University, Tamil Nadu.
- Dr. Rajasekharan. P.E. - Co-chairman/member for two students of M.Sc., Horticulture, College of Horticulture, Mudigere.
- Dr. Rajiv Kumar - Chairperson for one M.Sc., (Hort) Student and Member, Advisory committee for one M.Sc., and one Ph.D. student, UHS, Bagalkot.
- Dr. Sadashiva, A. T. – Major Advisor for one M. Sc. student and Member, Advisory Committee for one Ph.D student, UHS, Bagalkote
- Dr. Sathisha, J. – Guide, University of Horticultural Sciences, Bagalkot.
- Dr. Selvakumar, G. - Guide for one M.Sc. student of VIT, University.
- Dr. Sreenivasa Murthy, D. - Chairperson for three M.Sc. (Agriculture Economics) students, UAS, Bengaluru.
- Dr. Tejaswini - Chairman for one Ph.D. student, Department of Floriculture & Landscaping, UHS, Bagalkot and Guide, Jain University, Bengaluru.

- Dr. Tripathi, P.C. -Guide, University of Agriculture and Horticultural Sciences, Shimoga.
- Dr. Veere Gowda, R. - Major Guide for one M.Sc.(Horticulture) student, Member, Advisory Committee for four M.Sc. (Horticulture) students,UHS, Bagalkote, Member, Advisory Committee for one M. Sc. and one Ph.D (Hort.) students, UAS, Department of Horticulture, Bengaluru.

6.1.4. Award of M.Sc.(Ag), M.Sc. (Hort) and Ph.D. Degrees

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

Sl. No.	Student	University	Degree	Thesis title	Name of the Guide
1	Mr. K.V. Aswathappa	UAS, Bengaluru	M.Sc. (Ag)	Molecular characterization and diagnosis of cucumber mosaic virus (CMV) infecting hot and bell pepper *(Capsicum annuum)*	Dr. M.Krishna Reddy
2	Basavaraj N. Dadawad	UAS, Bengaluru	M.Sc.(Ag.Eco.)	Spatio-temporal dimension of crop diversification in Gadag district of Karnataka – An economic analysis	Dr.T.M. Gajanana
3	Mr. Bharathkumar, M.V.	UHS, Bagalkot	M.Sc. (Hort.)	Development of F_1 hybrids with resistance to early blight (*Alternaria solani*) in Tomato (*Solanum lycopersicum* L.)	Dr. A.T. Sadashiva
4	Ms.B.B. Channabasamma	UAS, Bengaluru	M. Tech.	Design and development of a motorized garlic bulb breaker	Dr. A. Carolin Rathinakumari
5.	Ms.Girija Kumari	UHS, Bagalkot	M.Sc. (Hort.)	Standardization of planting density, propagule size and post-harvest practices for higher flower productivity and quality of tuberose (*Polianthes tuberose* L.) cv. Prajwal	Dr. Sujatha A. Nair
6	Ms. Prathibha, G	UHS, Bagalkot	M.Sc. (Hort.)	Extraction and quantification of lycopene from tomato peel (*Solanum lycopersicum* L.) cv. Arka Rakshak and its utilization for value added products	Dr. Narayana, C.K.
7	R. Ellango	Kuvempu University, Shimoga	Ph.D.	Identification of target genes for RNAi mediated gene silencing and elucidation of molecular genetic differences of whitefly, *Bemisia tabaci* G (Hemiptera) and diamondback moth, *Plutella xylostella* L. (Lepidoptera)	Dr. R. Ashokan
8	Mr.H. M. Mahadevasamy	Kuvempu - University, Shimoga	Ph.D.	Cloning and characterization of coleopteran and nematode active cry genes from *Bacillus thuringiensis*	Dr. R. Ashokan
9	Mr. Naresh, P.	UHS, Bagalkot	Ph.D.	Genetic and molecular analyses for resistance to viruses (cucumber mosaic virus & chilli veinal mottle virus), drought tolerance and fruit quality traits in chilli (*Capsicum annuum* L.)	Dr. K.Madhavi Reddy
10	Rashmi B. Artal	Kuvempu University, Shimoga-	Ph.D.	Bio-intensive management of tomato wilt caused by *Ralstonia solanacearum* E.F. Smith (Yabuuchi et al., 1995)	Dr. C.Gopalakrishnan
11	K. B. Rebijith	Kuvempu University, Shimoga	Ph.D.	Molecular approaches in identification, diversity and management of important insect vectors (*Thrips palmi* (Thysanoptera) & *Aphis gossypii* (Hemiptera)	Dr. R. Ashokan

Sl. No.	Student	University	Degree	Thesis title	Name of the Guide
12	Reshmi Upreti	JNTU, Hyderabad	Ph.D.	Host-pathogen *(Ralstonia Solanacearum)* - bacterial endophyte interaction in tomato	Dr. Pious Thomas
13	Ms. Sowmya D.S.	JNTU, Hyderabad	Ph.D.	Bio-technological approaches for the management of disease complex in carrot (*Daucas carota* L.) and gladiolus (*Gladiolus grandiflorus* H.) using the combination formulation of bio-pesticides and molecular characterization of fluorescent pseudomonads	Dr.M. S. Rao
14	Subhash B Kandakoor	UAS, Bengaluru	Ph.D.	Effect of elevated temperature & carbon dioxide, plant secondary metabolite on growth and development of melon fruit fly and genetic diversity in Karnataka.	Dr. A.K. Chakravarthy

6.1.5. Thesis Evaluation

1. Dr. Ganeshan, S. evaluated the Ph. D. thesis entitled "Studies on distribution, chemical profiling & molecular characterization of spilanthes- medicinal herb from peninsular India" submitted by Ms. Lavanya Kotekar to Department of Applied Botany, Kuvempu University, Karnataka.

2. Dr. Krishna Reddy, K. evaluated Ph.D thesis entitled "Diagnosis and management of Dasheen mosaic virus infecting *Amorphophallus paeoniifolius* through biotechnological approaches" submitted by Ms. Kamala, S to Kerala University, Trivendrum, Kerala.

3. Dr. Madhavi Reddy, K. evaluated Ph.D (Hort.) thesis entitled "Exploitation of heterosis for growth, earliness, yield and resistance to bacterial wilt in brinjal (*Solanum melongena* L.)" submitted by Ms. Syed Sadarunnisa to Dr. YSR University of Horticultural Sciences, Tadepalligudem, Andhra Pradesh.

4. Dr. Madhavi Reddy, K. evaluated Ph.D (Hort.) thesis entitled "Morphological Characterization and evaluation of jack bean (*Canavalia ensiformis* (L.) DC.) genotypes for yield and quality characters" submitted by Ms. Pradeepthi Lenkala to Dr. YSR University of Horticultural Sciences, Tadepalligudem, Andhra Pradesh.

5. Dr. Tejaswini evaluated two Ph.D. thesis and one M.Sc. thesis of TNAU, Coimbatore and two Ph.D. thesis of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Krishi Nagar, Akola, Maharashtra

6. Dr. Veeregouda, R. evaluated Ph.D (Horticulture) thesis entitled "Studies on heterosis combining ability and stability for yield and its components in brinjal *(Solanum melongena* L)submitted by Mr. Siva Kumar Vavilapalli, to Dr. YSR Horticultural University, Tadepalligudem, Andhra Pradesh.

7. Dr. Veeregouda, R. evaluated Ph.D. (Horticulture) thesis entitled "Evaluation of pre and post emergence herbicides for their efficiency and selectivity in onion and tomato submitted by Mr. Venkateswara Reddy, to Dr. YSR HorticulturalUniversity, Tadepalligudem, Andhra Pradesh.

6.1.6. IIHR Scientists as External Examiners

The following Scientists acted as external examiners for the following students

- Dr. Girija Ganeshan acted as a member in M.Sc student's final qualifying colloquium of Mr. Bharathkumar, V., UHS, Bengaluru on June 10, 2014.

- Dr. Narayana, C. K. conducted student's *viva voce* for the Post Graduate degree at Gandhigram Rural University, Dindigul on May 01, 2014.

- Dr. Rajasekharan, P. E. acted as external examiner of student, Dhanya, C.S., KAU, M.Sc. in integrated biotechnology.

- Dr. Rajasekharan, P. E. acted as Chairman for the Open Defense and *viva-voce* of G. Jayakrishnan, Ph.D student, School of Biosciences, MG University, Kottayam, Kerala for the thesis entitled "Autechological studies

on the river mangrove *Aegriceras corniculatum* (L.) Blanco on July 18, 2014.

- Dr. Rajasekharan, P.E. acted as Chairman for the Open Defense and *Viva-voce* of Benoy Jose, Ph.D student, School of Life Sciences, MG University, Kottayam, Kerala for the thesis entitled "Induction of genetic variation through *in vitro* methods in *Plumbago rosea* L. on September 29, 2014.

- Dr. Rajasekharan. P.E. was nominated as Member Ph.D Adjudication Committee of the following thesis of the students:

  i. Ravikumar, P. – Ethno-agricultural practices of Kurichiyan, Mullakuruman, Thachananden Muppen and Wayanadan Chetti of Wayanad district, Kerala, Mahathma Gandhi University, Kottayam, Kerala.

  ii. Archana, C.P. – Scaling up of micrhisome and minirhizome technology for disease free planting material production in ginger and turmeric, Kannur University.

  iii. Binoy Jose – Induction of genetic variation through *in vitro* methods in *Pumbago rosea* L., Kannur University.

  iv. Krishna Kumar, G. – Phyto pharmacological and tissue culture studies on *Ophiorrhiza prostrate* D. Don, Kerala University.

  v. Jayakrishnan, G. Autechological studies on the river mangrove *Aegriceras corniculatum* (L.) Blanco in Kerala, Mahathma Gandhi University, Kottayam, Kerala.

- Dr. Sankar, V. acted as external examiner for final v*iva-voce* examination of Ph.D student, Department of Vegetable Crops, Horticultural College and Research Institute, TNAU, Coimbatore on May 08, 2014.

- Dr. Sreenivasa Murhty, D. acted as External Examiner for conducting the *Viva-voce* Comprehensive Examination of two PG students of ICAR-NDRI, SRS, Bengaluru on September 27, 2014.

- Dr. Sreenivasa Murthy, D. acted as External Examiner for conducting the *Viva-voce* Comprehensive Examination of two PG students of ICAR-NDRI, SRS, Bengaluru on 27.09.2014.

- Dr. Sudhakar Rao, D.V. acted as an external expert for the thesis of Ms. Pushkala Ramachandran, Ph.D student, Department of Home Science, Sri Sathya Sai Institute of Higher Learning, Prashanthi Nilayam, Ananthapur, Andhra Pradesh on April 18, 2014.

6.2. Training and Capacity Building

6.2.1. Training attended

As a part of Human Resources Development, the following staff members of IIHR, Bengaluru and its regional stations were deputed to undergo training in various fields as mentioned below:

- Dr. Anuradha Sane attended the 'Short Term Workshop in Molecular Phylogenetics-2014" organized by Indian Institute of Science, Bengaluru during August 01-05, 2014.

- Dr. Carolin Rathinakumari, A. attended two days training programme on "Advanced manufacturing technologies" held at Chennai during November 17-18, , 2014.

- Dr. Senthil Kumaran, .G. attended the training program for the Technical Committee Primary Member of Agriculture and Food Processing Equipment Sectional Committee, FAD 20 of Bureau of Indian Standards , New Delhi for two days at NITS, Noida, New Delhi during January 27-28, 2015.

- Dr. Senthil Kumaran, G. attended NCCD-Danfoss Cold Chain training at Danfoss Training Centre, Chennai during August 07-09, 2014

6.2.2. Deputation Abroad

The following scientists were deputed abroad

Sl. No.	Name of the staff with designation	Period	Purpose and country
1	Dr. Sriram, S.	16-17.06.2014	Australian Vegetable Soil Borne Diseases Diagnostics Workshop held at Melbourne, Australia
2	Dr. Sumangala, H. P.	07.07. -31.08.2014	Herrenhausen Research Fellowship-2014 Garden Art and Landscape Architecture (CGL) held at Leibniz University of Hannover, Germany
3.	Dr. Prakash Patil	12.-14. 08.2014	8th Session of International Symposium on Tropical Fruits Network (TFNet) Board of Trustees Meeting and International Symposium on Tropical Fruit held Seri Pacific Hotel, Kuala Lumpur, Malaysia
4.	Dr. Bharathi, L. K.	17-22. 08.2014	29th International Horticultural Congress-2014, held at Brisbane, Australia
5.	Dr. Asokan, R.	17-22. 08.2014	29th International Horticultural Congress-2014, held at Brisbane, Australia
6.	Dr. Reddy, Y. T. N.	17-22. 08.2014	29th International Horticultural Congress-2014, held at Brisbane, Australia
7.	Dr. Dinesh, M. R.	17-22. 08.2014	29th International Horticultural Congress-2014, held at Brisbane, Australia
8.	Dr. Usharani, T. R.	23-27.08.2-14	II Stewardship training program for capability enhancement in the aspects of (i) Safety, (ii) Compliance, (III) Containment and confinement, (iv) Product identity and (v) Quality and sustainability, Queensland University of Technology, Australia

6.2.3. Participation in Conference/ Seminar/ Symposium/Workshop *etc.*

As a part of human resources development and capacity building, the staff members of the Institute were deputed to participate/ present papers in various national and international seminars/symposia /conferences/workshops/group meetings *etc.* During the year 2014-15 the staff members of the Institute were deputed to a total of 81 such events conducted across the country and presented a total of 257 research papers. The combined number of participation of the staff members in such events during the year has been 357.

6.2.4. Training Imparted

- Mr. Chandra Prakash, M. K. and Reena Rosy Thomas imparted five days training on 'Relational database development and management' to ARS scientists during August 04-08, 2014.
- The scientists of Division of PGR imparted training program to four staff of M/s VNR seeds on ITM-CPC platform on pollen cryopr-eservation in vegetable crops during October 12-22, 2014.
- The scientists of Division of PGR imparted training to Ashwini Chouhan, Scientist, Directorate of Onion and Garlic Research, Pune Maharashtra on "*In vitro* conservation of genetic resources particularly in vegetative propagated crops during December 01 17, 2014.
- Dr. Panneerselvam, P., imparted training to Ms Janani, M.Sc. student from Coimbatore on "Basic and advanced microbial techniques".
- Dr. Panneerselvam, P. and Dr. Selvakumar, G. imparted training to Dr. Lubna Mohamed Musa, Associate Professor and Head Department of Soil and Water Sciences, Faculty of Agricultural Sciences, University of Gezira, Sudan who

visited IIHR under the C.V. Fellowship Program of DST on "Microbial Consortia and its use in horticulture" and "Composting and compost tea preparation technique" respectively.

- ❖ Dr. Bhanuprakash, K., imparted training to Mrs. Pratima Pandey, scientist from Nepal for six months on "Advanced aspects of seed priming" sponsored and funded by NAM &ST centre , Delhi.
- ❖ The scientists of Section of Seed Science and Technology imparted two day training program on 'Papaya seed extraction, processing and storage of seed' to the staff members of Amruth seeds Pvt. Ltd. Bengaluru.

6.3. Summer Institute/Short Course Organized

6.3.1. Summer School on Advances in Molecular Diagnostics of Emerging Plant Diseases for Biosecurity

The Institute conducted ICAR sponsored Summer School on 'Advances in Molecular Diagnostics of Emerging Plant Diseases for Biosecurity' in the Division of Plant Pathology during August 01-21, 2014. The main theme of the Summer School was to give hands on training on molecular diagnostic methods to detect and identify emerging plant pathogens.

Dr. T. Manjunatha Rao, Director, IIHR, Bengaluru inaugurated the Summer School on August 01, 2014. During the 21 days training Dr. N. K. Krishna Kumar, DDG (Hort. Sci.), ICAR, New Delhi and Dr. R. K. Jain, Joint Director (Edn.) & Dean, IARI, New Delhi also addressed the participants. Besides the faculty from IIHR, Bengaluru many resource persons came from different ICAR institutes to give talks on various aspects of diagnostics. Important topics like extraction of DNA/RNA from plant pathogens, PCR and Real Time PCR based detection diagnostics, and electron microscopy, SSR finger printing, immunological techniques and recent techniques like next generation sequencing, rolling cycle amplification and loop mediated isothermal amplification *etc.* were covered during the training. Twenty five trainees from 14 states participated in the program. The participants included six from NEH region, 19 participants with teaching responsibility at SAUs participated in the program. The feedback from participants showed that 19 participants rated the training as excellent while six rated as very good.

6.4. Short Term Project Work

A total of 21 M.Sc. and M.Tech, five B.Sc. and B.Tech and three Ph.D. students from various universities /colleges underwent short term project work as partial fulfillment of their degree programs.

7. Awards and Recognitions

7.1. Awards

- ICAR- Indian Institute of Horticultural Research, Bengaluru has been awarded Quality Management System ISO 9001:2008 and the scope of supply is "Research, Development and Transfer of Technology in All Aspects of Fruit, Vegetable, Ornamental, Medicinal Crops and Mushrooms".
- ICAR- Indian Institute of Horticultural Research, Bengaluru was awarded "Best Stall Award" at the National Krishi Mela organized by UAS, Bengaluru during November 19-21, 2014.
- ICAR- Indian Institute of Horticultural Research, Bengaluru was awarded "Best Stall Award" at the Southern Regional Agricultural Fair -2015 jointly organized by Ministry of Agriculture, Govt. of India and Tamil Nadu Agriculture University, Coimbatore at Coimbatore during January 06 -09, 2015.
- The machinery, "Onion Seed Extractor, designed and developed by IIHR, Bengaluru was awarded First Prize in Horticulture Mega Fair held at UHS, Bagalkot, December 11-15, 2014.
- The machinery, "Motorized Garlic Bulb Breaker" designed and developed by IIHR, Bengaluru was awarded Third Prize in Horticulture Mega Fair held at UHS, Bagalkot, December 11-15, 2014.
- The Central Horticulture Experiment Station, Chettalli was awarded First Prize at the National Citrus Diversity Fair-2014 held at NRCC, Nagpur during October 30-31, 2014.
- The ICAR- Indian Institute of Horticultural Research, Bengaluru bagged the overall Champion for the fourth consecutive time with 74 points in the ICAR South Zone Sports Meet held at Bengaluru during October 13-17, 2015.
- The ICAR- Indian Institute of Horticultural Research, Bengaluru bagged the overall Runners up Champion in ICAR Inter- Zone Sports Tournament held at ICAR-NDRI, Karnal during March 11-14, 2015.
- Dr. Dinesh, M. R. has been conferred "Shri. GirdharLal Chadha Memorial Gold Medal Award" in recognition of his outstanding contribution in Fruit Science by the Horticultural Society of India during the 6th January Indian Horticulture Congress 2014, organized by the Horticultural Society of India, New Delhi at TNAU, Coimbatore during November 06-09, 2014.
- Dr. Sadashiva, A. T. was awarded the "Dr. Kirthi Singh Gold Medal-2014" by the Horticultural Society of India during the 6th Indian Horticulture Congress 2014, organized by the Horticultural Society of India, New Delhi at TNAU, Coimbatore during November 06-09, 2014.
- Dr. Krishna Reddy, M. was awarded the "Prof. B. B. Mundkur Memorial Lecture Award" by Indian Phytopathological Society.
- Dr. Venkattakumar, R. received "Young Scientist Award" 2014 at the 7th National Extension Education Congress held at Barapani during November 08-11, 2014.
- Dr. Sudha Mysore was awarded Smt. Revati Singh Memorial Award for significant contibutions to Horticulture & Social Sciences, by Society for Recent Development in Agriculture (SRDA), Meerut.
- Dr. Sriram, S. has been awarded "Dr. B. S. Bhumannavar Best Team Research Award" by Society for Bio control Advancement for the year 2014.
- Dr. Srinivas, P. has been awarded "Prof. M. K. Patel Memorial Young Scientist Award" by Indian Phytopathological Society.
- Dr. Narayanaswamy, B. has been awarded the "Farmers Friendly Scientist" Award by the UAS, Bengaluru under DBT Project "Rural Bio- Reserve Complex" at Doddaballapur on September 02, 2014.
- Dr. Madhavi Reddy, K. and Dr. Ravishankar, K.V. has been awarded "Dr. Harbhajan Singh Memorial Award 2012" for the best paper entitled 'Variability in capsaicinoid content and

phylogenetic analysis of AT3 and acyltranferase gene in chilli (*Capsicum annuum* L.)' published in Vegetable Science, **39** (1):16-20, 2014.

7.2. Best Paper/Poster Awards

The following papers presented by the scientists of the Institute were awarded best paper/best poster award in various seminar/symposium/ conference *etc.* during the year under report.

- Studies of flowering behaviour of avocado accessions under humid tropical conditions of Coorg region by Tripathi, P. C., Sankar, V., Jayanthimala, B. R, Sunanada, S., and Karunakaran, G. - Best paper award at National Seminar Cum- Workshop on Physiology of Flowering in Perennial Fruit Crops held at CISH, Lucknow, May 24-26, 2014.
- Effect of *In situ* rainwater harvesting and mulching on growth and yield of guava variety 'Arka Amulya' in eastern India by Deepa Samant - Best Research Paper award at Global Conference, NAU, Navsari, Gujarat.
- *Geolite Pravidhi: BeejBhandran Mein Iska Mahatwa* by Bhanuprakash. K. - First prize for oral presentation of paper at National Hindi Seminar on 'The Role of Agricultural Science & Technology in Food and Nutritional Security' at IIHR, Bengaluru, June 04-05, 2014.
- *PTD- a Sustainable Innovative Method* by Narayanaswamy, B. -Best Paper Presentation Award at National Hindi Seminar on 'The Role of Agricultural Science & Technology in Food and Nutritional Security' at IIHR, Bengaluru, June 04-05, 2014.
- Design and development of an animal drawn onion seeder - First Prize Research Paper Award at National Hindi Seminar on The Role of Agricultural Science & Technology in Food and Nutritional Security at IIHR, Bengaluru, June 04-05, 2014.
- *Arka Aadya and Arka Archana: China aster Ki Nai Kisme* by Rajiv Kumar, Manjunatha Rao, T. and Janakiram, T. - Second best prize for oral paper presentation at National Hindi Seminar on 'The Role of Agricultural Science & Technology in Food and Nutritional Security' at IIHR, Bengaluru, June 04-05, 2014.
- *Krishi mein data mining ka prayog* by Radhika, V. - Second prize for the presentation at National Hindi Seminar on 'The Role of Agricultural Science &Technology in Food and Nutritional Security' at IIHR, Bengaluru, June 04-05, 2014.
- Intense association of non-culturable endophytic bacteria with antibiotic-cleansed *in vitro* watermelon and their activation in degenerating cultures. *Plant Cell Reports* by Pious Thomas - Best Research Paper Award by the Vision Group on Science and Technology (VGST), Govt. of Karnataka, June 25, 2014.
- Breeding tomato (*Solanum lycopersicum* L) for high nutritive value by Sadashiva, A. T., Shivashankar, K. S., Rao, V. K., Ravishankar, K. V., Kavitha, P. and Shilpa, P. - Best Poster Presentation Award at '6th Indian Horticulture Congress for Inclusive Growth', TNAU, Coimbatore, November 06-09, 2014.
- Rootstock regulates fruit and wine quality parameters in cabernet sauvignon grapevines (*Vitis vinifera* L.) by Satisha, J. - Best Poster Presentation Award at '6th Indian Horticulture Congress for Inclusive Growth', TNAU, Coimbatore, November 06-09, 2014.
- Nutritional and unexploited indigenous vegetables of Kodavas in Western Ghats, Coorg by Tripathi, P. C., Sankar, V. and Senthil Kumar, R. - Best Poster Presentationat '6th Indian Horticulture Congress for Inclusive Growth', TNAU, Coimbatore, November 06-09, 2014.
- Studies on variability in morphological and physico-chemical characters of karonda by Tripathi, P. C., Sankar, V. and Senthil Kumar, R. - Best Poster Presentation Award in National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits at CHES, Chettalli,December 01-03, 2014.
- Inspirational and successful growers: Growing high value tree fruits of exotic origin by Tripathi, P. C., Sankar, V. and Senthil Kumar, R. - Best Poster Presentation Award at National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits at CHES, Chettalli, December 01-03,2014.
- The nutrient profile of important *Garcinia* species of India by Utpala Parathasarathy, Nandkishore, O. P., Senthilkumar, R. and Nirmal Babu, K. - Best Poster Presentation Award at National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits at CHES, Chettalli, December 01-03,2014.

- Optimizing soil fertility foster productivity of mango: an appraisal on soil fertility status and development of nutrient delineation maps of India by Satisha, G. C. and Ganeshamurthy, A. N. - Best Paper Presentation Award at Indian Science Congress-2015, Mumbai, January 07, 2015.
- Potential of mushroom technology in NER region by Meera Pandey Best Research Paper Award in International Conference on Technological Intervences in Agricultural Sciences for Enhanced Productivity, Nutrition Quality and Value Addition (TIAS-2014), held at CIA, Dimapur, Nagaland, February 17-19, 2015.
- Sustainable development of urban and peri-urban horticulture with special reference to landscape gardening for environmental services by Sumangala, H. P. – Best Paper Presentation Award at 'International Symposium on Commercial Floriculture and Landscape Gardening for Urban and Peri-Urban Horticulture' held at Chandigarh, February 21-22, 2015.
- Value chain management for efficient marketing of banana by Narayana, C. K. - Best Research Paper Award at 'International Conference on Dynamics of Technology for Quality Production of Banana' held at Jain Hills, Jalgaon, Maharashtra, March 15-17, 2015.

7.3. Recognitions

7.3.1. ICAR Recognitions

- Dr. Narayana, C. K. has been nominated by Governing Body, ICAR, New Delhi as Regional Coordinator (South) on National Agricultural Education Accreditation Board, ICAR, New Delhi for a period of three years from February 2015.

7.3.2. Professional Societies

- Dr. Srinivas, P. has been elected as President, Zonal Chapter of Indian Phytopathological Society, Eastern Zone.
- Dr. Madhavi Reddy, K. has been elected as General Secretary, Society for Promotion of Horticulture, IIHR, Bengaluru for 2014-15.
- Dr. Shivashankara, K. S. has been elected as Joint Secretary, Society for Promotion of Horticulture, IIHR, Bengaluru.
- Dr. Narayana, C. K. has been elected as Fellow of National Academy of Biological Sciences, Chennai and was conferred the Fellowship on 20.07.2014.
- Dr. Narayana, C. K. was nominated as Executive Councillor of Horticultural Society of India, New Delhi for the year 2015.
- Dr. Rajasekharan, P. E. has been conferred ISPGR Fellowship in March, 2015
- Dr. Madhavi Reddy, K. has been conferred Fellowship of the Indian Society of Vegetable Science 2013 for significant contribution in the field of Vegetable Research.
- Dr. Rajiv Kumar has been inducted as Fellow of Hind Agri-Horticultural Society (FHAS) in the recognition of the significant contribution towards the advancement of Horticulture in Agricultural Sciences.
- Dr. Selvakumar, G. was selected as an Associate of the National Academy of Agricultural Sciences (NAAS), New Delhi in the Section of Plant Protection.
- Dr. Pious Thomas, Principal Scientist, Division of Biotechnology was admitted as a Life Member of ASIAN PGPR Society, Hyderabad.
- Dr. Sudhamoy Mandal received “Certificate of Excellence in Reviewing” by the journal 'Physiological and Molecular Plant Pathology'.

7.3.3. Member in Editorial Boards of Journal/ Referee/ Reviewer

- Dr. Leela Sahijram has been nominated as Editor, 2010-12 for the Journal of Horticultural Sciences, published by Society for Promotion of Horticulture at IIHR, Hessaraghatta, Bengaluru.
- Dr. Sujatha A. Nair has been nominated as Associate Editor in the Editorial Board of the Journal of Horticultural Sciences for the 2014-15 and 2015-16 published by the Society for Promotion of Horticulture, IIHR, Bengaluru.
- Dr. M.V. Dhananjaya has been nominated as Associate Editor of the Journal of Horticultural Sciences of the Society for Promotion of Horticulture, IIHR, Bengaluru.
- Dr. N. Mohan, N. has been nominated as a Member in the Editorial Committee of Journal of Horticultural Sciences published by Society

for Promotion of Horticulture, IIHR, Bengaluru.

- Dr. Leela Sahijram has been recognized as Member, Editorial Board, Journal of Enzymology and Metabolism, Open Science Publications, Hyderabad.
- Dr. Varalakshmi, B. has been nominated as Member of Editorial Board for "Indian Journal of Agricultural Research" for the year 2014 by ARCC, Haryana Agricultural University, Karnal, Haryana.
- Dr. Srinivas, P. has been nominated as Member, Editorial Board of Annals of Plant Protection Sciences.
- Dr. Srinivas, P. has been nominated as Member, Editorial Board of Indian Phytopathology.
- Dr. S. Ganeshan has been nominated as Member of Journal of Palynology.
- Dr. Panneerselvam P., was recognized as a reviewer by the following national/ international journals *viz.*, Journal of Horticulture Science, Proceedings of the National Academy of Sciences, Indian section B: Biological Sciences, Karnataka Journal of Agricultural Sciences.

7.3.4. Member in Management Committees / Others

- Dr. Narayana, C. K. has been nominated as RAC Member of ICAR-Indian Institute of Vegetable Research, Varanasi for a period of 3 years from 2014 to 2017.3
- Dr. Sreenivasa Murthy, D. has been nominated as the Member of RAC, CTCRI, Trivandrum.
- Dr. Venugopalan has been nominated as member of RAC, NHRDF, Nashik.
- Dr. Meera Pandey has been nominated as member of Institute Management Committee of Directorate of Mushroom Research, Solan for the period from 2014-15 for 3 years.
- Dr. Akella Vani, has been nominated as a member of the Institute Management Committee of National Research Centre for Plant Biotechnology, New Delhi.
- Dr. Leela Sahijram has been nominated as Member, Research Advisory Committee (RAC), Institute of Wood Science Technology (IWST), Bengaluru.
- Dr. Ganeshan, S. has been nominated as a Member of RAC, CSGRC, Hosur.
- Dr. Leela Sahijram has been nominated as Member, Planning and Program Committee, Visveswaraya Industrial & Technological Museum (VITM) (National Council of Science Museums- NCSM), Bengaluru, for 2 years from April 2014.
- Dr. Singh, H. S. has been nominated as member in the Constitution of the State Level Monitoring Committee for implementation of C.D.B. schemes for the year 2014-2015.

8. Linkages and Collabarations

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 and All India Co-ordinated Research Programs with State Agriculture/Horticulture 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, bio control strategies for disease management and pesticide residues were undertaken as Network or Outreach programs. The package of practices for various horticultural crops published by the universities are developed with IIHR scientists as resource persons. Scientists of the Institute actively collaborate with the state departments of horticulture/ agriculture in implementation of centrally aided schemes like RKVY, NHM, CHD, Watershed, etc. Following are the external aided projects under operation at the Institute.

8.1 International Aided Projects

Sl. No.	Title of the Project	Principal Investigator	Funding agency	Budget
1.	Conservation and sustainable use of cultivated and wild tropical fruit diversity: Promoting sustainable livelihoods, food security and ecosystem services (UNEP-GEF)	Dinesh, M.R. Thematic Expert only	Bioversity International, Italy, Rome	USD 9,49,645

8.2. National Fellow Project

Sl. No.	Title of the Project	Principal Investigator	Funding agency	Budget Sanctioned (in Rs.)
1.	Studies on phyto-semiochemicals involved in insect-Plant interaction of major horticultural pests: Deciphering chemical cues	Kamala Jayanthi, P.D.	ICAR	–

8.3. National Externally Funded Projects

Sl. No.	Title of the Project	Principal Investigator	Funding agency	Budget (Rs. In lakhs)
1.	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
2.	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
3.	Eco-friendly approaches for the management of Coffee white stem borer, *Xylotrenchus quadripes* Chev.	Shivananda, T.N.	Coffee Board	20.00

Sl. No.	Title of the Project	Principal Investigator	Funding agency	Budget (Rs. In lakhs)
4.	Monitoring of pesticide residues at national level	Soudamini Mohapatra	CSS	69.00
5.	Planting material production of betelvine, transfer of technology and mission management under the MIDH Scheme of the Directorate	Suryanarayana , M.A.	Directorate of Arecanut & Spices Development, MoA, GOI, Calicut	2.85
6.	Introgression of begomovirus resistance genes in tomato (Solanum lycopersicum L.) using MAS and Genomic approach	Sadashiva, A.T.	DBT	156.00
7.	Development of high throughput nano-biosensor for the detection of *Salmonella* spp. in food	Shamina Azeez	DBT	46.518
8.	Development of genotypic markers and PCR based diagnostic assay for identification of *Phytophthora infestans* associated with late blight of tomato	Krishna Reddy, M. (w.e.f. 11/09/14) Chowdappa, P. (upto 10/09/14)	DBT	21.00
9.	Development of national database on mango	Dinesh, M.R.	DBT	28.23
10.	Development of national database on mango	Singh, H.S.	DBT	26.38
11.	Evaluation of indigenous strain of fungal pathogen *Beauveria bassiana* against *Helopeltis* spp on guava, cashew and tea	Ganga Visalakshy, P.N.	DBT	17.968
12.	Identification of cytoplasmic male sterility – regulated novel open reading frames in vegetable crops by mitochondrial DNA sequencing	Lakshmana Reddy, D.C.	DBT	34.00
13.	Preventing Extinction and improving conservation status of threatened medicinal plants- *Madhucainsignis* through application of biotechnological tools	Rajasekharan, P.E.	DBT	37.416
14.	Development of suitable formulation using indigenous strains of NE India for crop improvement: a combined holistic approach	Rao, M.S.	DBT	18.638
15.	Development of bio-agent and mycorrhiza colonized seedlings of horticultural crops by rural women for dissemination of the technology	Rao, M.S.	DBT	14.91
16.	Morphological and molecular characterization of wild and indigenous mango varieties of Indo-Burma Region (North – Eastern Region)	Ravishankar, K.V.	DBT	24.6
17.	Metabolomics of tomato with special reference to fruit quality	Sadashiva, A.T.	DBT	40.59
18.	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

Sl. No.	Title of the Project	Principal Investigator	Funding agency	Budget (Rs. In lakhs)
19.	Development, dissemination of bio-intensive management of brinjal shoot & fruit borer, *Leucinodes orbonallis* in Karnataka and transfer of technology on mass production of *Trichogramma chilonis* at farmer's level	Ganga Visalakshy, P.N.	DST	14.05
20.	Ensuring livelihood security of farm women through appropriate horticulture technological innovations	Narayanaswamy, B.	DST	15.51
21.	Multi-transgene stacking with PR-3, PGIP & NPR 1 gene in tomato for induction of broad spectrum fungal resistance	Mythili, J.B.	DST	47.458
22.	Design and development of a computerized protray filling, dibbling, seeding and watering machinery for vegetable nurseryCarolin	Rathinakumari, A.	DST	23.241
23.	Bio-pesticide technology interventions for livelihood improvement of scheduled caste population in Vellore, Tamail Nadu	Rao, M.S.	DST	31.83
24.	Outreach program on management of sucking pests of horticultural crops	Asokan, R.	ICAR	1299.00
25.	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. (w.e.f. 10.09.2014) Chowdappa, P. (Up to 09.09.2014)	ICAR	1647.77
26.	Outreach programme on Phytophthora, Fusarium and Ralstonia on horticultural and field crops	Gopalakrishnan, C.	ICAR	49.52
27.	Undertaking the changes in host-pest interactions and dynamics in mango under climate change scenario	Kamala Jayanthi, P.D.	ICAR (NICRA)	15.00
28.	National initiative climate resilient agricultural technology package at village level	Loganandhan, N.	ICAR (NICRA)	90.00
29.	National initiative on climate resilient agriculture (NICRA) for XIth Plan	Bhatt, R.M.	ICAR (NICRA)	721.97
30.	Real time pest surveillance on tomato	Sridhar, V.	ICAR (NICRA)	30.00
31.	Network Project on Transgenics in Crops (NPTC) : Evaluation of transgenic tomato lines for resistance to TLCV (Discontinued w.e.f. 03.09.2014)	Akella Vani	ICAR (Network Project)	157.71
32.	Network Project on Transgenics in Crops (NPTC) : functional genomics in tomato	Sadashiva, A.T.	ICAR (Network Project)	145.00
33.	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
34.	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
35.	ICAR Network Project on Organic farming in horticulture	Anil Kumar Nair	ICAR (Network Project)	31.50
36.	All India Network Research Project on Onion & garlic	Veere Gowda, R.	ICAR (Network Project)	8.50

Sl. No.	Title of the Project	Principal Investigator	Funding agency	Budget (Rs. In lakhs)
37.	ICAR Network Project on Insect Biosystematics (NPIB)	Asokan, R.	ICAR (Network Project)	23.50
38.	Functional genomics: Fusarium wilt resistance and drought tolerance in banana	Ravishankar, K.V.	ICAR (Network Project)	304.18
39.	All India Network Project (AINP) on Pesticide residues	Soudamini Mohapatra	ICAR (Network Project)	89.72
40.	All India Network Project on Vertebrate pest management (Part C. Higher vertebrates (Monkey))	Chakravarthy, A. K.	ICAR (Network Project)	61.45
41.	Network project on Impact assessment of agricultural research and development	Gajanana, T.M.	ICAR (Network Project)	16.76
42.	Promotion of horticulture for tribal livelihood	Singh, H.S.	ICAR-TSP	200.00
43.	Theme Area- Improving hybridization efficiency and seeds set in paddy, pigeon pea, finger millet, maize, castor, tomato and brinjal under "ICAR Seed Project"	Yogeesha, H.S.	ICAR	52.65
44.	Theme Area- Development of e-module for Seed Knowledge Centre and Scheming Digital Weed Atlas under "ICAR Seed Project"	Bhanuprakash, K.	ICAR	30.83
45.	Popularization of bio-rational technology for management of mango inflorescence hoppers	Ganga Visalakshy, P.N.	NABARD	8.72
46.	Wide area dissemination of ecofriendly management of brinjal shoot and fruit borer (*Leucinodes orbonalis*) and enabling mass production units of egg parasitoid *Trichogramma chilonis*	Krishnamoorthy, A.	NABARD	7.45
47.	Transfer of patentable technology of bio-pesticide consortia among Karnataka farmers for sustainable vegetable crop production	Rao, M.S.	NABARD	18.638
48.	Developing Environment friendly and organic means of managing major insect pests of mango (cv. Totapuri in Karnataka) and impact on fruit quality	Shivananda, T.N.	NABARD	9.00
49.	Demonstration of Bio-management strategies of nematodes on European cucumber, capsicum and tomato under protected conditions in Karnataka	Rao, M.S.	NABARD	8.086
50.	Establishment of Arka microbial consortium production unit for promotion of organic farming	Saju George	NABARD	5.00
51.	Centre for Agricultural bioinformatics (under NAIP Component-I "Establishment of National Agricultural Bioinformatics Grid (NABG)")	Asokan, R.	NAIP	-
52.	Network Project on Market Intelligence Lead Centre: NCAR, N. Delhi	Sudha Mysore	NCAP	37.41
53.	Establishment of association of begomovirus species with yellow vein mosaic disease (YVMD) in wild and cultivated species of okra and identification of source of resistance to the most predominant virus	Krishna Reddy, M.	NFBSFARA (ICAR)	129.68
54.	Development of model nursery for highly traded / RET medicinal & aromatic crops (Under national mission on medicinal crops)	Sukanya, D.H.	NMPB	20.00

Sl. No.	Title of the Project	Principal Investigator P-I	Funding agency	Budget (Rs. In lakhs)
55.	Molecular characterization of citrus germplasam	Aswath, C.	NRC(C), Nagpur	2.00
56.	Production of haploids in vegetable crops	Aswath, C.	PPP mode -Amrut seeds, Neelamangala, Bengaluru	66.00
57.	Establishment of Referral Lab/accreditation to conduct special tests for plant variety protection in horticultural crops	Aswath, C.	PPV & FRA	6.70
58.	Establishment of DUS nodal centre at IIHR, Bangalore for carnation floricultural crop	Dhananjaya, M.V.	PPV & FRA	23.37
59.	DUS testing centre on mango	Dinesh, M.R.	PPV & FRA	5.00 /yr
60.	Formulation and validation of DUS testing guidelines for Betelvine (*Piper betle* L.)	Hima Bindu, K.	PPV & FRA (Network Project)	20.97
61.	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 (Network Project)	30.00
62.	Establishment of DUS testing centre for crossandra	Manjunatha Rao, T.	PPV & FRA	18.45
63.	Establishment of Nodal DUS centre at IIHR, Bangalore	Meenakshi Srinivas	PPV & FRA (Network Project)	12.60717
64.	Establishment of DUS nodal centre at IIHR, Bangalore for China aster floricultural crop	Rajiv Kumar	PPV & FRA	7.05
65.	Preparation for Plant Variety Protection and DUS Testing through ICAR-SAU system (Tomato, Brinjal, Okra and Garden Pea)(DUS Project entitled Validating crop specific DUS Testing guidelines for Cucumber (*Cucumis sativus*), Bottle gourd (*Lagenaria sinceraria*), Bitter gourd (*Momordica charantia*), Pumpkin (*Cucurbita moschata*) and Pointed gourd (*Trichosanthes dioca*) (Referred as IIVR Cucurbit DUS Project merged w.e.f. April, 2014)	Sadashiva, A.T.	PPV & FRA (Network Project)	37.98
66.	Establishment of DUS nodal centre at IIHR, Bangalore for jasmine floricultural crop	Sujatha A. Nair	PPV & FRA	11.35
67.	Establishment of national repository of rose at IIHR (referred as rose repository DUS project)	Tejaswani	PPV & FRA	55.882
68.	DUS centre for ornamental crops (rose & chrysanthemum)	Tejaswini	PPV & FRA	10.00
69.	Validation of DUS testing guidelines for marigold	Tejaswini	PPV & FRA	10.72
70.	Formulation and validation of DUS testing guidelines for amaranth, palak and ridge gourd	Varalakshmi, B.	PPV & FRA (Network Project)	15.00
71.	Validation of DUS testing guidelines for papaya (*Carica papaya* L.) and custard apple (*Annona squammosa*) (developing national repository & creating facilities for DUS testing in papaya & custard apple)	Vasugi, C.(Papaya) Sampathkumar,P. (Custard apple)	PPV & FRA (Network Project)	9.57
72.	Capacity building of horticulture officers of department of horticulture and horticulture farmers of Karnataka	Balakrishna, B.	RKVY, Dept. of Hort., Karnataka	100.00

Sl. No.	Title of the Project	Principal Investigator	Funding agency	Budget (Rs. In lakhs)
73.	Demonstration of biological control of pest and diseases and integrated crop management practices in protected cultivation of vegetables and flowers	Balakrishna, B.	RKVY, Dept. of Hort., Karnataka	60.00
74.	Rapid multiplication of IIHR varieties of fruit crops P.I.:Chithiraichelvan, R (upto 30/4/14) Reddy, Y.T.N. (May to Sept, 2014)	Dinesh, M.R. (w.e.f. 20/09/14)	RKVY, Dept. of Hort Karnataka	50.00
75.	Production of quality planting material of Coorg manadarin (*Citrus reticulanta* Blanco)	Tripathi, P.C.	RKVY, Dept. of Hort., Karnataka	70.00
76.	Production of quality planting material of Coorg Mandarin and future horticultural crops through CHES, Chettalli	Tripathi, P.C.	RKVY, Dept. of Hort., Karnataka	80.00
77.	Multiplication and popularization of IIHR developed flower crop varieties for improving the livelihood status of farmers	Manjunath Rao, T.	RKVY, GOK	200.00
78.	Participatory seed production and distribution system for recently released vegetable cultivars	Loganandhan, N.	RKVY, GOK	40.00
79.	Establishment of energy and water efficient model oyster mushroom production unit	Meera Pandey	RKVY, GOK	64.00
80	Hybrid vegetable seed production (polyhouse) PI- Prabhakar, M.(Upto 30.09.2014)	Hebbar, S.S. (w.e.f. 01/02/2015)	RKVY, GOK	104.00
81.	Vegetable seed production (open pollinated)	Sadashiva, A.T.	RKVY, GOK, B'lore	7.5
82.	Formulation of Coleoptera active Cry toxins of *Bacillus thuringiensis*	Asokan, R.	ICAR AMAAS (Network Project)	-
83.	Network project on Impact assessment of agricultural research and development	Gajanana, T.M.	ICAR (Network Project)	16.76
84.	Consortium Research Platform (CRP) on Nanotechnology Project 3: Development of nano-biosensors to detect spoilage pathogens in packaged and storage foods	Lakshmana Reddy. D C	ICAR (Network Project)	34.00
85.	Consortium Research Platform (CRP) on Nanotechnology Project 4: Studies on nanomaterial (Nanoparticles) penetration, transport and their bio-effects (positive and negative) in important vegetable crops.	Lakshmana Reddy. D C	ICAR (Network Project)	34.00

8.4. Flagship Program (Initiated in XII Plan)

Sl. No.	Title of the project	Principal Investigator	Funding agency	Budget(Rs. In lakhs)
1.	Management of papaya ring spot virus through breeding approaches (papaya-PRSV)	Dinesh, M.R.	ICAR	280.00
2.	Male sterility in vegetables and flower crops	Veere Gowda, R.	ICAR	480.00

8.5. New Initiatives programme (Intiated in XII plan)

Sl. No.	Title of the Project	Principal Investigator	Funding agency	Budget(Rs. In lakhs)
1.	Micronutrient management in horticultural crops	Ganeshamurthy, A.N.	ICAR	680.00
2.	Protected horticulture	Hebbar, S. S	ICAR	460.00
3.	Socio-economic impact and PRA studies on technology adoption	Sudha Mysore	ICAR	100.00

8.6. Centre of Excellence (Initiated in XII Plan)

Sl. No.	Title of the project	Principal Investigator	Funding agency	Budget(Rs. In lakhs)
1.	Centre of Excellence on Betelvine	Hima Bindu, K.	ICAR	200.00

8.7. Consortia Research Platform (Initiated in XII Plan)

Sl. No.	Title of the project	Principal Investigator	Funding agency	Budget(Rs. In lakhs)
1.	Consortium Research Platform (CRP) on Natural Fibres - IIHR-PHT; CIRCOT, Mumbai-Consortium Leader Component No. 15- Development of eco-friendly packaging materials, moulded products using biomass from horticultural crop residues	Narayana, C.K.	ICAR (Network Project)	275.00
2.	Consortium Research Platform (CRP) on Borers	Krishnamoorthy, A.	ICAR	2375.00
3.	Consortium Research Platform (CRP) on High Value Compounds	Shivashankar, S.	ICAR	360.00
4.	Consortium Research Platform (CRP) on Vaccines and diagnostics	Krishna Reddy, M.	ICAR	7500.00
5.	Consortium Research Platform (CRP) on Water (Theme-2 : Efficient utilization of water- Theme & Components – 2.3: Irrigation methods including pressurized irrigation system	Anil K. Nair (CC-PI)	ICAR	298.00

8.8. Coordinated Projects

Sl. No.	Title of the Project	Principal Investigator	Funding agency
1.	All India Co-ordinated Research Project on Fruits	Prakash Patil	ICAR AICRP
2.	All India Co-ordinated Research Project on Sub Tropical Fruits	Reddy, Y.T.N.	ICAR AICRP
3.	All India Co-ordinated Research Project on Arid Zone Fruits	Dinesh M.R.	ICAR AICRP
4.	All India Co-ordinated Research Project on Vegetable crops	Sadashiva, A.T.	ICAR AICRP
5.	All India Co-ordinated Research Project (Floriculture)	Manjunath Rao, T.	ICAR AICRP
6.	All India Co-ordinated Research Project on MAP and Betelvine - IIHR centre	Vasanth Kumar, T.	ICAR AICRP
7.	All India Co-ordinated Research Project on Biological Control of Crop Pests and Weeds	Krishnamoorthy, A.	ICAR AICRP

8.9. 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.

8.10. Linkages with Private Sector:

The Institute has strong linkages with the private sector particularly with seed companies and pesticide producing 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. Adiga, J. D., Kalaivanan, D., Meena, R. K., Mohana, G. S. and Lakshmipathi. (2014). Performance of vigorous cashew cultivars as influenced by dwarf rootstocks. *Int'l. J. Pl. Res.* (Vegetos),**27**(2):242-248.

2. Ambresh, Veere Gowda, R., Varun Amingada, S. and Ansar, H. (2014). Studies on seed set abilities of male sterile and male fertile lines of tropical onion (*Allium cep* L.), *Green Farming,***5**(1):152-154.

3. Archana, S. Rao, Girija Ganeshan, Ramachandra, Y. L., Chethana, B. S. and Bellishree, K. (2015). Bioefficacy of fungicides against *Alternaria porri* (Ellis) Cif. causing purple blotch of onion (*Allium cepa*L.). *Environ. Ecolo.***33**:99-104.

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5. Asokan, R., Mahadevaswamy, H. M., Geetha, G., Thimme Gowda and Riaz Mahmood. (2014). Diversity analysis and characterization of coleoptera, hemiptera and nematode-active *cry* genes in native isolates of *Bacillus thuringiensis*. *Annals of Microbiol.* **64**:85-98.

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35. Tripathi, P. C., Sankar, V. and Senthilkumar, R. (2015). Fruit cracking in litchi. *Coffee Land News*, February 02, 2015, **16**(50):5-7.

36. Varalakshmi, L. R., Sathisha, G. C. and Ganeshamurthy, A. N. (2014). *Khari mitti and Khara paani paristhithi me kele ko badhava dene ka neethiyaa*. *Bagwani,* Vol. (**5**), IIHR, Bengaluru.

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9.5. Technical Bulletins/ Folders

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2. George, S., Veerendra Kumar and Prabhakar, B. (2014). Pepper and vegetable crops- Kannada, Technical Bulletin, KVK, Gonikoppal.

3. Krishnamoorthy, A., Reddy, P. V. R. and Verghese, A. (2014). Borer pests: status and challenges. Technical Bulletin, IIHR, Bengaluru.

4. Kundan Kishore and Singh, H. S. (2014). Performance of mango varieties and hybrids under tropical eastern region of India. CHES, Bhubaneswar.

5. Meera Pandey, Senthil Kumaran, Veena S. S, and Tewari, R. P. (2014). Production technology of edible and medicinal mushroom (revised

Edition-Kannada), Technical Bulletin, IIHR, Bengaluru.

6. Narendra Pratap Singh, Manjunath, B. L., Desai, A. R., Raj Narayan, Sunetra Talaulikar and Gaonkar, V. Y. (2014). Technology package for nutritional and livelihood security through homestead farming, Technical Bulletin,

7. Sangeetha, G., Srinivas, P., Kundan Kishore and Singh, H. S. (2014). Bordeaux mixture and its use in plant disease management, Technical Bulletin, CHES, Bhubaneswar.

8. Sankar, V., Tripathi, P. C., Karunakaran, G., Senthil Kumar, R. and Hegde, M. R. (2014). Pummelo, Technical Bulletin, CHES, Chettalli.

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13. Tripathi, P. C., Karunakaran, G., Sankar, V., Senthil Kumar, R. and Hegde, M. R. (2014). Prospectus of off season litchi cultivation in Coorg, Technical Bulletin, CHES, Chettalli.

14. Tripathi, P. C., Karunakaran, G., Sankar, V., Senthil Kumar, R. and Hegde, M. R. (2014). Karonda - A potential fresh fruit of future, Technical Bulletin, CHES, Chettalli.

15. Tripathi, P. C., Karunakaran, G., Sankar, V., Senthil Kumar, R. and Hegde, M. R. (2014). Dragon fruit - Nutritive and ruminative fruit, Technical Bulletin, CHES, Chettalli.

16. Tripathi, P. C., Prabhkara, B., Veerendrakumar, K.V. and Suresh, S. C. (2014). Documentation of ATMA Activities– Kodagu KVK experience.

17. Tripathi, P. C., Sankar, V., Senthil Kumar, R., Karunakaran, G. and Hegde, M. R. (2014). Sour Sop - An emerging fruit of future, Technical Bulletin, CHES, Chettalli.

9.6. Extension Bulletins/ Folder

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2. Kamala Jayatnthi, P. D., Abraham Verghese, Arthikirubha, Sowmya, B. R. and Bhatt, R. M. (2014). Emerging pesta of mango under changing climate scenario. Extnsion Folder, IIHR, Bengaluru.

3. Kundan Kishore, Singh, H. S., Mandal, S., Sangeetha, G. and Srinivas, P. (2014). Calender of operations for mango cultivation. Extnsion Folder, CHES, Bhubaneswar.

4. Narayanaswami, B. and George, S. (2014). Protray cultivation of vegetables -women friendly technology (Kananada). Extnsion Folder-2, IIHR, Bengaluru.

5. Narayanaswamy B., Saju George and Hegde, M. R. (2014). Nursery- a way of women entrepreneurship-Kannada, Extnsion Folder, IIHR, Bengaluru.

6. Ramesh, R., Manjunath, B. L., Maruthadurai, R., Mahajan, G. R. and Singh, N. P. (2014). Cowpea (*Vigna Unguiculata*) (*Alsando*), Extension Folder-65, ICAR Research Complex for Goa, Old Goa.

7. Singh, H. S., Kundan Kishore, Bharathi, L. K., Mandal, S., Srinivas, P., Deepa Samant and Sangeetha, G. (2014). Technologies of CHES (IIHR)-A Glimpse.

8. Sridhar, V., Abraham Verghese, Kamala Jayatnthi, P. D. and Bhatt,R. M. (2014). Climax simulations as a tool for predicting climate change mediated distribution of oests and their management in horticultural ecosystems.

9. Sukanya, D. H. and Suryanarayana, M. A. (2014). Ashwagandha an ancient medicinal herb, Extension Folder-90, IIHR, Bengaluru.

10. Suryanarayana, M. A., Hima Bindu, K., Sukanya, D. H., Vasantha Kumar, T. and Lalitha, B. R. (2014). Herbs for households, Extension Bulletin-17, IIHR, Bengaluru.

11. Sadashiva, A. T., Prabhakar, M., Hebbar, S. S.,

Narayanaswamy, B., Kashinath, B. L. and Nagegowda, N. S. (2014). *Arka Rakshak and Arka Samrat* – Thriroganerodhaka Adhika Iluvary Tomato. Pub by the Director, IIHR, Bengaluru.

12. Reddy Madhavi, K. (2015). Production technology of chilli-ATIC pocket diary series-1, Gaddagimath, P. B., Ravishankar, H., Hegde, M. R., Venkattakumar, R. (Eds), Director, IIHR, Bengaluru.

13. Reddy Madhavi, K. (2015).Production technology of bell pepper - ATIC pocketdiary series-2, Gaddagimath, P. B., Ravishankar, H., Hegde, M. R., Venkattakumar, R. (Eds), Director, IIHR, Bengaluru.

14. Aghora, T. S., Mohan, N., Krishnamurthy, P. N. and Sadashiva, A. T. (2015). Production technology of French bean-ATIC pocketdiary series-3, Gaddagimath, P. B., Ravishankar, H., Hegde, M. R., Venkattakumar, R. (Eds), Director, IIHR, Bengaluru.

15. Sreenivasa Rao, E., Pitchaimuthu, M. and Nair, Anil Kumar (2015). Cultivation practices of muskmelon and watermelon-ATIC pocketdiary series-4, Gaddagimath, P. B., Ravishankar, H., Hegde, M. R., Venkattakumar, R. (Eds), Director, IIHR, Bengaluru.

16. Panneerselvam, P., Selvakumar, G. and Ganeshamurthy, A. N. (2015). Arka microbial consortium for sustainable vegetable production-ATIC pocketdiary series-5, Gaddagimath, P. B., Ravishankar, H., Hegde, M. R., Venkattakumar, R. (Eds), Director, IIHR, Bengaluru.

17. Sadashiva, A. T., Chakravarthy, A. K., Girija Ganeshan, Ranganath, H. R., Sridhar, V. and Kashinath, B. L. (2015). Intergated pest management of tomato (Kannada)-ATIC pocketdiary series-6, Gaddagimath, P. B., Ravishankar, H., Hegde, M. R., Venkattakumar, R. (Eds), Director, IIHR, Bengaluru.

18. Aghora, T. S., Mohan, N. and Balakrishna, B. (2015). Improved technology of French beans (Kannada)-ATIC pocketdiary series-7, Gaddagimath, P. B., Ravishankar, H., Hegde, M. R., Venkattakumar, R. (Eds), Director, IIHR, Bengaluru.

10. Research Projects

List of Ongoing Institute Projects (2014-15) (With New Project Codes)

HORTIIHRCIL2013(common for all projects)

Division of Fruit Crops

010 / (1.1): Genetic improvement of fruit crops. Project Leader: Dinesh, M.R. (IXX01470)

Sub projects

010 (1) / 1.1.1: Improvement of mango for yield and quality. PI: Dinesh, M.R.

010 (2) / 1.1.2: Improvement of jamun and sapota for dwarf tree stature and higher productivity. PI: Rekha, A.

010 (3) / 1.1.3: Evaluation of under-utilized fruits for yield, quality and adaptability. PI: Saktivel, T.

010 (4) / 1.1.4: Improvement of jack fruit for quality and productivity. PI: Prakash Patil.

010 (5) /1.1.5: Breeding papaya for PRSV tolerance. PI:Dinesh, M.R.

010 (6) / 1.1.6: Incorporation of bacterial blight resistance in pomegranate. PI: Murthy, B.N.S.

010 (7) / 1.1.7: Breeding purple passion fruit and strawberry for superior traits. PI: Murthy, B.N.S

010 (8) / 1.1.8: Rootstock and mildew resistance breeding in grapes. PI: Karibasappa, G.S.

010 (9) / 1.1.9: Improvement of guava for yield and quality. PI: Vasugi.

010 (10) / 1.1.9: Improvement of annona for yield and quality. PI: T. Sakthivel,

010 (11): Radiation Induced Mutation Breeding in Papaya (*Carica papaya* L.,) (CHES, Hirehalli). PI: Karunakaran, G.

011 / (1.2): Enhancement of productivity in fruit crops. Project Leader: Reju M. Kurian (IXX01471)

Sub projects

011 (1) / 1.2.1: Canopy architecture for higher productivity (mango and grapes). PI: Kurian, R.M.

011 (2) / 1.2.2: Enhancing productivity through integrated nutrition, high density planting and crop regulation (guava, jamun, papaya, annona, fig, pomegranate, grape). PI: Sampath Kumar, P.

011 (3) / 1.2.3: Exploitation of stock-scion interactions for canopy vigor management and sustainable productivity (mango, guava, annona & jackfruit). PI:Sulladmath, V.V.

011 (4) / 1.2.4: Optimizing water productivity and nutrient dynamics through integrated water and nutrient management of fruit crops (mango, grapes and sapota). PI: Manjunath, B.L.

011 (5) / 1.2.5: Organic production of fruit crops (mango, papaya and sapota). PI:Kurian, R.M.

011 (6) / 1.2.6: Intercropping systems in young orchards (annona, mango and sapota). PI: Kurian,R.M.

Division of Vegetable Crops

020 / (2.1): Breeding tropical vegetable crops for resistance to biotic and abiotic stresses with high yield and quality attributes through marker-assisted selection (MAS). Project Leader: Sadashiva, A.T. (IXX01472)

Sub-Project

020 (1) / 2.1.1: Breeding tomato for resistance to biotic and abiotic stresses and gene pyramiding for ToLCV resistance. PI: Sadashiva, A.T.

020 (2) / 2.1.2: Breeding hot & sweet peppers (*Capsicum annuum* L.*)* for biotic and abiotic stress resistance integrating marker-assisted selection (MAS). PI:Madhavi Reddy, K.

020 (3) / 2.1.3: Breeding brinjal for resistance to bacterial wilt with high yield and quality attributes through marker-assisted selection (MAS). PI: Singh, T.H.

020 (4) / 2.1.4: Breeding Cucurbitaceous crops (watermelon, pumpkin and muskmelon) for yield & resistance to biotic stresses through marker assisted selection (MAS). PI: Sreenivasa Rao, E.

020 (5) / 2.1.5: Breeding okra varieties/ hybrids for yield, quality & resistance to biotic stresses through MAS. PI:Pitchaimuthu, M.

020 (6) / 2.1.6: 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) / 2.1.7: Breeding peas for biotic and abiotic stresses and Dolichos for yield and quality attributes through marker-assisted selection (MAS). PI: Mohan, N.

020 (8) / 2.1.8: 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) / 2.1.9: Evolving F_1 hybrids in tropical carrots with high yield and quality through marker-assisted selection (MAS). PI: Veere Gowda, R.

020 (10) / 2.1.10: Breeding tropical cauliflower for high yield and quality. PI: Varalakshmi, B.

020 (11) / 2.1.11: 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) / 2.1.12: Breeding cucumber varieties hybrids for resistance to biotic stresses through marker assisted selection. PI: Pitchaimuthu, M.

021 / 2.2: Developing production technology for tropical vegetables.Project Leader: Hebbar, S.S. (IXX01473)

Sub-Project

021 (1) / 2.2.1: Water management and rainfed production in vegetable crops. PI: Nair, A.K.

021 (2) / 2.2.2: Organic farming in vegetable crops. PI: Nair, A.K.

021 (3) / 2.2.3: Protected cultivation & precision farming in vegetable crops. PI: Hebbar, S.S.

Division of Ornamental Crops

030 / 3.1: Genetic improvement of ornamental crops. Project Leader: Tejaswini (IXX01474)

Sub-Project

030 (1) / 3.1.1: Genetic improvement of tuberose for high concrete yield and resistance to nematode. PI: Meenakshi Srinivas.

030 (2) / 3.1.2: Genetic improvement of gladiolus for quality and resistance to biotic stresses. PI: Rao, T. M.

030 (3) / 3.1.3: Evolving rose varieties (both open and polyhouse) for quality and resistance to powdery mildew, black spot and thrips. PI: Tejaswini.

030 (4) / 3.1.4: Breeding *Dianthus* species (carnations, pinks and sweet Williams) for quality. PI: Dhananjaya, M.V.

030 (5) / 3.1.5: Breeding Gerbera for quality. PI: Rajiv Kumar.

030 (6) / 3.1.6: Breeding Chrysanthemum and China aster for quality. PI: Rajiv Kumar.

030 (7) / 3.1.7: 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 jasmine)*and blossom midge (*Contariniam aculipennis*). PI: Sumangala, H.P.

031 / 3.2: Enhancing quality and production of ornamental crops through cultural practices. Project Leader: Sujatha A. Nair (IXX01475)

Sub-Project

031 (1) / 3.2.3: Enhancing cut foliage production through cultural interventions. PI: Sujatha A.Nair.

031 (2) / 3.2.5: Adaptability and utilization of ornamentals for landscaping. PI: Sumangala, H. P.

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-Project

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. 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.

Division of Plant Pathology

050 / 6.1: Development of disease diagnostics and molecular characterization of plant pathogens infecting horticultural crops.Project Leader: Krishna Reddy, M. (IXX01482)

Sub-Project

050 (1) / 6.1.1: Development of diagnostics and molecular characterization of bacteria, virus, viroid and phytoplasma infecting horticultural crops. PI: Krishna Reddy, M.

050 (2) / 6.1.2: Development of recombinant protein and phage display based diagnostic kits for citrus greening bacterium, citrus Tristeza virus and cucumber mosaic virus. PI: Samuel, D.K.

050 (3) / 6.1.3: Development of molecular diagnostics for rapid detection of quiescent infections of *Colletotrichum* and *Alterneria* in fruits and vegetables. PI: Krishna Reddy, M.

051 / 6.2: Development of forecasting systems for effective management of diseases of fruits and vegetables. Project Leader: Krishna Reddy, M. (IXX01483)

Sub-Project

051 (1) / 6.2.1: Development of disease prediction models for yellow rust in grapes. PI: Saxena, A.K.

051 (2) / 6.2.2: Development of disease forecasting models for the management of leaf blights in tomato. PI: Krishna Reddy, M.

051 (3) / 6.2.3: Studies on the mechanism of the virus-vector-host interactions in virus disease of vegetable crops. PI: Krishna Reddy.

051 (4) / 6.2.4: Host pathogen interactions with special reference to fungal wilts of fruit crops. PI: Sriram, S.

052 / 6.3: Development of integrated disease management strategies in horticultural crops.

Project Leader: Girija Ganeshan (IXX01484)

Sub-Project

052 (1) / 6.3.1: Integrated management of pre and post-harvest diseases of fruits & vegetables (mango, banana & capsicum). PI: Saxena, A.K

052 (2) / 6.3.2: Integrated management of bacterial diseases of horticultural crops (pomegranate, tomato &brinjal). PI: Gopalakrishnan, C.

052 (3) / 6.3.3: Identification and field evaluation of new bioagents for the integrated disease management of *Alternaria* blight in tomato and onion. PI: Girija Ganeshan.

052 (4) / 6.3.4: Integrated disease management of foliar diseases of ornamental crops. PI: Sriram, S.

053 / 6.4: Collection, improvement and utilization of mushrooms. Project Leader: Meera Pandey (IXX01485)

Sub-Project

053 (1) / 6.4.1: 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 / 7.1: Pest management in fruit crops. Project Leader: Reddy, P.V.R. (IXX01486)

Sub Project

060(1) /7.1.1 Surveillance and management of fruit crop pests. PI: Reddy, P.V.R.

061 / 7.2: Pest management in vegetable crops. Project Leader: Ranganath, H.R. (IXX01487)

Sub-Project

061 (2) / 7.2.3: Development of IPM for the major pests of cucurbitaceous vegetables. PI: Ranganath, H.R.

061 (2) / 7.2.3: Development of IPM for the major pests of cucurbitaceous vegetables. PI: Ranganath, H.R.

061 (3) / 7.2.4: Monitoring and management of insecticide resistance in major pests of horticultural crops. PI: Sridhar, V.

062 / 7.4: Bio-intensive management of major

pests of horticultural crops. Project Leader: Krishnamoorthy, A. (IXX01489)

Sub-Project

062 (1) / 7.4.1: Bio-intensive management of mealy bugs in horticultural crops (papaya, guava). PI: Krishnamoorthy, A.

062 (2) / 7.4.2: Bio-intensive management of thrips in horticultural crops (chilli, capsicum, rose and onion). PI: Ganga Visalakshy, P.N.

062 (3) / 7.4.3: Bio-intensive management of white flies in horticultural crops (brinjal, tomato, gerbera, etc.). PI: Pillai, G.K.

063 / 7.5: Management of nematodes in horticultural crops. Project Leader: Rao, M.S. (IXX01490)

Sub-Project

063 (1) / 7.5.1: Studies on the management of nematode induced disease complexes in horticultural crops (banana, papaya, capsicum, carrot, onion, gerbera and gladioli). PI: Rao, M. S.

Division of Plant Physiology and Biochemistry

070 / 5.1: Investigations on tolerance to biotic and abiotic stresses for sustainable productivity in horticultural crops. Project Leader: Bhatt, R.M. (IXX01480)

Sub-Project

070 (2) / 5.1.6: 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) / 5.1.7**:** Physiological studies on impact of low-moisture and high temperature stresses in capsicum (*Capsicum annum* L.). PI: Bhatt, R.M.

070 (4): 5.1.8: Phenotyping pea and french bean accessions for tolerance to high temperature stress. PI: Laxman, R.H

071 / 5.2: Investigations on physiological factors limiting productivity and quality of horticultural crops. Project Leader: Ravindra, V. (IXX01481)

Sub-Project

071 (1) / 5.2.2: Biochemical and molecular assessment of chilling injury in mango. PI:Shivashankara, K.S.

071 (2) / 5.2.3: Isolation of natural antioxidants from mango processing waste. PI: Rao, V. K.

072 / 5.3: Biochemical basis of fruit disorders. Project Leader: Shivashankar, S. (IXX09540)

Sub-Project

072 (1) / 5.3.1: Biochemical studies on jelly seed formation in Amrapali mango. PI: Shivashankar, S.

Division of Soil Science and Agricultural Chemistry

080 /8.1. Dynamics of soil and plant nutrient and their management in horticultural crops. Project Leader: Raghupathi, H.B. (IXX01491)

Sub-Project

080 (1) / 8.1.1: Micronutrient related constraints in fruit and vegetable crops for correcting nutrient imbalances. PI: Satisha, G.C.

080 (2) / 8.1.4: Nutrient dynamics in fruit and vegetable crops. PI: Ganeshmurthy, A.N.

080 (3) / 8.1.6: 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 dip fertigation in horticultural crops. (banana, papaya, tomato and brinjal). PI: Varalakshmi, L R.

081/ 8.2. Soil health, food and environmental safety in horticultural cropping system. Project Leader: Ganesh Murthy, A.N. (IXX014992)

Sub-Project

081 (1) / 8.2.1: Pesticide residue studies in fruits and related environment. PI: Soudamini Mohapatra.

081 (2) / 8.2.2: Behavior and fate of pesticide residues in fresh and processed vegetables. (Sub-Project Concluded, final report to be submitted).PI: Debi Sharma.

081 (3) / 8.2.4: Development of microbial consortium for sustainable production of horticultural crops and improving soil health. PI: Paneerselvam, P.

081 (4) / 8.2.5: Sustaining productivity of horticultural crops under adverse soil and water conditions in fruit and vegetables (high salinity and heavy metal toxicity). PI: Varalakshmi, L.R.

081 (5) / 8.2.6: Evaluation and improvement of soil quality of fruit orchards in Southern India (grapes, mango, pomegranate, citrus, guava and sapota). PI: Ganeshamurthy, A.N.

081 (6) / 8.2.7: Microbial bioconversion of horticultural

wastes for enhanced plant nutrient mobilization and disease suppression. PI: Selvakumar, G.

081 (7) / 8.2.8: 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 / 10.1: Impact assessment and transfer of technology in horticulture. Project Leader: Venkattakumar, R.(IXX01496)

Sub-Project

090 (1) / 10.1.1: Identification of research and extension gaps for varieties and technologies of IIHR through PRA. PI: Balakrishna, B.

090 (2) / 10.1.3: Impact of capacity building of trainees on adoption of IIHR technologies including identification of future training needs. PI: Achala Paripurna.

090 (3) / 10.1.4: Assessment and refinement of IIHR technologies through farmers participatory demonstrations. PI:Achala Paripurna.

090 (4) / 10.1.5: a) Application of innovative extension, information and communication methodologies for transfer of technology in horticulture. PI: Narayanaswamy, B.

c) Development of an information system for AICRP on tropical fruits. PI: Reena Rosy Thomas.

090 (5) / 10.1.6: Gender mainstreaming in horticulture. PI: Nita Khandekar.

Division of Plant Genetic Resources

100 / 11.1: Exploration, collection, domestication and conservation of genetic resources in horticulture crops. Project Leader: Ganeshan, S. (IXX01498)

Sub-Project

100 (1) / 11.1.1: Mapping hotspot areas of horticultural gene pool, distribution and database development. PI: Ganeshan, S.

100 (2) / 11.1.2: Optimization of germplasm domestication strategies for introducing new species of horticultural importance for crop diversification. PI: Ganeshan, S.

100 (3) / 11.1.3: Development of complementary conservation strategies for horticulture PGR's (recalcitrant seed, pollen and in vitro material). PI: Rajasekharan, P.E.

101/11.2: Evaluation, characterization, quarantine, exchange and documentation of germplasm. Project Leader: Anuradha Sane (IXX01499)

Sub-Project

101 (1) / 11.2.2: Identification of zygotic seedlings in polyembryonic varieties of mango using molecular approach. PI: Anuradha Sane.

101(2) / 11.2.3: DNA fingerprinting and genetic diversity analysis of horticultural crops germplasm. PI: Anuradha Sane.

101 (3) / 11.2.4: Studies on monitoring and screening of introduced plant material for pest & disease incidence and pollinator diversity in horticultural germplasm. PI: Shivaramu, K.

101 (4): Characterization and genetic diversity analysis of 'future fruit crop' genetic resources. PI: Anuradha Sane.

Division of Biotechnology

110 / 9.1: Development of molecular markers for application in horticultural crops. Project Leader: Ravishankar, K.V. (IXX01493)

Sub-Project

110 (1) / 9.1.1: Development of microsatellite markers in pomegranate. PI:Kanupriya.

110 (2) / 9.1.7: *In silico* mining of expressed sequence tags (ESTs) for markers in horticultural crops. PI: Radhika, V.

110 (3): Identification of SSR markers to screen resistance bacterial wilt brinjal breeding lines and its integration in marker assisted selection (MAS). PI: Lakshman Reddy, D.C.

110 (4): Development of microsatellite markers in okra (*Abelmeschous esculantus* L.Moench). PI: Ravishankar, K.V.

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

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

111 / 9.2: Gene cloning, regeneration systems and transgenic development for important horticultural traits. Project Leader: AkellaVani (IXX01494)

Sub-Project

111 (1) / 9.2.1: Development of somatic embryogenesis protocols in pomegranate cvs. Bhagwa and Ganesh for application in obtaining non-chimeric transgenics. PI: Leela Sahijram.

111 (2) / 9.2.2: Development of transgenic pomegranate cv. Bhagwa for bacterial wilt resistance.

111 (2.1) / 9.2.2.1: Genetic transformation of pomegranate for bacterial blight resistance. PI: Nandeesha, P.

111 (2.2) / 9.2.2.2: Electroporation mediated transgenic development using *Xa21* gene. PI: Akella Vani

111 (3) / 9.2.3: Developing transgenic fruit crops resistant to PRSV in papaya and Tristeza in citrus. PI: Akella Vani.

111 (4) / 9.2.4: Development of transgenic tomato resistant to early blight & chilli for Anthracnose. PI: Mythili, J.B.

111 (5) / 9.2.5: 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.

111 (6) / 9.2.6: Development of Bt transgenic brinjal for resistance to the shoot and fruit borer, *Leucinodes orbonalis* Guenee. PI: Vageeshbabu, H.S.

111 (7) / 9.2.7: Gene mining and trait based pyramiding for abiotic stress tolerance PI: Manamohan, M.

111 (8): Production of haploids in solanaceous vegetables. PI: Aswath.

111 (9): Introgression of *cry1f* bt gene into brinjal. PI: Vageeshbabu, H.S.

111 (10): Modifying genome methylation pattern in embryos to harness useful and stable variants in horticultural crops. PI: Leela Sahijram.

111 (11): Developing cucumber mosaic virus (CMV) resistant transgenic chilli (*Capsicum annum*) through RNAi strategy. PI: Usharani, T.R.

111 (12): Cloning and characterization of NematicidalBt genes effective against the nematodes infesting horticultural crops. PI: Nandeesha, P.

112/9.3: Endophytic and molecular microbiology. Project Leader: Pious Thomas (IXX01495)

Sub-Project

112 (1) / 9.3.1: Tissue culture systems in horticultural crops with reference to management and exploitation of endophytes. PI: Pious Thomas.

112 (2) / 9.3.2: Use of endophytic bacteria for alleviating Ralstonia bacterial wilt in tomato. PI: Pious Thomas.

Section of Medicinal Crops

120 / 3.3 Genetic improvement of medicinal crop. Project Leader: Vasantha Kumar, T. (IXX01476)

Sub-Project

120 (1) / 3.3.1: Identification of high yielding lines of *Aloe vera* for leaf and gel yield. PI: Vasantha Kumar, T.

120 (2) / 3.3.2: Evaluation of *Coleus forskholii* hybrids for tuber yield and forskolin content. PI: Hima Bindu, K.

120 (3) / 3.3.3: Identifying high yielding and high L-dopa lines in *Mucuna species.* PI: Hima Bindu, K.

120 (4) / 3.3.4: Evolving Kokum (*Garcinia indica*) lines for yield and chemical content. PI: Vasantha Kumar, T.

120 (5) / 3.3.5: Evolving Ashwagandha varieties for high root yield and active ingredient. PI: Sukanya, D.H.

120 (6): Genetic improvementof *Centella asiatica* for yield and quality. PI: Sukanya, D.H.

121/3.4: Production, chemistry and related studies on plants of medicinal and agrochemical importance. Project Leader: Eugene Sebastian, J.N. (IXX01477)

Sub-Project

121 (1) / 3.4.1: Standardizing organic farming technology for export value medicinal crops (*Aswagandha, Kalmegh* and *Coleus forskohlii*). PI: Suryanarayana, M.A.

121 (2) / 3.4.2: Chemical characterization of antifungal plant compounds and synthesis of some novel fungicides active against pathogens of horticultural crops. PI: Eugene Sebastian, J.N.

Section of Seed Science and Technology

130/11.4: Multiplication and quality assurance of seed propagated horticultural crops. Project Leader: Naik, L.B. (IXX01500)

Sub-Project

130 (1) / 11.4.1: Studies on precision production practices for enhancement of seed yield and quality. PI: Naik, L.B.

130 (2) / 11.4.2: Restoration of fertility in interspecific F_1 hybrid between *Solanum melongena* and *Solanummacrocarpon.* PI:Padmini, K.

130 (3) / 11.4.3: Ultra drying as a cost effective technique to extend seed longevity of horticultural germplasm under ambient conditions (crops – papaya, frenchbean, onion, china aster). PI: Yogeesha, H.S.

130 (4) / 11.4.4: Value addition to seeds through coating and pelleting in horticultural crops (papaya, onion, carrot, china aster). PI: Yogeesha, H.S.

130 (5) / 11.4.5: 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 / 4.2: Mechanization of production and processing of horticultural crops. Project Leader: Senthil Kumaran, G. (IXX01479)

Sub-Project

140 (1) / 4.2.1: Development of cultivation systems and machinery for mechanization of vegetable crops. PI: Carolin Rathinakumari.

140 (2) / 4.2.2: Development of cultivation systems and machinery for mechanization of fruit crops. PI: Senthil Kumaran, G.

140 (3) / 4.2.3: Development of cultivation systems (including greenhouse and machinery for mechanization of ornamental and medicinal crops). PI: Carolin Rathinakumari.

Section of Economics and Statistics

150/10.2: Economic research, statistical modeling and computer applications in horticulture. Project Leader: Gajanana, T.M. (IXX01497)

Sub-Project

150 (1) / 10.2.1: Socio-economic impact of horticultural technologies on crop diversification, farm income, employment and trade. PI: Sudha Mysore.

150 (2) / 10.2.2: Economics of post harvest loss, marketing efficiency, price analysis and export. PI: Gajanana, T.M.

150 (3) / 10.2.3: Economics of factor productivity and production efficiency in horticultural crops. PI: Sreenivasa Murthy, D.

150 (4) / 10.2.4: Development of statistical modeling for horticultural crops research. PI: Venugopalan,R.

150 (5) / 10.2.5: Bioinformatics application and development of database in 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 / C1.1: Collection & evaluation of underutilized fruits for humid tropics and purification of papaya. Project Leader: Tripathi, P.C. (IXX01503)

Sub-Project

170 (1) / C.1.1.1: Collection and evaluation of under-utilized fruits for humid tropics. PI: Tripathi, P.C.

170 (2) / C.1.1.2: Selection of stable hermaphrodite types of Coorg Honey Dew Papaya. PI: Senthil Kumar, R.

171 /C2.1: Horticulture intervention to improve the productivity and soil health in fruit crops under humid tropics. Project Leader: Sankar, V. (IXX01506)

Sub-Project

171 (1) / C.2.1.1: Refinement of technologies for improved productivity of Coorg mandarin. PI: Sankar, V.

173 / C4.2: Demonstration and impact studies of CHES technologies. Project Leader: Reddy, T.M. (IXX09080)

Sub-Project

173 (1) / C.4.2.1: Demonstration and impact of technologies on Coorg mandarin. PI: Reddy, T.M.

174:Pest management and pollinators in humid tropics. Project Leader: Jayanthi Mala, B.R.

Sub-Project

174 (1): Pest management of major and emerging pests of citrus. PI: Jayanthi Mala, B.R.

174 (2): Studies on bee pollination and bee keeping under humid tropics. PI: Jayanthi Mala, B.R.

175: 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: Sankar, V.

Sub-Project

175 (1): Performance evaluation of vegetables in humid tropic region of Coorg. PI: Sankar, V.

175 (2): Management of Coorg Mandarin decline. PI: Priti Sonavane.

Central Horticultural Experiment Station, Bhubaneswar

180 / B1: Plant genetic resource management and improvement in horticultural crops. Project Leader: Singh, H. S. (IXX01501)

Sub-Project

180(1)/B1.1: Collection, evaluation, characterization, conservation and documentation of germplasms of fruit crops of Eastern India. PI: Kundan Kishore.

180 (2) / B1.2: Identification of varieties/hybrids and local elites of fruit crops suitable for Eastern India. PI: Kundan Kishore.

180 (3) / B1.3: Collection, evaluation, characterization, conservation and documentation of germplasm of underutilized cucurbits. PI: Bharathi, L.K.

180 (3.1) / B1.3.1: Collection, evaluation, characterization, conservation and documentation of germplasms of teasel gourd. Pl: Bharathi, L.K.

180 (3.2) / B1.3.2: Conservation and maintenance of germplasms of underutilized cucurbits. PI: Bharathi, L.K.

180 (4) / B1.4: Improvement in cucurbit crops. PI: Bharathi, L.K.

180 (4.1): Improvement in dioecious *Momordica* species through inter specific hybridization. PI: Bharathi, L.K.

180 (4.2): Manipulation of planting time for round the year availability of Momordicasuboica Bharathi in Eastern India. PI: Bharathi, L.K.

180 (5): Crop Improvement in locally cultivated vegetables (Chillies, *Dolichos*, Amaranth and Drumstick) of eastern India. PI: Singh, H. S.

180 (5.1): Collection and evaluation of hot chillies from different geographical regions of north eastern India and identification of elite lines for pungency and resistance to leaf curl virus and Anthracnose.

180 (5.2): Collection and evaluation of Moringa germplasms for leaf iron content, earliness and pod quality.

180 (5.3): Collection and evaluation of Amaranth germplasms for foliage yield, growth rate and stem tenderness.

180 (5.4): Collection and evaluation of tribal region Dolichos germplasms.

180 (5.5): Evaluation of chilli lines for abiotic (salt, drought and food) and biotic (leaf curl) tolerance.

181 / B2: Development of production technologies of horticultural crops for Eastern India. Project Leader: Singh, H.S. (IXX01507)

Sub-Project

181 (1) / B2.1: Development of production technologies of fruit crops. PI: Deepa Samant.

181 (1.1): Field trial on the effectiveness of IIHR micronutrient formulations for increasing fruit yield of mango variety 'Banganapalli' & 'Amrapali'. PI: DeepaSamant.

181 (1.2): Promotion of uniform, early and higher flowering and fruiting in Arka Neelachal Kesri mango using paclobutrazol. PI: Kundan Kishore.

181 (1.3): Observational trial on canopy height reduction in grown-up aonla trees planted at 5 m X 5 m spacing. PI: Deepa Samant.

181 (1.4): Effect of planting density on growth, yield and quality of guava var. Lucknow-49 PI: Deepa Samant.

181 (1.5) / B2.1.5: Canopy architecture modification by trellising for enhancement of productivity and quality in mango variety Arka Neelachal Kesri. PI: Kundan Kishore.

181 (1.6) / B2.1.1: Determination of ideotype tree architecture for fruit crops (mango). PI: Deepa Samant.

181 (1.7) / B2.1.2: Increasing the water use efficiency in Amrapali mango. PI: Deepa Samant.

181 (1.8) / B2.2: Development of organic production technology for mango in Eastern India. PI: Srinivas, P.

181 (1.9): Flowering manipulation and vigour management in 'Amrapali' mango with paclobutrazol (PBZ) and KNO_3. PI: Kundan Kishore.

182 / B3: Management of biotic stress in horticultural crops for eastern India. Project Leader: Singh, H. S. (IXX01502)

Sub-Project

182 (1) / B3.1**:** Management of insect pests in fruit and vegetable crops. PI: Singh, H. S.

182 (1.1) / B3.1.2: Monitoring and management of selected insect pests in fruit crops. PI: Singh, H. S.

182 (2) / B3.2: Monitoring & management of diseases in fruit crops. PI: Sangeetha, G.

182 (2.1): Seasonal abundance and severity level of diseases of major fruit crops. PI: Sangeetha, G.

182 (2.2): Management of major diseases in mango. PI: Sangeetha, G.

182 (3) / B 3.3**:** Bio-prospecting of agriculturally important micro-organisms. PI: Srinivas, P.

182 (3.1) / B3.3.1: 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.

182 (4): Monitoring and management of major diseases in vegetable crops. PI: Mandal, S.

182 (4.1): Management of downey mildew of cucurbits. PI: Mandal, S.

182 (4.2): Evaluation of available brinjal lines against bacterial wilt disease. PI: Srinivas, P.

List of New Project / Sub-Project Concluded during 2014-15

061 / 7.2: Pest Management in vegetable crops. Project Leader: Krishna Murthy, P. N.

Sub-Project

061 (1) / 7.2.2: Use of essential oils & botanicals for the management of insect pests of vegetables. PI: Krishna Murthy, P.N.

070 / (5.1): Investigations on tolerance to biotic and abiotic stresses for sustainable productivity in horticultural crops. Project Leader: Bhatt, R.M.

Sub-Project

070 (1) / 5.1.4: Studies on the impact of elevated temperature on growth, physiology and quality of horticultural crop. PI: Laxman, R.H.

List of Ongoing In-house Projects/Sub-projects

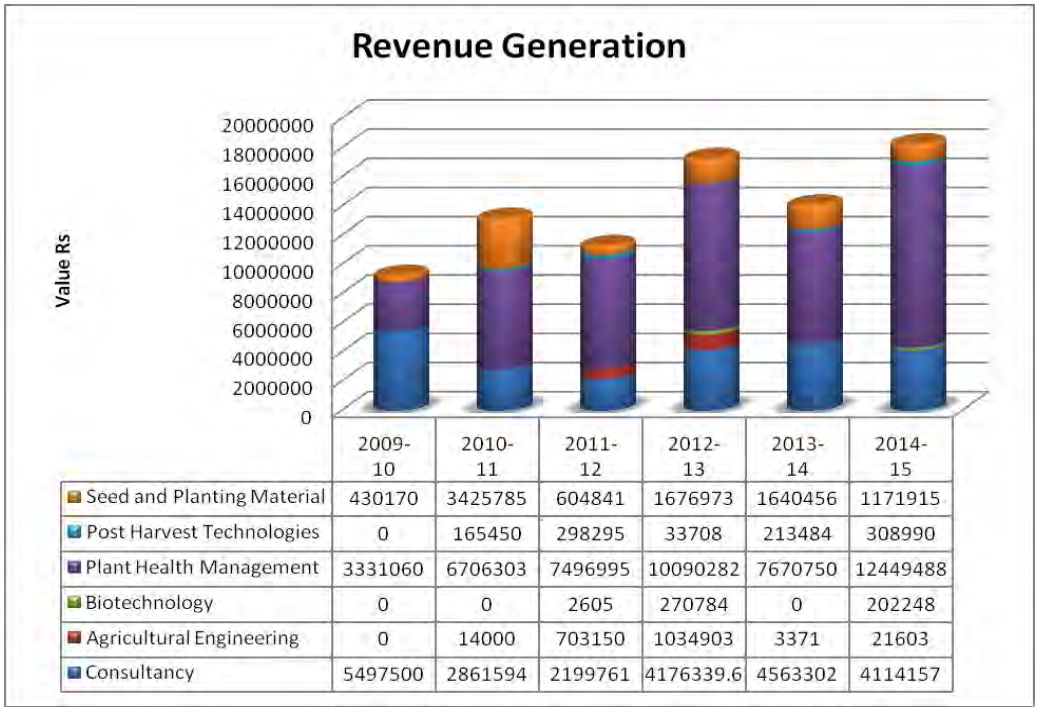
Sl. No.	Name of the Division / Section	No. of Projects	No. of Sub - Projects
1	Fruit Crops	2	16
2	Vegetable Crops	2	15
3	Ornamental Crops	2	10
4	Post-Harvest Technology	1	8
5	Plant Pathology	4	12
6	Entomology and Nematology	4	7
7	Plant Physiology and Biochemistry	3	6
8	Soil Science and Agricultural Chemistry	2	10
9	Extension and Training	1	5
10	Plant Genetic Resources	2	7
11	Biotechnology	3	17
12	Medicinal Crops	2	8
13	Seed Science and Technology	1	4
14	Agricultural Engineering	1	2
15	Economics and Statistics	1	6
16	CHES, Chetttalli	5	8
17	CHES, Bhubaneswar	3	10
	TOTAL	**39**	**151**

11. Commercialization of Technologies

The Institute Technology Management Unit (ITMU) is playing a major role in commercializing the technologies developed at the Institute. ITMU is assisted by Varietal and Technology Identification Committee (VTIC). During the year 2014-15, 30 technologies were transferred to 62 companies and 18 KVKs by adopting Public Private Partnership models and an amount of Rs 1,41,54,247/-was generated as income from IP assets the details of which are given in the below table.

Theme area wise revenue generation

Sl. No.	THEME AREA	LICENSEE		NO. OF TECHNOLOGIES COMMERC-ILALIZED	REVENUE (Rs.)
		COMPANIES	KVK'S		
1	SEED & PLANTING MATERIAL	3	—	3	11,71,915/-
2	BIOPESTICIDES	37	5	5	1,10,33,752/-
3	CROP PROTECTION	10	13	12	14,15,736/-
4	POST HARVEST TECHNOLOGY	4	-	3	3,08,990/-
5	AGRICULTURAL ENGINEERING	6	—	5	21,603/-
6	BIOTECH TECHNOLOGY	2	—	2	2,02,248/-
	GRAND TOTAL	**62**	**18**	**30**	**1,41,54,247/-**



	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Seed and Planting Material	430170	3425785	604841	1676973	1640456	1171915
Post Harvest Technologies	0	165450	298295	33708	213484	308990
Plant Health Management	3331060	6706303	7496995	10090282	7670750	12449488
Biotechnology	0	0	2605	270784	0	202248
Agricultural Engineering	0	14000	703150	1034903	3371	21603
Consultancy	5497500	2861594	2199761	4176339.6	4563302	4114157

In addition to revenue generation, ITMU has organized many awareness and business programs to take further the technologies developed by the Institute, the details of which are given below.

Events Organized

CHES-Industry Interaction Meet

The ITMU of the Institute and the CHES, Bhubaneswar jointly organized an Industry Intraction Meet at CHES, Bhubaneswar on June 30, 2014. Dr T. Manjunatha Rao, Director, IIHR, Bengaluru inaugurated the Meet in presence of Dr. S. S. Nanda, Dean, Directorate of Extension Education, OUAT, Bhubaneswar. Dr. A. Krishnamoorthy, Chairman, ITM & CPC briefed the delegates about the Meet and its relevance for popularization of the IIHR/CHES technologies among the farmers. Dr. H. S. Singh, Head, CHES, Bhubaneswar made a presentation on technologies developed by CHES, Bhubaneswar for adoption by the entrepreneurs and other stakeholders. Dr. S. K. Chadha, Director, Directorate of Horticulture, Govt. of Odhisha also attended the Meet and addressed the gathering. An exhibition was put up displaying the horticultural technologies developed by IIHR, CHES and RC-CTCRI for creating visual impact on the participants.

A view of the exhibition stall of IIHR-CHES Bhubabaneswar

AgrIp 2014 Annual Meeting cum Workshop

The Institute Technology Management Unit, Indian Institute of Horticulture Research, Bengaluru in collaboration with Zonal Technology Management Centre, South Zone, Central Institute of Fisheries Technology (CIFT), Cochin organized a two day Annual Meeting-cum-Workshop - AgrIP 2014 during October 09-10, 2014. The workshop was organized as part of the ICAR efforts for facilitating systematic and harmonious technology management activities in south zone. Dr. S. Mauria ADG (IP&TM), ICAR was the Chief Guest and Dr. R. Kalpana Sastry, Joint Director, NAARM, Hyderabad, Dr. C. N. .Ravishankar, Director, CIFT, Cochin were the Guests of Honour on the occasion. Dr. Mauria highlighted the progress achieved by the IP&TM in the last few years and presented the proposed plan of action of IP &TM and Agri Business incubation facilities in the XII Plan EFC. Invited talks on “Role of AgrInnovate in Commercialization of Technologies" by Dr.S.Saxena, CEO, AgrInnovate, New Delhi and “IP Management” by Smt. Rama, Founder Director, IBHA IP Solutions were presented on the occasion. Annual progress reports by all ITMUs of South Zone ICAR Institutes were also presented on the occasion.

Group photo of the participants

One Day Horticulture-Institute Industry-Interface Meet

Commercialization through licensing has become the order of the day for effective technology dissemination & transfer. The ICAR-Indian Institute of Horticultural Research has actively been involved in technology dissemination through commercialization for over the past five years with more than 365 clients and sustainable revenue generation from IP assets. Under the XII Plan EFC of the IP&TM, the present ITMU, IIHR has been elevated to a Zonal Technology Management Centre, representing horticulture institutions in the South. In an attempt to take these efforts ahead with an aim of bringing together entrepreneurs, industry and famers on a common platform for sharing the spectrum of new technologies developed by IIHR, Bengaluru and other participating ICAR research institutes, the Institute organized its Fourth Horticulture-Institute Industry Interface Meet on February 10, 2015 at its campus. Five sister ICAR institutions *viz.* Indian Institute of Spices Research, Calicut; Directorate of Cashew Research, Puttur, Central Tuber Crops Research Institute, Trivandrum, Indian Institute of Vegetable Research, Varanasi, Directorate of Onion and Garlic Research, Pune also participated in the meet. Dr. S. Mauria, Additional Director General (IP&TM), the Chief Guest inaugurated the Meet and Dr. D. L. Maheswar, Vice Chancellor, University of Horticultural Sciences, Bagalkote, was the Guest of Honour. A total of 150 participants representing 40 representatives from 23 private enterprises & companies, 25 representatives

(scientific and technical staff) from five sister ICAR institutions and State Horticultural University, Bagalkote and 60 odd scientist innovators participated in the deliberations

Addressing the participants Dr. Mauria, the Chief Guest informed about the budgetary allocations of ICAR in the XII plan for technology commercialization and innovation activities. The National Agriculture Innovation Foundation (NAIF) with Rs. 284.74 crores aims at accelerating technology transfer and commercialization through various programmes and new initiatives such as Grass Root Level innovations, Incubation fund & Attracting & Retaining Youth in Agriculture (ARYA) through KVKs, besides the regular IP&TM activities. In the segment of Grass root level innovation, individuals from rural areas with innovative ideas can participate in an open advertisement and get funding for initiating and scaling up of their programme to the tune of Rs. 1 to 10 lakhs. Under the incubation fund, 50 Business planning & development facilities will be established in different ICAR institutes & SAUs including at the rural areas. A publication on Commercialization of Technologies of IIHR, Bengaluru was released on the occasion.

An exhibition showcasing the technologies developed by IIHR, Bengaluru and the other five participating ICAR institutes for the benefit of the participants was inaugurated by Dr. D. L. Maheswar along with the Chief Guest.

New technologies ready for commercialization were presented by scientist innovators from IIHR, Bengaluru & other horticultural institutes during the technical sessions. An entrepreneur- scientist interaction was organized on the occasion during which, two license agreements, one for three technologies, *i.e.,* two Bio-pesticides & VAM and a second one for marigold advanced breeding lines were finalized and executed.

Publication on Commercialization of Technologies being released

Dr. D. L. Maheshwar inaugurating the exhibition

12. RAC, IRC, QRT, IMC – Major Recommendations

12.1. Research Advisory Committee

A new Research Advisory Committee (RAC) has been constituted by Director General, Indian Council of Agricultural Research in respect of Indian Institute of Horticultural Research, Bangalore for a period of three years w .e. f. 07.09.2013 to 06.09.2016 vide office order no. F. No. Hort-7-8/2013-IA-V dated October 03, 2013. The composition of the RAC is as under:-

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, IIHR, Bengaluru

Member-Secretary: Dr. B.N.S. Murthy

The first meeting of the full committee was held under the Chairmanship of Prof. Gautam Kalloo, former DDG (Hort.), ICAR & former Vice Chancellor, JNKVV, Jabalpur at IIHR, Hesaraghatta, Bengaluru on April 08-09, 2014. Dr. D. P. Singh, former ADG (Hort.), ICAR, Dr. R.T. Patil, former Director, CIPHET, Ludhiana, Dr. K. Krishnaiah, former Director, DRR, Hyderabad, Dr. D.M. Hegde, former Director, DOR, Hyderabad, Dr. N.K. Singh, National Professor, B. P. Pal Chair, Dr. S.K. Malhotra, ADG (Hort-II), ICAR, New Delhi, Mr. A. Shivanna and Mr. B. Dongare, IMC Members, IIHR, Bengaluru, Dr. C.K. Narayana, Director (Acting), IIHR, Bengaluru 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 farm 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

- Nutrient film techniques/hydroponics work may be initiated in crops wherever feasible.
- There is need to develop network project on vector research, especially for the control/ management of diseases caused by viruses.
- Double-haploid production may be attempted in different fruit and vegetable crops for fast development of inbreed/homozygous lines. This may be taken up in priority crops like chilli, corn *etc.*
- An interface with Ministry of Food Processing is required for conducting research on large-scale processing of fruits and vegetables. The available technologies may be prioritized and commercialized/demonstrated at pilot level.
- Market intelligence research and crop cycle studies integrating market price is the immediate need of the farmers. It may be taken up in priority crops.
- Impact analysis of horticultural technologies should be studied on priority and may be taken up in priority crops.
- Soil micro-nutrient status should be considered along with crop specific formulations. Also micronutrient studies in relation to fruit quality need to be taken up.
- Feasibility of continuation/closing of old experiments may be assessed to rationalize the resources for conducting research on emerging problems.
- A National conference on use of wild taxa for transfer of genes from wild sources to commercial variety may be organised which

will help in reducing the problems of biotic and abiotic stresses.

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 84th IRC Meeting was held during April 21st to May 08th, 2014, under the Chairmanship of Director, 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 major recommendations of the IRC.

Major recommendations of 84th IRC meeting (2014-15)

1. **Evaluation of under-utilized fruits for yield, quality and adaptability:** There is need for prioritizing the crops for in depth studies, accordingly, Rose-apple, Sweet Tamarind, Bael, Wood apple and Khirni were suggested as prioritized crops.

2. **Incorporation of bacterial blight resistance in pomegranate:** There is need to screen the sub-Himalayan collections and progenies derived from chemical and physical mutagens for bacterial nodal blight resistance.

3. **Breeding tomato for resistance to biotic and abiotic stresses and gene pyramiding for ToLCV resistance:** Work on GBNV may be intensified with Ty genes background.

4. **Breeding okra varieties / hybrids for yield, quality & resistance to biotic stresses through marker-assisted selection (MAS):** Genetics of resistance to YVMV should be worked out in resistant lines different genetic system in okra.

5. **Evolving F_1 hybrids in tropical carrots with high yield and quality through marker-assisted selection (MAS):** Genes and their inheritance pattern to be studied before development of molecular markers for male sterility and nematode resistance in carrot.

6. **Evolving rose varieties (both open and polyhouse) for quality and resistance to powdery mildew, black spot and thrips:**

   - Breeding programme in rose for cut flowers for export purpose should be targeted especially FOR red and orange colours, as they are in great demand.
   - Root stock studies have to be taken up considering Natal Briar as a possible replacement. A study on the life span of the crop with respect to root stocks may be taken up. This should also address the issues of abiotic stress like soil salinity and poor quality water.

7. **Development of recombinant protein and phage display based diagnostic kits for citrus greening bacterium, Citrus Tristeza virus and cucumber mosaic virus:** Diagnostics based on phage display to be concluded by next year.

8. **Development of molecular diagnostics for rapid detection of quiescent infections of *Colletotrichum* and *Alternaria* on fruits and vegetables:**

   - Contribution of each pathogenic factor for yield loss in a crop needs to be addressed rather than single pathogen in targeted vegetable crops.
   - Copper residues due to Bordeaux mixture application in the tomato fruits to be monitored.

9. **Studies on the mechanism of the Virus-Vector host interactions in virus disease of vegetable crops:** Temporal and spatial analysis of PRSV and aphid vector needs to be studied using most recent software available.

10. **Integrated management for pre and post-harvest diseases in fruits and vegetables:** Post-harvest disease scoring to be made based on sporulation, lesion size and lesion development instead of lesion size alone.

11. **Integrated disease management for bacterial blight of pomegranate and bacterial wilt of tomato and brinjal:** Develop molecular probe for soil diagnostics of wilt and oily leaf spot pathogen.

12. **Development of IPM for major pests of cucurbitaceous vegetables:** Demonstration of cue-lure and bait spray/ splashes to manage melon flies on bitter gourd may be taken up in the current rainy season.

13. **Monitoring and management of insecticide**

resistance horticultural crops (Thrips, mealy bugs, mites, brinjal shoot and fruit borer etc.): Baseline susceptibility data for new chemicals used against *L. orbonalis* like rynaxypyr, indoxacarb, flubendiamide may be generated.

14. **Biochemical and molecular assessment of chilling injury in mango:** Specific biochemical markers for chilling injury may be defined from the work carried out so far under the sub-project.

15. **Development of microbial consortium for sustainable production of horticultural crops and improving soil health:** All microbial consortium should be advised for use with recommended levels of FYM/Compost as otherwise the effect of consortium will not be satisfactory.

16. **Assessment and refinement of IIHR technologies through farmers' participatory demonstrations:** While conducting demonstrations on IIHR technologies, data may be collected to identify the factors which are contributing to higher or lower yield in different farmers' field. Through this effort a checklist may be developed on factors contributing to higher yield.

17. **Mapping hotspot areas of horticultural gene pool, distribution and data base development:**

- Diversity maps for mainstream indigenous horticulture crops and their wild species need to be generated using ARC GIS software, identifying hotspot areas.
- Ground survey data should be corroborated with satellite generated data through a temporal periodicity.
- Introspection of the data generated by the satellite images specifying their limitations and come out with close to the reality information.

18. **Optimization of germplasm domestication strategies for introducing new species of horticultural importance for crop diversification:** Minor fruit, *Canthium parviflorum* (local name: Kare) diversity may be collected from surrounding areas.

19. **Development of microsatellite markers in okra (*Abelmeschous esculantus* L. Moench):** It is important to develop a marker-linked to YVMV and also correlate copy number to the level of resistance since okra has a variable ploidy level. Exploration for funding through a BIRAC programme in collaboration with companies like Chromus who are already into developing markers for okra may be explored.

20. ***Agrobacterium* and Biolistic mediated transgenic development using AMP gene:**

- Vector control should be used in the transformation protocol and reported genes such as GFP to validate transformation protocols.
- Tomato transgenic with AMP, defensin and Pflp may also be tested for resistance to Ralstonia and Xanthomonas.
- Establish consistent and efficient regeneration and transformation protocol using cotyledon with vectors having reporter genes.

21. **Development of Bt transgenic brinjal for resistance to the shoot and fruit borer, *Leucinodes orbonalis* Guenee:** It is important to generate molecular biology data such as PCR, southern, ELISA, quantitative ELISA, junction fragment analysis on selected events, correlate LC50 with level of protein expression and he should take it to event selection trials.

22. **Ultra drying as a cost effective technique to extend seed longevity of horticultural germplasm under ambient conditions (Crops - papaya, onion, china aster):** Ultra drying technique for storage of large quantity of seeds needs to be explored.

23. **Value addition to seeds through coating and pelleting in horticultural crops (papaya, onion, carrot, China aster):** Work on seed coating, pelleting with growth promoting bacteria and micro nutrients to enhance seed germination needs to be done.

24. **Socio-economic impact of horticultural technologies on crop diversification, farm income, employment and trade:** Policy Analysis Matrix (PAM) may be attempted to study the impact of policy changes on the export performance of processed fruit and vegetable products.

25. **Economics of factor productivity and production efficiency in horticultural crops:** Decline in factor productivity in horticulture is a serious concern. This project must bring out the

factor productivity of all those inputs which are indiscriminately used leading to imbalances and decline in productivity like fertilizers, water, pesticides etc.

12.3. Institute Management Committee

During the period from 1.4.2014 to 31.3.2015, 81st and 82nd IMC meetings were held on 27.06.2014 and 25.02.2015 respectively with the following members present.

12.3.1. 81st Institute Management Committee Meeting

Chairman: **Dr. T. Manjunatha Rao,** Director, IIHR, Bengaluru

Members: **Dr.Sreenath Dixit**
Zonal Project Director,
Zonal Project Directorate, Zone-VIII,
Bengaluru – 560 024.

Dr.P.C.Tripathi
Principal Scientist & Head,
CHES, Chethalli, Karnataka.

Dr (Mrs). Anita Karun
Principal Scientist,
CPCRI, Kasaragod – 671 124, Kerala.

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 state

Member-Secretary:

Shri Charles Ekka
Senior Administrative Officer,
IIHR, Bengaluru

Special Invitees from IIHR, Bengaluru

Dr. M. R. Hegde
Chairman, RPMEC, & Head,
Division of Extension & Training

Dr.R.M.Bhatt
Head, Division of Plant Physiology & Biochemistry

Dr. M.Krishna Reddy
Chairman, P. G. Education (represented by Dr.R.Venugopalan)

Dr. Y.T.N.Reddy
Chairman, FMC(represented by Dr. Reju M. Kurian)

Dr. P. Chowdappa
Chairman (Works) (represented by Dr. Senthil Kumaran)

Dr. B. N. S. Murthy
Chairman, SPC

Shri. P. Balabrahmaiah
Chief Finance & Accounts Officer

Major Recommendations

1. Pungency problem: The labourers are facing lot of problems during chilli seed extraction. To overcome drudgery of extraction of chilli seeds, there is need to fabricate chilli seed extracting machine.

2. Steps need to be taken to document the impact of training programmes being conducted for officers and farmers

3. Looking into the efficient working of ATIC at IIHR, an interactive meeting needs to be held at IIHR by ZPD-Zone VIII to facilitate ATIC's of Zone-VIII.

4. An administrative staff needs to be provided to KVK, Hirehalli.

5. A "Farmers monthly meeting" is being organized at Jalna District of Maharashtra on 5.8.2014 and experts from IIHR should be deputed. There is need to interact on onion production technology & demonstrations on improved varieties of onion need to be taken up.

6. There has been a lot of trespassing by public and school children to the quarter's area at KVK, Gonikoppal. In order to overcome this problem, it was recommended to provide chain link mesh around residential quarters at KVK, Gonikoppal.

7. In order to provide better facilities to farmers and guests coming to hostel it was recommended to provide flooring (vitrified tiles) for the farmer's hostel at KVK, Gonikoppal since the cement flooring in the hostel is old and damaged.

8. The water supplying pipes are completely rusted, leading to contamination at KVK, Gonikoppal quarters. Hence it was recommended to provide a common water tank of 5,000 liters capacity (2 Nos.) for the residential quarters with plumbing lines and platform.

9. Three old quarters (one is occupied and two currently unoccupied) need to be repaired, as they are very old and it is necessary to repair and maintain the quarters as five more staff are to be recruited for the KVK. It was recommended that the three old quarters (type-III) at KVK, Gonikoppal be repaired.

10. Presently there is no accommodation in IIHR for PG students. Until the facility is created, it was proposed to convert eight type-III quarters into P.G. accommodation for use by Ph.D. students deputed from IARI to IIHR for their Ph.D. work in IIHR. Each type-III quarters with two rooms will be used to house two Ph.D. students. A total of 16 such students have to be accommodated during the current year. It was recommended to convert eight type III quarters to P.G. accommodation/hostel at IIHR, Hesaaghatta, Bengaluru.

11. As and when the posts are vacant, in addition to the Dealing Assistant, the post of AAO & AFAO may be filled up in the respective Regional Stations.

12. Since, the EFC Memo is still awaited from the Council, an amount of Rs.153 lakhs has been allotted for the budget allocation for the year 2014-15 including the spill over items during the year 2013-14 (could not be made due to late receipt of funds from Council). Hence, it was recommended to procure the same during the current financial year as per details furnished in the list enclosed with suitable justification. The proceedings of the Stores Purchase committee has also been approved by the Director along with the list of approved items. Further it was also recommended that common facilities mentioned in the list may be given priority for procuring.

12.3.2. 82nd Institute Management Committee Meeting

Chairman: **Dr.T.Manjunatha Rao**
Director (A),
IIHR, Bengaluru

Members: **Dr.Sreenath Dixit**
Zonal Project Director,
Zonal Project Directorate, Zone-VIII,
Hebbal, Bengaluru

Dr.D.P.Kumar
Director of Education,
University of Agrl. Sciences,
Bengaluru

Dr.P.C.Tripathi
Principal Scientist & Head,
CHES,Chethalli,
Karnataka

Shri K. M. Parashiva Murthy
Addl. Director of Horticulture (Fruits),
Dept. of Horticulture,
(Represented by Dr.M.Mahadevamma,
Deputy Director of Hort. (Fruits)
Lalbagh, Bengaluru

Shri P.A.Vishwanath
Finance & Accounts Officer, NBAIR,
Bengaluru

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,,Ramanagar district,
Karnataka

Member Secretary: **Shri Charles Ekka**
Senior Administrative Officer
IIHR, Bengaluru

Special Invitees from IIHR, Bengaluru

Dr.M.R.Hegde
Chairman, RPMEC

Dr.A.K.Chakravarthy
Head, Division of Ent. & Nematology

Dr. Sudha Mysore
Chairperson, ITMU & CPC

Dr. R.Venkattakumar
Head, Division of Extension and Training

Dr. L. B. Naik (represented by Dr. Shankar Hebbar)
Chairman, Farm Management Committee

Dr. C.R.Ramesh
Chairman (Works)

Dr. M. Krishna Reddy
Chairman, P.G.Education (represented by Dr.R.Venugopalan,).

Shri A. Srinivasa Murthy
FAO, (represented by
Shri.B.N.Ramachandrappa, AFAO)

Dr. G. Senthil Kumaran
Principal Scientist & Convener of NEH Programme
Dr. T. S. Aghora
Controlling Officer (Vehicles)
Dr. B. N. S. Murthy
Chairman, Stores Purchase Committee

Major Recommendations

1. There is a need to develop non-pesticide management strategies and also training programmes for KVK staff on eco-friendly crop protection for horticultural crops highlighting mainly on diagnostic kits developed like identification of thrips species may be organized.

2. Management practices to protect horticultural crops from monkey and wild boar menace may be made known.

3. Experts for training on eco-friendly management of pests may be sent to KVK, Jalna for training the staff of the KVK.

4. Information on suitability of various nets on bird scare and mortality of birds may be provided.

5. A survey on nature of colouring agents used & its effect in fruits & vegetables may be carried out.

6. Capacity building programmes for KVK personnel representing areas where horticulture crops are predominantly grown may be organized by the Institute.

7. The training calendar for the programmes of Division of Extension and Training may be prepared in advance and uploaded in the website.

8. Collaboration with Krishi Bhagya Yojana for rain water harvesting related work in the KVKs may be explored.

9. Fund requirement for fencing at KVK, Hirehalli may be booked under the budget provided for farm development.

10. The motorcycle (Bullet) at CHES, Bhubaneswar purchased during the year 1997 was quite old and was and auctioned and presently there is no two wheeler for the station without which it is difficult to carry the day to day official work inside city, visiting farmers' field etc. and hence there is a need to purchase a new one . Similarly, the Old Tata Sumo bearing Regn.No.OR-02-F-8817 purchased during the year 1997 has covered maximum kilometres and utilized to its maximum capacity. The old vehicle cannot be used any longer and its maintenance is very expensive and most of the time the vehicle is off the road due to frequent major repairs. Hence the said vehicle is needs to be written off/condemned and a replacement is essentially required for the day to day office use / farm visit. It was recommended to purchase as replacement in lieu of old motorcycle (Bullet) bearing Regn. No.OR-02-G-3413 and Tata Sumo bearing Regn.No.OR-02-F-8817 following all official formalities for CHES, Bhubaneswar.

11. At the main station, Hesaraghatta, two LMVs. *i.e.,* Old Tata Sumo (2 Nos.) (Telco Model) purchased in the year 2000 have out-lived their life and it is not economical to run these two vehicles further, since the repair/replacement of spares has already cost nearly Rs.5.00 lakhs and present condition of these two vehicles is not good and the same needs to be condemned written off and to be disposed of through Public Auction. Two new vehicles as replacement for these two needs to be done for the day to day official work. Further, the Tempo Traveller (Bajaj Tempo Ltd) purchased during the year 2002 has also outlived its service and is not economical to run this vehicle any longer due to the escalation cost of repairs/replacement of spares. Besides, it is under frequent repair and due to outdated model, the spares are not easily available in the market. Hence, this vehicle needs to be condemned and a replacement is sought for day to day official work at the Institute. It ws also brought to the notice that as per the ICAR letter No.6(3)/92-CDN (A&A) dated 25th May, 2009 replacement of Motor vehicles in terms of distance is 1,50,000 or 6 1/2 years and all the above mentioned vehicles meet the requirement in kms. & years of purchase. It was recommended to dispose of the old vehicles (LMV) and purchase of similar vehicles as replacement for IIHR, Hesaraghatta, Bengaluru

12. The proposal of utilizing the funds to purchase of equipment and machinery under NEH funds of ICAR-IIHR under the head “Capital” may be forwarded to Council for approval.

13. Papers Presented in Seminar/Symposium/Conference *etc.*

1. **Business Meet on Protected Cultivation of Vegetable Crops, Bengaluru, April 07, 2014.**

- Sharma, D. - Pesticide residue management in vegetables grown under protected cultivation.

2. **Indo-German Collaborative Workshop on Microbial Ecology, IARI, New Delhi, April 07-10, 2014.**

- Pious Thomas - The intra plant ecosystem of bacterial endophytes.

3. **National Conference on Productivity and Sustainability Role of Agriculturally Important Microorganisms, Bengaluru, April 10-12, 2014.**

- Panneerselvam, P., Prajwala, M., Sneha, P., Sindhu, B. L., Saritha, B., Poovarasan, S. and Ganeshamurthy, A. N. - Actinobacteria- a potential biocontrol agent against banana wilt causing *Fusarium oxysporum* f. sp. *cubense*.

- Panneerselvam, P., Selvakumar, G. and Ganeshamurthy, A. N. - Arka microbial consortium for sustainable vegetable production.

- Saritha, B., Panneerselvam, P., Sindhu, B. L., Sneha, P., Prajwala, M., Poovarasan, S. and Ganeshamurthy, A. N. - Bio-control potential of *Streptomyces* sp against plant pathogenic *Alternaria solani.*

4. **One Day Workshop regarding Ripening of Mango, organized by Department of Horticulture, Government of Karnataka, Shimoga, April 29, 2014.**

- Sudhakar Rao, D. V. - Low cost ripening of mango.

5. **Workshop on Potentials of Processing and Value Addition in Agro, Dairy, Poultry and Fish Products, organized by State Planning Commission, Government of Tamil Nadu, Chennai, May 08, 2014.**

- Sudhakar Rao, D. V. - Conversion of horticulture processing waste into wealth.

6. **Seminar on Production Technology, Post Harvest Management, Processing and Marketing of Mango, organized by Dept. of Horticulture, ZP, Nanjangud and JSS Krishi Vighyan Kendra, Suttur, Mysuru, May 13, 2014.**

- Sudhakar Rao, D. V. - Post harvest management of mango.

7. **ICAR-DAC Interface Meeting, New Delhi, May 15-16, 2014.**

- Murthy, B. N. S. - Production technologies recommended for tropical fruit crops.

8. **International Symposium on Jackfruit and Breadfruit of the Tropics-Genetic Diversity, Management, Value Addition and Marketing Strategies, UAS, Bengaluru, May 15-16, 2014.**

- Patil, P. - Genetic diversity of jackfruit maintained at IIHR Bengaluru.

- Prakash Patil, A. and Anuradha Sane - Morphometric evaluation of jackfruit accessions.

- Tiwari, R. B., Patil, P. and Jalali, S. - Evaluation of jackfruit selection at IIHR for osmotic dehydration.

9. **National Seminar-Cum-Workshop on Physiology of Flowering in Perennial Fruit Crops, CISH, Lucknow, May 24-26, 2014.**

- Dinesh, M. R. - Differential scope of molecular / traditional breeding for regularity in bearing habit of fruit crops.

- Kanupriya and Ravishankar, K. V. - Molecular aspects of flowering behavior in perennial fruit crops.

- Kundan Kishore - Temporal variation in flowering behavior and sex expression in mango under tropical humid climate of Odisha.

- Srinivas, P. and Singh, H. S. - Incidence of mango malformation in coastal region of India.

- Tripathi, P. C., Jayanthimala, B. R., Sunanada, S. and Sankar, V. - Studies on flowering pattern of Coorg Mandarin as influenced by changing climatic conditions.
- Tripathi, P. C., Sankar, V., Jayanthimala, B. R., Sunanada, S. and Karunakaran, G. - Studies of flowering behaviour of avocado accessions under humid tropical conditions of Coorg region.
- Upreti, K. K. - Regulatory roles of phytohormones and carbohydrates of flowering in mango.
- Ravindra, V. - Physiological signals, environmental cues and their interactions for induction of flowering in perennials – lessons for mango.

10. Workshop on Advances in Fruit Cultivation, organized by Odisha Horticulture Development Society, Bhubaneswar, May 25-26, 2014.

- Deepa Samant - Suitable fruit crop varieties in the state of Odisha.

11. National Symposium on Plant Pathology in Genomic Era, IGKV, Raipur, Chhatisgarh, May 26-28, 2014.

- Srinivas, P. - Incidence of post-harvest diseases in different mango varieties in coastal Odisha.
- Srinivas, P. - Emerging diseases and disorders of fruit crops in eastern India.
- Gopalakrishnan, C. - Is bacterial blight of pomegranate a manageable disease?

12. Global Conference on Technological Challenges and Human Resources for Climate Smart Horticulture-Issues and Strategies, NAU, Navsari, Gujarat, May 28-31, 2014.

- Deepa Samant - Effect of *In situ* rainwater harvesting and mulching on growth and yield of guava variety 'Arka Amulya' in eastern India.
- Sangeetha, G., Srinivas, P., Kishore, K. and Singh, H. S. - Prevalence and current status of mango diseases in Odisha.
- Sumangala, H. P. - Landscape gardening for environmental services.

13. National Seminar in Hindi on the Role of Agricultural Science and Technology in Food and Nutritional Security, IIHR, Bengaluru, June 04-05, 2014.

- Achala Paripurna - Recently released varieties/hybrids in fruits and vegetables from IIHR.
- Bhuvaneswari, S., Senthil Kumaran, G. and Narayana, C. K. - Design and development of storage box for shelf life extension of coriander leaves.
- Kanupriya and Mythili, J. B. - *Falon va sabjiyon ki bhandaran kshamata ke vikas hetu jaivproudyougiki ki bhumika.*
- Narayanaswamy, B., Hegde, M. R. and Saju George - PTD-a sustainable innovative method.
- Radhika, V. - *Krishi mein data mining ka prayog.*
- Rajiv Kumar, Dhananjaya, M. V., Sridhar, V. and Sriram, S. - *Gerbera ki sanrakchit krishi.*
- Rajiv Kumar, Manjunatha Rao, T. and Janakiram, T. - *Arka Aadya and Arka Archana: China aster ki nai kisme.*
- Senthil Kumaran, G., Carolin Rathinakumari, A. and Dayananda, P. - Design and development of animal drawn onion seeder.
- Sudhakar Rao, D. V. - *Falon ko krithrim roop se pakane sahi vidhi.*
- Tripathi, P. C. and Sankar, V. - *Kokam vans ke paundhon ka arthik aur ausadhiya mahattva.*
- Tripathi, P. C. and Karunakaran, G. - *Bharat main alpa upyogi uposhna katibandhiya phalon ki kheti ki sambhawanayain.*

14. Workshop on Post-Harvest Technologies in Mango for Processing and Export, organized by the Department of Horticulture, Government of Andhra Pradesh jointly in Association with APEDA, Hyderabad, Chittoor, June 17, 2014.

- Sudhakar Rao, D. V. - Post harvest management aspects of mango.

15. National Conference on Challenges and Opportunities for Production and Supply Chain of Pomegranate organized by University of Horticultural Sciences, Bagalkot, June 17-19, 2014.

- Murthy, B. N. S. - Breeding of pomegranate.
- Gopalakrishnan, C. - Orchard health management schedule and its impact on bacterial blight of pomegranate in south Karnataka.
- Sasireka, B. and Akella Vani - Transgenic T_1 pomegranate derived from cultivar Bhagwa towards resistance to bacterial nodal blight resistance.

16. Fish Farmers Day, Extension Information Centre, KVASPU, Hesaraghatta, July 10, 2014.

- Narayanaswamy, B. - IIHR farmer friendly technologies and integrated farming systems.

17. Annual Technical Review & Planning Meeting and 10th NPSC Meeting of UNEP-GEF Project, IIHR, Bengaluru, July 10-12, 2014.

- Gajanana, T. M. - Baseline report- Chittoor.

18. National Conference on Pre- Post Harvest Losses & Value Addition in Vegetables, Varanasi, July 12-13, 2014.

- Narayana, C. K. - Post harvest losses in vegetables.
- Tiwari, R. B. and Jalali, S. - Retention of vitamin C during blanching and freezing of vegetables.
- Sudhakar Rao, D. V., Srivastava, A. and Ranjitha, K. - Active and smart packaging in vegetables.

19. Technology Entrepreneurship Development Programme, VIT, Vellore, July 22, 2014.

- Sudha Mysore - World Bank sponsored NAIP on business planning and development in horticulture.
- Ganeshan, S. - Value added products for venture creation in horticulture.

20. Rashtriya Hindi Vigyan Sammelan - 2014, jointly organized by M.P. Science & Technology Council, Vigyan Bharati and Atal Bihari Vajpey Hindi University, Bhopal, August 01-02, 2014.

- Jagadeesan, A. K. and Tiwari, R. B. - *Bagwani vishay mein hindi mein prakashan ki samasyayein.*

21. Workshop on Tropical Exotic Fruit Production: Challenges and Opportunities (FALAM'14), KVK, Pattanamthitta, Kerala, August 07-08, 2014.

- Karunakaran, G., Sakthivel, T., Thiruganavel, A., Tripathi, P. C., Sankar, V. and Senthilkumar, R. - Challenges and possibilities in canopy management and high density planting of tropical exotic fruit crops.
- Karunakaran, G., Thiruganavel, A., Sakthivel, T., Tripathi, P. C., Sankar, V. and Senthilkumar, R. - Possibilities and techniques for production of quality planting materials for exotic fruit crops.

22. National Seminar cum Workshop on Strategies for Improvement, Enhancing Productivity and Utilization of Cucurbits, Bhubaneswar, August 08-10, 2014.

- Bharathi, L. K., Mishra, A. B. and Srinivas, P. - Potential of minor cucurbits for enhanced income for livelihood support for small and marginal farmers of Odisha.
- Bharathi, L. K. - Wide hybridization studies in the genus *Momordica.*
- Ganeshan, S. - Genetic resources in cucurbits: diversity, conservation and utilization.
- Narayana, C. K. and. Sudhakar Rao, D. V. - Post harvest management and value addition of cucurbits.
- Prabhakar, M., Hebbar, S. S, Nair, A. K., Rajeshwari, R. S. and Bharathi, L. K. - High tech production technologies for cucumber and melon cultivation.
- Sharma, D. - Pesticide residues in cucurbitaceous vegetables- status and management.
- Singh, H. S. - Single line trellis-an alternative strategy for pest management in small cucurbit.

- Srinivas, P., Krishna Reddy, M., Mandal, S., Sangeetha, G., Bharathi, L. K. and Singh, H. S. - Predominant viruses of minor cucurbits in Odisha.
- Ranganath, H. R., Timmanna, S., Saroja and Singh, H. S. - Management of melon fly *bactrocera cucurbitae* (coquillet) diptera: tephritidae in cucurbits.
- Umamaheshwarappa, P., Krishnappa, K. and Pitchaimuthu, M. - Effect of varying levels on nitrogen, phosphorus and potassium on growth and yield of bottle gourd under southern dry region of Karnataka.
- Umamaheshwarappa, P., Krishnappa, K. and Pitchaimuthu, M. - Effect of varying levels on nitrogen, phosphorus and potassium on flowering, fruit set and sex ratio of bottle gourd under southern dry region of Karnataka.
- Umamaheshwarappa, P., Krishnappa, K. and Pitchaimuthu, M. - Effect of varying levels on nitrogen, phosphorus and potassium on flowering, fruit set and sex ratio of cucumber (*Cucumis sativus* L.) under southern dry region of Karnataka.
- Umamaheshwarappa, P., Krishnappa, K. and Pitchaimuthu, M. - Growth and yield of cucumber (*Cucumis sativus* L.) as influenced by varying levels of nitrogen, phosphorus and potassium under southern dry region of Karnataka.
- Umamaheshwarappa, P., Krishnappa, K. and Pitchaimuthu, M. - Uptake of nitrogen, phosphorus and potassium by plant and leaf chlorophyll content of bottle gourd Cv. Arka Bahar under southern dry region of Karnataka.
- Varalakshmi, B., Kanupriya, Ansar Wani and Pitchaimuthu, M. - Present status and future breeding strategies for improved cultivation of cucumber and native melons in India.
- Varalakshmi, B., Pitchaimuthu, M. and Lakshman Reddy, D. C. - Present status and future breeding strategies for improved cultivation of bottle gourd.

23. Symposium on Developing Research to Enhance Market Demand and Profitability of Tropical Fruits, Putrajaya, Malaysia, August 14, 2014.

- Patil, P. - Research advances in tropical fruit research in India.

24. 29th International Horticulture Congress and Mango Workshop, Australia, August 17-21, 2014.

- Bharathi, L. K. - Synthesis and preliminary characterization of a new synthetic *Momordica* species with potential as a new vegetable crop.
- Dinesh, M. R. - Evaluation and *ex-situ* conservation of indigenous (Naati) mango varieties.
- Reddy, Y. T. N. - Canopy management in mango.

25. Academic Industry Interaction Meet, organized by Lady Doak College, Madurai, August 26, 2014.

- Ganeshan, S. - Incubation, establishing of start-ups and business opportunities in the domain of horticulture.

26. Brainstorming Session on Insecticide Resistance Management in Horticultural Crops, IIHR, Bengaluru, August 30, 2014.

- Sharma, D. - Pesticide residue management in horticultural produce.

27. Seminar on Status and Scope of Mechanization in Horticulture, CHES, Bhubaneswar, September 01-03, 2014.

- Senthil Kumaran, G. - Machinery for horticulture.

28. Asain Solanaceous Round Table 2014: Disease and Insect Pest Resistance in Solanaceous Vegetables: Successes and Challenges, APSA, ICAR, IIHR, Bengaluru, September 09-10, 2014.

- Krishna Reddy, M. - Tospovirus – the challenge and building a resistance program in tomato.
- Madhavi Reddy, K. - Strategy to breed hot pepper for chilli leaf curl and tospovirus resistance.
- Sadashiva, A. T., Ravishankar, K. V., Girija Ganeshan, Krishna Reddy, M., Gopala Krishnan, C., Singh, T. H., Punit Kumar, R., Domnic D'mello, Bharath Kumar, M. V.,

Amrutha Sindu and Shwetha, N. - Breeding tomato for resistance to early blight in combination with bacterial wilt and tomato leaf curl virus.

29. Workshop on New Initiative in Horticultural Crops - National Network Project Micronutrient Management in Horticultural Crops, September 10, 2014.

- Chandra Prakash, MK and Reena Rosy Thomas - Micronutrient management in horticultural crops.

30. XXII Group Meeting of AICRP on Medicinal, Aromatic Plants and Betelvine, IIHR, Bengaluru, September 17, 2014.

- Hima Bindu, K. - Status of plant genetic resources of medicinal plants.

31. International Symposium on Conservation and Management of Pollinators for Sustainable Agriculture and Ecosystem Services, New Delhi, September 24-26, 2014.

- Reddy, P. V. R., Varun Rajan, V., Vasugi, C. and Verghese, A. - Pollinator profile of mango, *Mangifera indica* L.
- Jayanthimala, B. R., Tripathi, P. C., Sankar, V. and Sunanada, S. - Flowering pattern of Coorg Mandarin as influenced by changing climatic conditions.

32. International Research Conference on Incubation & Regional Development, Toulouse Business School, Toulouse, France, October 23, 2014.

- Sudha Mysore, Ganeshan, S., Krishnamoorthy, A., Sivakumar, P. and Kavitha, M. - Business incubators and incubation policies & approaches for enhanced regional development a case study of horticulture in India.

33. 3rd International Conference on Agriculture & Horticulture Sciences, OMICS Group Conferences, Los Angeles, CA, USA, Hyderabad, October 27-29, 2014.

- Bhuvaneswari, S., Narayana, C. K. and Udhayakumar, R. - Effect of packaging film of different thicknesses on shelf life and quality of minimally processed onion.
- Mohapatra, S. - Dynamics of difenoconazole and propiconazole residues on pomegranate over a period of two years under field conditions.
- Rajiv Kumar, Gayatri Khangjarakpam, Manjunatha Rao, T. and Dhananjaya, M. V. - Genetic variability for quantitative traits in China aster.
- Ranjitha, K. - Human pathogenic bacteria associated with fresh vegetables and advances in their control strategies.

34. 6th Indian Horticulture Congress 2014, organized by the Horticultural Society of India, New Delhi, TNAU, Coimbatore, November 06-09, 2014.

- Akella Vani - Shrinking breeding time in fruit trees through transgenic means and obtaining a non-GM tree.
- Carolin Rathinakumari, A., Senthil Kumaran, G. and Sidhu, A. S. - Effect of different planting orientations on growth parameters of garlic crop relevant to development of garlic planter.
- Dinesh, M. R. - Breeding strategies for important fruit crops.
- Karunakaran, G., Prasath, D., Tripathi, P. C., Senthil Kumar, R., Sankar, V. and Sakthivel, T. - Nutritional and unexploited indigenous vegetables of Kodavas in Western ghats, Coorg.
- Kavitha, Shivashankar, K. S., Sadashiva, A. T., Rao, V. K., Ravishankar, K. V. and Shilpa, P. - Assessment of genotypic variability of tomato for volatile constituents using SPME technique.
- Leela Sahijram - Modifying DNA methylation pattern in embryos for application in horticultural crop improvement.
- Meera Pandey and Punita, G. - Introduction and acclimatization of new culinary medicinal mushrooms.
- Pious Thomas - Somatic embryogenesis mediated micro propagation in papaya (*Carica papaya*) cv. Surya.
- Pitchaimuthu, M., Krishna Reddy, M., Sreenivasa Rao, E., Nageshwari, K. and Bharathi, L. K. - Screening advanced lines and wild species of okra for resistance to yellow vein mosaic virus in natural hotspots.

- Prathibha, G., Narayana, C. K. and Sreenivas, K. N. - Influence of pectinase enzyme on lycopene extraction from tomato peel.
- Sadashiva, A. T., Krishna Reddy, M., Ravishankar, K. V., Girija Ganeshan, Gopalakrishna, C., Madhavi Reddy, K., Singh, T. H., Dominic P D'mello, Punith Kumar, R., Amrutha Sindhu, B., Shwetha, N., Aradana Singh and Kashinath, B. L. - Breeding tomato (*Solanum Lycopersicum* L.) for triple disease resistance to tomato leaf curl virus, bacterial wilt and early blight.
- Sadashiva, A. T., Shivashankar, K. S., Rao, V. K., Ravishankar, K. V., Kavitha, P. and Shilpa, P. - Breeding tomato (*Solanum lycopersicum* L) for high nutritive value.
- Sangama - Effect of pre cooling and packaging on quality of *jasminum sambac* flowers during road transport.
- Sankar, V. and Tripathi, P. C. - Feasibility and economic viability of vegetable cultivation in rice fallow areas of Kodagu.
- Sankar, V., Tripathi, P. C., Sadashiva, A. T. and Aghora, T. S. - Performance evaluation of improved vegetables varieties of IIHR under hilly regions of Coorg.
- Sasirekha and Akella Vani - Role of plant kinases in conferring resistance to bacteria a case study of Xa21 gene of rice conferring resistance to nodal blight in pomegranate.
- Satisha Jogaiah, Anuradha Upadhyay, Smita, R., Maske Dipankar Malakar, Akanksha Singh, Manoj Pillai, Amruta, R. Kitture and Kaushik Banerjee. - Proteome and metabolome variations in Thompson Seedless grapes during veraison stage as influenced by rootstocks.
- Satisha Jogaiah, Kitture, A. R., Sharma, A. K., Jagdev Sharma, Upadhyay, A. K. and Somkuwar, R. G. - Rootstock regulates fruit and wine quality parameters in cabernet sauvignon grapevines (*Vitis vinifera* L.).
- Senthil Kumaran, G., Carolin Rathinakumari, A., Dayananda, P. and Pushpalatha, V. - Energy efficient hot water treatment plant for mango.
- Singh, T. H., Sadashiva, A. T. and Madhavi Reddy, K. - Breeding for resistance to bacterial wilt (*Ralstonia solanacearum*) in eggplant (*Solanum melongena* L.).
- Sudhakar Rao, D. V. - Technological advances in packaging of horticultural produce.
- Tripathi, P. C., Karunakaran, G., Sankar, V. and Senthil Kumar, R. - Evaluation of kokum collections for yield and quality under humid tropics conditions of Western ghats.
- Tripathi, P. C., Sankar, V. and Senthil Kumar, R. - Status and scope of cultivation of humid tropical underutilized fruits in India.
- Upreti, K. K. - Plant growth regulators in horticultural crops: global advances and potential use in India.
- Varalakshmi, B., Chowdappa, P., Krishnamurthy, D. and Sanna Manjunath, K. S. - Reaction of ridge gourd advanced selections against downy mildew.
- Vasugi, C., Sunil Gowda, Dinesh, M. R., Krishna Reddy, M. and Shivashankar, K. S. - Evaluation of intergeneric hybrid progenies of papaya for PRSV tolerance.

35. 55th Annual Conference of the Association of Microbiologists of India, TNAU, Coimbatore, November 12-14, 2014.

- Asha, K., Selvakumar, G., Thippeswamy, B. and Ganeshamurthy, A. N. - Screening of lignolytic fungi isolated from composts.
- Selvakumar, G., Ram Kumar, P., Roopa, H. K. and Asokan, R.- Effect of growth media on conidial production and infectivity of the entomopathogenic fungus *Isaria fumosorosea* against sucking pests.
- Hema Bindu, G., Selvakumar, G. and Ganeshamurthy, A. N. - Rhizosphere competence traits of osmotolerant plant growth promoting rhizobacteria.
- Panneselvam, P., Ganeshamurthy, A. N., Selvakumar, G., Anani, R. and Saritha, B.-Antagonistic potential of actinobacteria against pomegranate wilt causing *Ceratocystis fimbraita*.

36. National Symposium on Entomology as a Science and IPM as a Technology- the Way Forward, Passighat, Arunachal Pradesh, November 14-15, 2014.

- Reddy, P. V. R. and Verghese, A. - Plant-

pollinator interactions in relation to climate change: expected shifts and implications.

37. National Symposium on Agriculture Diversification for Sustainable Livelihood and Environmental Security, organized by Indian Society of Agronomy, New Delhi, Punjab Agricultural University, Ludhiana, November 18-20, 2014.

- Manjunath, B. L. - Sources of nutrients in influencing the organic rice yield and the economics.
- Singh, N. P. and Manjunath, B. L. - Integrated farming systems for livelihood security of small and marginal farmers.
- Singh, N. P., Manjunath, B. L., Gopal Mahajan, Priya Devi, Desai, A. R., Das, S. K., Chakurkar, E. B. and Swain, B. K. - Development of integrated farming system models for west coast region.

38. National Symposium on Plant Health for Sustainability in the Field and Horticultural Crops, Citrus Research Station, Dr. Y.S. R. Horticultural University, Andhra Pradesh, November 18-20, 2014.

- Krishna Reddy, M. - Diagnosis and manage-ment of virus and phytoplasma diseases of papaya.

39. 8th International Conference on Mushroom Biology and Mushroom Products, New Delhi, November 19-22, 2014.

- Pandey, M., Rajeshbabu, D., Satisha, G., Shivshankara, K. S., Shamina Azeez, Roy, T., Jameel, M., Nandini, R., Punita Kumari and Swarnlatha, P. - Conservation and characterization of *pleurotus* variability of India.
- Ramakrishna, M., Veena, S. S., Rajeshbabu, D., Meera Pandey and Nageswara Rao, G. - Comparative study on bioactive constituents and biological activities of indigenous cultivated strains of *Ganoderma lucidum*..
- Saikiran, M., Meera Pandey and Rajeshbabu, D. - *In vitro* antioxidant properties of cultivated edible mushroom *Agrocybe aegerita.*

40. Seminar-cum- NRDC Industry Interaction Meet on Technology Transfer- Innovation is Key to Change, organized by NRDC in Association with Tamil Nadu Technology Development & Promotion Centre (TNTDPC) of CII, Chennai, November 21, 2014.

- Sudha Mysore - Technologies developed by IIHR & ready for commercialization by the industries.

41. The International Symposium, Brains-torming Meeting on Proteomics: Present and Future, CCMB, Hyderabad, November 22-24, 2014.

- Smita, R. Maske, Satisha Jogaiah, Anuradha Upadhyay, Dipankar Malakar, Akanksha Singh, Manoj Pillai, Amruta, R. Kitture and Kaushik Banerjee. Rootstock's influence on proteome and metabolome variations in Thompson Seedless grapes during 3-4 mm berry stage (el 29) stage of berry development.

42. 79th Annual Convention of Indian Society of Soil Science, Hyderabad, November 24-27, 2014.

- Panneerselvam, P., Selvakumar, G., Ganeshamurthy, A. N., Ragini, B. and Saritha - *Bacillus aryabhattai* inoculation improves the zinc content of French bean.

43. National Seminar on Developments in Soil Science-2014, Prof. Jayashankar Telangana Agril. University, Rajendranagar, Hyderabad, November 24-27, 2014.

- Varalakshmi, L. R. - Effect of different fertilizers in drip fertigation on growth and yield of tomato and soil and leaf N, P, K status.

44. National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits, CHES, Chettalli, December 01-03, 2014.

- Anuradha Sane, Shetti, D. L. and Ganeshan, S. - Morphological and molecular characterization of Governor's Plum (*Flacourtia montana* J Graham) - a less known fruit.
- Deepa Samant - Prospects of preservation of star gooseberry (*Phylanthus acidus* Skeels) as Murabba.
- Ganeshan, S. - Genetic resource management of underutilized fruits of Western Ghats.
- Ganga Visalakshy, P. N., Swathi, C., Darshana, C. N. and Pillai, G. K. - Prospects of biological control of *Helopeltis antonii* Signoret by using entomopathogen *Beauveria bassiana*.

- Jayalakshmi, K., Raju, J., Sangeetha, K. D. and Priti, S. Sonavane - Post harvest diseases of rambutan (*Nepheliuml appaceum* L.*)*.
- Jayanthimala, B. R., Sunanda Sanganal and Tripathi, P. C. - Pollinators diversity and their roll in pollination of rambutan.
- Karunakaran, G., Tripathi, P. C., Sakthivel, T., Ravishankar, H., Sankar, V. and Senthil Kumar, R. - Evaluation of kokum accessions for yield and quality traits in high rainfall zone of Kodagu.
- Kundan Kishore and Singh, H. S. - Status and potential of underutilized fruits in eastern tropical region of India.
- Kundan Kishore - Performance of rose apple and watery rose apple under eastern tropical region of India.
- Karunakaran, G., Tripathi, P. C., Sakthivel, T., Ravishankar, H., Sankar, V. and Senthil Kumar, R. - Evaluation of avocado accessions for yield and quality traits.
- Karunakaran, G., Tripathi, P. C., Sankar, V., Sakthivel, T. and Senthil Kumar, R. - Dragon fruit - a new introduction crop to India: a potential market with promising future.
- Karunakaran, G., Tripathi, P. C., Sankar, V., Sakthivel, T. and Senthil Kumar, R. - Inspirational and successful growers: growing high value tree fruits of exotic origin.
- Narayana, C. K. and Shamina Azeez - Post harvest management and value addition of tropical and subtropical under-utilized fruits.
- Patil, P. and Najeeb, N. - Advances in jackfruit production technology.
- Priti S. Sonavane, Saxena, A. K. and Tripathi, P. C. - Major fungal diseases in rambutan: causes, status and need based management.
- Raju, J., Jayalakshmi, K., Priti, S. Sonavane and Sangeetha, K. D. - Avocado – pre and post harvest diseases and their control.
- Ravishankar, H. and Sakthivel, T. - Rambutan (*Nephilium lappaceum* L.) and prospects of its genetic improvement.
- Reddy, P. V. R., Shivaramu, K., Achala Paripoorna, K., Patil, P. and Suryanarayana, M.A. - Scope of host plant resistance in selected under-utilized fruit crops: an appraisal of germplasm evaluation.
- Reddy, T. M. - Factors determining cultivation of underutilized fruits in Coorg region.
- Reddy, T. M. - Marketing of underutilized fruits in Coorg region.
- Rekha, A., Anuradha Sane and Dinesh, M. R. - Polyembryony among jamun (*Syzygium cumini* (L.) Skeels) accessions.
- Sangeetha, K. D., Jayalakshmi, K., Raju, J. and Priti, S. Sonavane. - Anthracnose of carambola - a menace in quality fruit production.
- Sangeetha, K. D., Priti, S. Sonavane, Jayalakshmi, K. and Raju, J. - Phytophthora root rot – a serious menace in avocado.
- Sankar, V., Tripathi, P. C., Karunakaran, G., Sakthivel, T., Ravishankar, H. and Senthil Kumar, R. - Evaluation of elite pummelo (*Citrus maxima*) lines for yield and yield contributing parameters and fruit quality under Coorg conditions.
- Sankar, V., Tripathi, P. C., Karunakaran, G., Sakthivel, T., Ravishankar, H. and Senthil Kumar, R. - Evaluation of Malayan apple (*Syzygium malaccense*) lines for growth, yield and fruit quality.
- Saxena, A. K., Rathnamma, K. and Thilaka Rani, R. - Production of disease free planting material for cultivation of some underutilized fruits.
- Senthil Kumar, R., Tripathi, P. C., Karunakaran, G., Sakthivel, T., Sankar, V. and Ravishankar, H. - Characterization of Malabar tamarind (*Garcinia gummigutta L.)* accessions at Kodagu region of Karnataka.
- Senthil Kumar, R., Tripathi, P. C., Karunakaran, G., Sakthivel, T., Sankar, V. and Ravishankar, H. - Characterization of yellow mangosteen (*Garcinia xanthochymus* Hook.*)* accessions at Kodagu region of Karnataka.
- Shivaramu, K., Rekha, A. and Anuradha Sane - Screening of jamun (*Syzigium cumini*) germplasm against leaf damage by insect pests.

- Singh, H. S. - Reaction of apma (*Emblica officinallis* Gaertn.) varieties to shoot gall maker *Betousa stylophora* (Swinhoe) (Thyrididae: Lepidoptera) in eastern India.
- Singh, H. S. and Mandal, S. - Insect pests of tropical and sub-tropical underutilized fruits.
- Sudhakar Rao, D. V. and Narayana, C. K. - Post harvest management of pomegranate fruits.
- Thejangulie Angami, Satisha, G. C., Lembisana Devi, H., Prativa Sahu and Sakthivel, T. - Composition of mineral elements in different accessions of jamun (*Syzygium cumini* L. Skeels) seed.
- Tiwari, R. B., Sarojini Jalali and Tripathi, P. C. - Dehydrated processed products from underutilized fruits work done at IIHR.
- Tripathi, P. C., Karunakaran, G., Sakthivel, T., Sankar, V., Senthil Kumar, R. and Ravishankar, H. - Evaluation of rambutan accessions under humid tropical conditions of Western ghats.
- Tripathi, P. C., Karunakaran, G., Sakthivel, T., Sankar, V., Senthil Kumar, R. and Ravishankar, H. - Studies on variability in morphological and physico-chemical characters of karonda.
- Utpala Parathasarathy, Nandkishore, O. P., Senthil Kumar, R. and Nirmal Babu, K. - The nutrient profile of important *garcinia* species of India.
- Yogeesha, H. S., Ganeshan, S., Shivashankara, K. S., Shetty, D. L. and Anil Kumar, C. - Seed germination studies in *Baccaurea courtellensis*-Muell Arg. - a threatened under-utilized fruit species of Western ghat region.
- Vishal Nath, Amrendra Kumar, Patel, R. K., Pandey, S. D., Kuldeep Srivastava and Karunakaran, G. - Potential of off season litchi cultivation in humid tropical zones of Western ghats.
- Uthaiah, B. C., Tripathi, P. C., Sankar, V. and Senthil Kumar, R. – Under exploited fruits of Western ghats.
- Attri, B. L. and Tripathi. P. C. - Under exploited and nutritionally rich wild fruits of Uttarakhand.

45. National Seminar on Beneficial Fungi with Special Reference to Mushroom Cultivation, Mycorrihza and Bio-control Agents, Nirmala College, Muvattupuzha, Ernakulum, December 04-05, 2014.

- Meera Pandey and Senthil Kumaran - Mushroom technology as a potential biological tool for sustainable development.
- Senthil Kumaran, G. - Farm design, tools and machinery for mushroom spawn production and cultivation.

46. National Seminar-cum-Exhibition on Pomegranate for Nutrition, Livelihood Security and Entrepreneurship Develo-pment, jointly organized by ICAR-National Research Centre on Pomegranate, Solapur and Society for Advancement of Research on Pomegranate, Solapur, December 05-07, 2014.

- Chandrakant Awachare - Biochemical profiling in pomegranate *(Punica granatum* L.) cv. Bhagwa.
- Gopalakrishnan, C. - *In vitro* evaluation of botanicals against *Xanthomonas axonopodis* pv. *punicae* causing bacterial blight of pomegranate.
- Kanupriya, Ravishankar, K. V. and Murthy, B. N. S. - Molecular markers in genetic improvement of pomegranate.
- Murthy, B. N. S. - The quest to develop pomegranates cultivars for alimentation, sustenance and entrepreneurship: intricacies and accomplishments.
- Panneerselvam, P., Selvakumar, G. and Ganeshamurthy, A. N. - Microbial consortium and their role on pomegranate plant health management.
- Saxena, A. K. - Management of important fungal diseases in pomegranate.
- Usharani, T. R., Sunisha, Sowmya, Poovarasan and Meenakshi - Transformation and evaluation of pflp gene in transgenic pomegranate cv. Bhagwa against *Xanthomonas axonopodis punicae* causing bacterial blight disease.

47. Mango Seminar organized by KVK, Gangavathi, Koppal, Karnataka, Gangavati ARS/KVK Campus, December 09, 2014.

- Reddy, Y. T. N. - High density planting technology in mango.

48. Workshop on Medicinal Plants Role of State Forest Departments in Conservation, Cultivation, Harvesting, Marketing and Benefits Sharing by the Communities for the Senior Officers of the Indian Forest Service, Kerala Forest Research Institute, Peechi, Thrissur, Kerala, December 09-10, 2014.

- Rajasekharan, P. E. - Conservation of RET medicinal plants.

49. International Symposium on Plantation Crops (PLACOSYMXXI), IISR, Calicut, December 10-12, 2014.

- Ganga Visalakshy, P. N., Swathi, C., Bhat, P. S., Babu, A., Sree Kumar, K. and Darshana, C. N. - Cross infectivity and bioassay studies of entomopathogens *Baeuveria bassiana* isolates against *Helopeltis spp* infesting plantation crops.

50. One Day Workshop on the Biological Diversity Act and Rules and to Create Understanding on Access and Benefit Sharing Provisions, Prior Informed Consent, Mutually Agreed Terms, Material Transfer Agreement, organized by Karnataka Biodiversity Board, Government of Karnataka, Bengaluru, Institute of Wood Science and Technology, Bengaluru, December 11, 2014.

- Ganeshan, S. - Access and benefit sharing.

51. National Symposium on Plant Diseases: New Perspectives and Innovative Management Strategies, UAS, Dharwad, December 11-12, 2014.

- Samuel, D. K., Krishna Reddy, M., Jalali, S. and Reddy, H. C. - Phyto Sanitary Certificate (PSC) issuing workflow at Indian Institute of Horticultural Research.

- Samuel, D. K., Krishna Reddy, M., Jalali, S. and Reddy, H. C. - Real-time polymerase chain reaction detection of phytoplasmal infection in vegetables.

- Priti, S. Sonavane and Prameela Devi, T. - A comparative taxonomic study employing morphological and molecular method for re-evaluation of *Helminthosporium* species complex.

52. Bruhat Udhya Mela Horticulture Fair, University of Horticultural Sciences, Bagalkot, December 11-15, 2014.

- Senthil Kumaran, G. - Mechanization in vegetable crops.

- Senthil Kumaran, G., Carolin Rathinakumari, A. and Nagaraj, G. - Mechanization in vegetable crops.

53. National Seminar on Extension Management Strategies for Sustainable Agricultural Challenges and Opportunities, Agricultural College and Research Institute, TNAU, Madurai, December 12-13, 2014.

- Venkattakumar, R. - Attracting rural youth and fostering entrepreneurship in agriculture: lessons for Indian Agricultural Universities from Michigan State University, USA.

- Narayanaswamy, B., Hegde, M. R., George, S. and Naika, R. K. - An effectiveness of participatory extension approach for IPM technologies.

- Narayanaswamy, B., Gowda, K. N. and Naika, R. K. - An analysis of SHG members for their constraints.

54. The Indian Scenario 3rd Biodiversity Congress, Chennai SRM University, December 17-20, 2014.

- Souravi, K. and Rajasekharan, P. E. - Access and benefit sharing with special reference to medicinal plants.

- Pranay Kumar, Raviraja Shetty, Souravi, K. and Rajasekharan, P. E. - Tissue culture studies in *Decalepis hamiltonii* and endemic threatened medicinal plant.

55. XXIII National Conference on Recent Trends in Virology Research in the Omics Era, Tamil Nadu Agricultural University, Coimbatore, December 18-20, 2014.

- Amrutha, S., Bhat, Laxmi Devi, V. and Krishna Reddy, M. - Diversity of tospoviruses infecting tomato, chilli and capsicum in southern India.

- Krishna Reddy, M., Hemachandra Reddy, P., Manasa, M., Swarnalatha, P., Jalali, S. and Samuel, D. K. - Emerging and re-emerging viruses and viroids associated with seed in vegetable crops.

- Samuel, D. K., Krishna Reddy, M., Jalali, S. and Hemachandra Reddy, P. - Phylogeography of simulated PRSV infection in Tamil Nadu using BEAST.
- Samuel, D. K., Krishna Reddy, M., Jalali, S. and Hemachandra Reddy, P. - Faceting to visually analyze high density multi-year, multi-centre multi-treatment data in GG plot using free R software.
- Samuel, D. K., Krishna Reddy, M., Jalali, S. and Hemachandra Reddy, P. - Detection of viral infections in tissue culture mother plants and their implications to domestic/international quarantine and mass multiplication.
- Samuel, D. K., Krishna Reddy, M., Jalali, S. and Hemachandra Reddy, P. - Associvity of *Phytophthora palmivora* Butler co-infection on papaya ring spot virus infected plants: implications for management.

56. National Seminar on Present Scenario and Future Strategies for Processing and Value Addition, organized by CIPHET, Ludhiana, December 19-20, 2014.

- Narayana, C. K. - Strategies to reduce processing wastes from fruit and vegetable processing industries and adding value.

57. National Dialogue of 25 years of Achievements of Horticulture Research & Development- the way forward, organized by NAAS, New Delhi, CICR, Nagpur, December 26-27, 2014.

- Ganeshan, S. - Cryopreservation in horticultural crops.
- Murthy, B. N. S. - ICT in horticulture.
- Sridhar, V. - Mitigating insecticide resistance with new molecules.
- Sudha Mysore - Commercialization of horticultural technologies.

58. Annual Breeder Seed Review Meeting – 2015 at ICAR Research Complex for NEH Region, Umiam, Meghalaya, January 07-08, 2015.

- Patil, P. - Seed and planting material production in fruits – issues and strategies.

59. National Symposium on Nematode Management: a Challenge to Indian Agriculture in the Changing Climate, YASHADA, Pune, January 08-10, 2015.

- Grace, G. N., Rao, M. S., Shivananda, T. N., Umamaheswari, R. and Priti, K. - *In vitro* studies on antagonistic effect of *Paecilomyces lilacinus* on *Meloidogyne incognita*.
- Kamalnath, M., Rao, M. S., Manoj Kumar, Rajinikanth, R. and Umamaheswari, R. - Biological control of root knot nematode *Meloidogyne incognita* in carrot (*Daucus carota*).
- Prabhu, P., Rao, M. S., Manoj Kumar, Vidyashree and Umamaheswari, R. - Induction of systemic resistance in bell pepper (*Capsicum annuum* L.) against root knot nematode *Meloidogyne incognita* by *Bacillus subtilis*.
- Rao, M. S. and Umamaheswari, R. - Mass production and commercialization of bioagents against nematodes.
- Umamaheswari, R. and Rao, M. S. - Mitigating nematode menace in protected horticulture

60. 3rd Kannada Sahithya Sammelana, Sira, Tumkuru, January 17-18, 2015.

- Narayanaswamy, B. - Women empowerment through self-help group approach and entrepreneurship.

61. National Meet on Distant Hybridization in Horticultural Crops, IIHR, Bengaluru, January 22-23, 2015.

- Aswath, C., Rao, T. M., Tejaswini, Dhananjaya, M. V., Rajiv Kumar and Padmini - Use of wild species in ornamental crops improvement (gerbera, anthurium, carnation and gladiolus).
- Balamohan, T. N., Kavitha, P. S. and Karunakaran, G. - Improvement of possibilities through species utilisation in banana.
- Bharathi, L. K. - Interspecific hybridization in *Momordica* improvement and way forward.
- Dutta, O. P., Sadashiva, A. T., Madhavi Reddy, K. and Pitchaimuthu, M. - Wild species utilization in vegetable crop improvement – challenges and way forward.
- Ganeshan, S. - Conservation and utilization of wild species in horticultural crop improvement.

- Karunakaran, G. - Commercial potential of new generation fruit crops.

- Padmini, K., Rajasekharan, P. E., Ganga Visalakshy, P. N., Singh, T. H. and Upreti, K. K. - Unlocking the potential of *Solanum macrocarpon* L for genetic enhancement in site-specific hybridization of brinjal *(Solanum melongena* L.*)* - challenges and approaches in distant hybridization in horticultural crop improvement.

- Rajasekharan, P. E. and Ganeshan, S. - Pollen cryopreservation for distant hybridization.

- Ravishankar, H**.,** Murthy, B. N. S. and Anuradha Sane - Genetic improvement of passion fruit (*Passiflora edulis* Sims.) for key economic traits.

- Senthil Kumar, R., Tripathi, P. C., Sankar, V. and Karunakaran, G. - Preliminary study on inter-generic hybridization between *Carica papaya* and *Vasconcellea cauliflora* at high altitude and high rainfall Kodagu region of Karnataka.

- Sudha Mysore - Prospects, opportunities & concerns for commercialization of hybrids.

- Sukanya, D. H. - Hybridizing genetically distant wild and cultivated types for crop improvement in ashwagandha (*Withania somnifera* Dunal).

- Sunil Gowda, D., Vasugi, C., Dinesh, M. R., Krishna Reddy, M. and Shivshankara, K. S. - Genetical studies in intergeneric progenies of papaya.

- Tripathi, P. C., Senthil Kumar, R., Sankar, V. and Karunakaran, G. - Wide hybridization in citrus for development of resistant rootstocks for biotic stress.

- Vasugi, C., Dinesh, M. R. and Rajasekharan, P. E. - Conservation of nuclear gene of *Vasconcellea* in papaya breeding.

- Vasugi, C., Lichamo and Krishna Reddy, M. - Further studies on overcoming the intergeneric crossing berries in papaya improvement.

62. Third National Agri-Festival (Agri-Fiesta' 2015), RARS, KAU, Ambalavayal, Kerala, January 27, 2015.

- Karunakaran, G., Tripathi, P. C., Sakthivel, T., Sankar, V., Thiruganavel, A. and Senthil Kumar, R. - Commercial potential of new generation fruit crops

63. Innovative Insect Management Approaches for Sustainable Agro Ecosystem, Agricultural College, TNAU, Madurai, January 27-30, 2015.

- Ganga Visalakshy, P. N., Darshana, C. N., Swathi, C., Krishnamoorthy, A. and Pillai, G. K. - Antagonistic effect of entomopathogen fungi *Metarhizium anisopliae* (IIHR strain) against plant pathogens *Colletotrichum gloeosporioides, Pestalotia mangeferae* and *Botrydiplodia threobranae*.

- Ganga Visalakshy, P. N., Swathi, C. and Darshana, C. N. - Evaluation of different media and methods of cultivation on the production of entamo pathogen *Baeuveria bassiana.*

- Sudhagar, S., Reddy, P. V. R., Nagalakshmi, G. and Varun Rajan, V. - Investigations on the endosymbionts in the gut of Indian honey bee, *Apiscerana* F. populations using 16S rRNA gene region.

64. National Symposium on Advances in Phytopathological Research in Globalized Era with Reference to Eastern Region, University Department of Botany, Ranchi University, January 29-30, 2015.

- Srinivas, P. - Bioprospecting of agriculturally important microorganisms for disease management and plant growth promotion.

65. National Symposium on Biotechnology and Molecular Biology for Industry and the Common Man, St. Aloysius College, Mangaluru, January 29-31, 2015.

- Pious Thomas - Do bacterial endophytes transmit vertically through seeds?

- Usharani, T. R., Sunisha, Sowmya and Poovarasan - Standardization of transformation protocol in pomegranate cv Bhagwa with GUS reporter gene.

66. National Symposium on Challenges and Management Approaches for Crop Diseases of National Importance organized by Indian Society of Mycology & Plant Pathology and TNAU, Madurai, February 12 -14, 2015.

- Saxena, A. K., Rathnamma, K., Thilaka Rani, R. and Shashank, S. - Influence of weather factors on black banded disease in mango.

67. International Conference on Technical Interventions in Agricultural Sciences for Enhanced Productivity, Nutritional Quality and Value Addition, Central Institute of Horticulture, Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India, Medziphema, Dimapur, Nagaland, February 17-19, 2015.

- Senthil Kumaran, G. - Machinery for mushroom cultivation and spawn production.
- Meera Pandey - Potential of mushroom technology in NER region.

68. Eastern Zone Regional Agriculture Fair, Patna, February 19-21, 2015.

- Tiwari, R. B. - Post-harvest technologies of horticultural crops.

69. International Symposium on Commercial Floriculture and Landscape Gardening for Urban and Peri-Urban Horticulture, Chandigarh, February 21-22, 2015.

- Sumangala, H. P. - Sustainable development of urban and peri-urban horticulture with special reference to landscape gardening for environmental services.

70. National Meeting on New/Safer Molecules and Bio Control Technologies for Integrated Pest Management in Crops, Karnataka Veterinary Council, Bengaluru, February 23, 2015.

- Sridhar, V. - New molecules for IRM in horticultural crops.

71. National Seminar on Recent Trends in Plant Sciences, Department of Botany, Andhra University, February 26-27, 2015.

- Akella Vani - RNAi in combating plant pathogens.

72. ISSP South Zonal Seminar on Crop Physiology-Emerging Challenges and Opportunities for Sustainable Agriculture, S. V. Agricultural College, Tirupati, March 03, 2015.

- Bhanuprakash, K., Umesh, H., Rajatha, K. D. and Shuba, A. C. - Seed quality appraisal towards sustainable agriculture.

73. National Conference on Emerging Tends in Agrinanotechnology (Agri Nano 2015), Tirupathi, Andhra Pradesh, March 11-13, 2015.

- Naveena, N. L., Saroja, S. and Ranganath, H. R. - Insects and nano science: an intimacy.

74. National Conference on Enzyme Research in Agriculture, Food and Industrial Biotechnology, Department of Biochemistry, March 12-13, 2015.

- Usharani, T. R., Sunisha, C., Meenakshi, Poovarasan, Sowmya, H. D. and Udaykumar, T. U. - Expression of sweet pepper ferredoxin-i protein and its efficacy to inhibit xanthomonas *in vitro*.

75. International Conference on Dynamics of Technology for Quality Production of Banana, organized by Jain Irrigation Systems Ltd. and Confederation of Horticultural Associations of India, Jalgaon, March 16- 17, 2015.

- Narayana, C. K. - Handling of fresh banana for export and product diversification.

76. National Symposium on Understanding Host-Pathogen Interaction through Science of Omics, organized by ICAR-Indian Institute of Spices Research, Calicut, Kerala and Indian Phytopathological Society, Calicut, Kerala, March 16-17, 2015.

- Srinivas, P. and Singh, H. S. - Bioprospecting of microorganisms from horticultural cropping systems for their antibiotic and phosphate solubilising activities.
- Krishna Reddy, M. - Phylogeography and molecular evolution of begomoviruses infecting okra.
- Gopalakrishnan, C. - Induction of systemic resistance by rhizobacteria in tomato against bacterial wilt caused by *Ralstonia solanacearum* E.F. Smith (Yabuuchi *et al*.).

77. VAARTAA-An Agriculture Meet, organized by TATA Steel, Gopalpur, Odisha, March 18-19, 2015.

- Bharathi, L. K. - Improved cultivars of vegetables and nursery rising.

78. The VII International Workshop on Management of the Diamondback Moth and other Crucifer Pests, Bengaluru, March 23-27, 2015.

- Onkar Naik, S., Sridhar, V., Jayashankar, M. and Chkravarthy, A. K. - Synergistic effect of oils on the bioefficacy of flubendiamide and indoxacarb against diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) on cabbage.

- Sridhar, V. and Chakravarthy, A. K. - Management of diamondback moth, *Plutella xyxostella* (L.) (Lepidoptera: Plutellidae) on cabbage.

79. Review Meeting of IIHR- North East Program at ICAR, Research Complex, Barapani, Shillong, March 24, 2015.

- Panneerselvam, P. - ICAR-IIHR microbial inoculants technology for North Eastern States.

- Aghora, T. S. - DUS guidelines in vegetable crops.

- Aghora, T. S. - Vegetable varieties and technologies suitable for NEH region.

80. Joint Rajbhasha Scientific Seminar, CSIR-IMMT, Bhubaneswar, March 27, 2015.

- Deepa Samant -Branch bending for enhancing productivity in guava.

14. Symposia/Seminars/Other Events

The Institute at Hesaraghatta, Bengaluru, its Regional Stations and Krishi Vigyan Kendras organized a good number of conferences/seminars/symposia/workshops/ meetings and many other events of importance, the details of which are given below.

14.1. Conferences / Seminars / Symposia Meetings

Review Meeting of 4th NABMGR

The Institute hosted the meeting of Directors of all institutes under the Horticulture Science Division (SMD) of ICAR, New Delhi convened by DDG (HS), ICAR, New Delhi on May 30, 2014 at its campus to review the action taken on the recommendations made for horticulture during the 4th NABMGR meeting held at NBAII & IIHR, Bengaluru. Dr. Rekha Choudhary representing NBPGR, New Delhi gave a brief presentation about the mandate of the National Advisory Board on Management of Genetic Resources.

Dr. N. K. Krishna Kumar, DDG (Hort.Sci.), ICAR, New Delhi addressing the participants presented issues related to horticultural plant genetic resources and informed that XII plan EFC of Crop Science Division has allocated Rs.1.5 crores to establish clonal repositories for horticultural crops in CITH, Srinagar and NBPGR, Hyderabad. Regarding collections of germplasm from outside India, he appreciated the efforts by the pomegranate breeder/curator at IIHR, Bengaluru in introducing 132 accessions through NBPGR and appealed to all the institutes under Horticulture Division to collaborate with NBPGR to collect germplasm from outside India and solicited proposals for introducing trait specific PGR for processing with other ministries. He also requested NBPGR to identify one person exclusively for each crop linking with one nodal PGR scientist at each institute. Institute wise action taken report on the recommendations of the 4th meeting of NABMGR held during October 2013 was discussed with the Directors of the respective institutes and finalized for presentation at the 5th NABMGR meeting to be held at NBPGR, New Delhi on June 16-17, 2014. A total of 22 horticultural research institutes under the Horticulture SMD of ICAR participated in the review meeting

DDG (Hort. Sc.), ICAR, New Delhi conducting the Meeting

Review Meeting of DUS Workers

The Institute organized Review meeting of all DUS workers to discuss administrative and scientific matters related to DUS testing in horticultural crops under the Chairmanship of Dr. T. Manjunatha Rao, Director at IIHR, Bengaluru on June 12, 2014. The meeting was attended by Dr. R.R. Hanchinal, Chairperson, PPV & FRA, New Delhi, Dr. R.C. Agrawal, Registrar General, PPV & FRA, New Delhi and Dr. K. Madhavi Reddy, Dr. T.H. Singh, Dr. N. Mohan, Dr. T.S. Aghora, Dr. B. Varalakshmi, Dr. M. Pitchaimuthu, Dr. E.S. Rao, Dr. M.R. Dinesh, Dr. BNS Murthy, Dr. Sampath Kumar, Dr. Vasugi, Dr. C. Ashwath, Dr. Lakshman Reddy, Dr. Meenakshi Srinivas, Dr.Tejswini, Dr. Dhananjaya and Sujatha Nair from IIHR, Bengaluru.

National Seminar cum Workshop on Strategies for Improvement, Enhancing Productivity and Utilization of Cucurbits

The Central Horticultural Experiment Station, Bhubaneswar and Society for Promotion of Horticulture, IIHR, Bengaluru organized a National Seminar cum Workshop on Strategies for Improvement, Enhancing Productivity and Utilization of Cucurbits during August 08-10, 2014 at Bhubaneswar. Shri Pradeep Kumar Maharathy, Hon'ble Minister for Agriculture, Fisheries and Animal Husbandry, Government of Odisha inaugurated the Seminar. Dr. Manoranjan Kar, Vice Chancellor, OUAT, Bhubaneswar delivered the Key note address. Shri S. K. Chadha, Director, Directorate of Horticulture, Govt. of Odisha was a special invitee. Three progressive successful farmers, each from Telangana, Maharashtra and Odisha States were

felicitated by the Hon'ble Minister. An exhibition on 'Cucurbits: Progress & Prospects' was organized depicting wide range of diversity available in Indian cucurbits and their commercial potential for post-harvest utilization. More than 200 delegates representing scientists from ICAR institutes and State Agricultural/Horticultural Universities, developmental personnel from state departments, representatives from private sector, students and farmers from nine states and 26 institutions participated in the deliberations.

Dr. N. K. Krishna Kumar, DDG (Hort. Sc.), ICAR, New Delhi chaired the plenary session on August 10, 2014. Dr. T. Janaki Ram, ADG (Hort.), ICAR, New Delhi co-chaired the Session. Concluding the Seminar, Dr. N. K. Krishna Kumar said that in coming years all the recommendations emerging out of this seminar be implemented in veracity and the review of the same would be taken up in the next follow up seminar after 2-3 years.

DDG (Hort. Sc.), ICAR, New Delhi interacting with the participants in the plenary session

Launching of Consortium Research Platform on Borers

The Institute organized launching program of the project on 'Consortium Research Platform (CRP) on Borers', sanctioned in the XII five year plan period on August 18, 2014 at its campus. Dr. N. K. Krishna Kumar, DDG (Hort. Sci.), ICAR, New Delhi was the Chief Guest. Launching the program, Dr. Krishna Kumar emphasized that borers, owing to their cryptic feeding habit, pose a challenge to develop effective management strategies and hence there is a need to address certain basic gaps in species identification, bio-ecology, host shift patterns and called upon all participating institutes to contribute effectively to come out with measurable output in the form of quality publications and technologies. A technical Bulletin entitled "Borer Pests: Status and Challenges" was released on the occasion. A Web Portal on Borers was also launched on the occasion. The launching program was attended by about 50 scientists representing all the participating centers of the platform. The consortium has 31 centers spread across the country representing ICAR Institutes, State Agricultural Universities and Coffee Board with IIHR, Bengaluru as the Lead center. The centers would address about 50 borers in about 37 crops including fruits, vegetables, flower crops and plantation crops and also has a center to work on pulse borers. The launching program was followed by a two day workshop and finalized technical program for the entire period of the program.

Technical bulletin entitled "Borer Pests: Status and Challenges" being released

Interactive Meeting on Plant Variety Protection and Participatory Research Appraisal in Ornamental Crops

The Institute organized an Interactive Meeting on Plant Variety Protection and Participatory Research Appraisal in Ornamental Crops at its campus on August 22, 2014 involving all the stake holders of floriculture industry. Legal experts, researchers, floriculture consultants, growers and exporters, members of International Flower Auction, LTD. Bengaluru (IFAB) and South India Floriculture Association (SIFA) participated in the discussion.

Apart from creating awareness about the Protection of Plant Varieties and Farmers' Rights Act and its implications on floriculture industry, many topics like 'royalty issues and legal impact on flower crops for domestic and export market', 'the present ground realities of floriculture industry in India *visa vis* the other leading countries in floriculture industry' *etc.* were presented for the benefit of the participants. Many researchable issues, production challenges faced by the industry, collaboration between research institutes, state agricultural/horticultural universities, development departments and the floriculture industry, planting material, marketing and export *etc.* were discussed in the Meeting. Prof. Ramakrishna, Centre for Intellectual Property Research and Advocacy, National Law School of India University,

Dr. T. Manjunatha Rao conducting the delibarations

Bengaluru, Mr. Pranav Kumar Mysore, Senior Associate, K&S Partners; a company of Intellectually Property Attorneys, Bengaluru, Mr. Anne Ramesh, SIFA President and Director of IFAB, Mr. Venkat Rao, MD, Iris Biotech, Mr. V. H. Prasad, Director, Blooms & Greens Pvt. Ltd. and Director, IFAB, Mr. Sridhar Chowdhary, MD, Vinayaka Agritech Ltd., Mr. Robert de Bos, Director, Plants First, Bengalureu and Dr. Tilak Subbaiah, Floriculture Consultant from the industry and scientists from IIHR, Bengaluru and other ICAR research institutes participated in the deliberations. Dr. T. Manjunatha Rao, Head, Division of Ornamental Crops, and Director, IIHR, Bengaluru Chaired and presided over the deliberations.

Brain Storming Session on Insecticide Resistance Management in Horticultural Crops – Way Forward!

IIHR, Bengaluru and the Association for Advancement of Pest Management in Horticultural Ecosystems, Bengaluru jointly organized a brain storming session on 'Insecticide Resistance Management in Horticultural Crops – Way Forward!' at its campus on August 30, 2014. Sixty five participants comprising of researchers from different ICAR institutes and State Agricultural Universities, representatives from private sector and students participated in the deliberations.

Dr. K. R. Kranthi, Director, CICR, Nagpur delivered the key note address on the overview of insecticide resistance in arthropods with special reference to cotton bollworms and *Bt* cotton. Dr. B. V. Patil, former the Vice Chancellor, UAS, Raichur emphasized the role of young researchers in educating the farmers. Dr. T. Manjunatha Rao, Director, IIHR, Bengaluru presided over the Session. The Brain storming was conducted in four sessions, *viz*., Chemical interventions for IRM, *Bt* crops/Molecular genetics, IPM and IRM – New molecules: Industries and farmers perspectives. Dr. Irani Mukerjee, IARI, New Delhi, Dr. B.V. Patil, UAS, Raichur, Dr. N. Srinivasa, GKVK, Bengaluru, Dr. K. S. Mohan, Monsanto, Bengaluru, Dr. G.M.V. Prasada Rao, ANGRAU, Guntur, Dr. T. Venkatesan, M. Mani, Mrs. Gandhi Gracy and Dr. M. Mohan from NBAII, Bengaluru and Dr. Debi Sharma, Mrs. D. Lokeshwari, Dr. S. Sriram, Dr. V. Sridhar, and Dr. M. R. Hegde from IIHR, Bengaluru were the resource persons who made presentations on various topics. The house deliberated on various issues of concern and emerged out with many recommendations for follow up.

The brain storming session in progress

Seminar on Status and Scope of Mechanization in Horticulture

The CHES, Bhubaneswar organized a seminar on 'Status and Scope of Mechanization in Horticulture' on September 02, 2014. More than 100 farmers from various villages, faculties and experts from ICAR institutes, OUAT, Bhubaneswar, NHB, NGO functionaries and students participated in the seminar. Inaugurating the event Prof. Manoranjan Kar, Vice Chancellor, OUAT, Bhubaneswar highlighted the importance of mechanization especially in fruit crops to enhance efficiency and productivity and called upon the farming community to use feasible tools and implements. Dr. S. K. Chadha, Director, Directorate of Horticulture, Govt. of Odisha, the Guest of Honour assured all possible support from the Directorate of Horticulture to the farming community through various schemes. Dr. Neelum Grewal, Director, DRWA, Bhubaneswar put forth the problems faced by women farmers in the farm activities and felt the need of women centric tools and implements for enhancing their efficiency. A compendium on 'Mechanization in Horticulture' was released on the occasion. Various presentations were made in three sessions on tools, implements and machinery developed by ICAR institutes, OUAT, Bhubaneswar, AICRP on Fruits and CIAF, Bhopal. Women friendly farm tools and implements, schemes of Directorate of Horticulture and National Horticulture Board were also highlighted. An exhibition on farm machinery, tools and implements was also organized with the participation of ICAR institutes and private agencies. A prototype of power tiller mounted fertilizer application device for perennial trees (CHES FERTREE Drill) designed by CHES, Bhubaneswar was inaugurated on the occasion.

A compendium on mechanization of horticulture being released during the Seminar

Brain Storming Session on Nematodes Problems under Protected Cultivation

The IIHR, Bengaluru and the AICRP on Nematodes organized a brain storming session on 'Nematodes problems under protected cultivation' at its campus on September 08, 2014. Dr. R. K. Jain, Project Coordinator, AICRP on Nematodes, Dr. P. Parvata Reddy, former Director, IIHR, Bengaluru, Dr. Uma Rao, Head, Division of Nematology, IARI, New Delhi, Dr. Basavaraj, Executive Director, Karnataka State Horticulture Mission, Dr. A. Chakravarty, Head and Dr. M. S. Rao, Principal Scientist, Division of Entomology and Nematology, IIHR, Bengaluru, Dr. Dhal Singh, Deputy Director, NHB, Bengaluru, delegates from Department of Horticulture of Punjab, Karnataka, Maharashtra, Haryana, Delhi, Tamil Nadu and Kerala states, scientists from various ICAR Institutions, SAUs and KVKs participated in the meeting. Dr. R. K. Jain, Dr. P. Parvata Reddy and Dr. Uma Rao addressed the gathering and explained the need for testing the soil before preparation of the beds in the polyhouses and suggested the farmers to use certain safe chemicals, bio-nematicides/ bio-pesticides along with organic materials *viz.,* vermicompost, FYM, neem/pongamia cakes during the bed preparation. Dr. M. S. Rao suggested the dosages and appropriate methods of use of bio-pesticides and certain chemicals for the integrated management of nematodes. Farmers shared their success stories of management of nematodes in their polyhouses by adopting the technologies developed at IIHR, Bengaluru. During the plenary session, officials from KVKs, departments of horticulture, ICAR institutes, SAUs and all the farmers interacted with the nematologists which resulted in drafting of various recommendations for management of nematode problem. More than 145 delegates participated in the deliberations.

Dr. R. K. Jain addressing the brainstorming inaugural session

Asian Solanaceous Round Table 2014 (ASRT 2014)

The Asia Pacific Seed Association (APSA), Thailand; an association of private seed companies, IIHR, Bengaluru and Society for Promotion of Horticulture (SPH), Bengaluru jointly organized a round table meet 'Asian Solanaceous Round Table (ASRT) – 2014' with the theme 'Disease and Insect Pest Resistance in Solanaceous Vegetables: Successes and Challenges' on September 09 - 10, 2014 at Bengaluru. The main objective of ASRT was to bring together researchers of high caliber in the areas of genetics and breeding, pathology, molecular biology and other areas on a common platform, identifying research needs that are major stumbling blocks in production of tomato and chilli, analyze market needs and trends, address issues for the benefit of farmers and strengthen public-private sector partnerships in the Asia-Pacific region. Sadguru Uday Singh, Chairman & Managing Director, Namdhari Seeds, Bengaluru inaugurated the Meet on September 09, 2014 and addressed the gathering. Dr. G. Kalloo, formerly DDG (Hort.) ICAR, New Delhi gave the opening remarks and Dr. N.K. Krishna Kumar, DDG (Hort. Sci.), ICAR, New Delhi delivered the Keynote address on 'Insect resistance using native genes in tomato and pepper: an entomologist's perspective on successes and challenges'. Dr. T. Manjunatha Rao, Director, IIHR, Bengaluru presided over. The inaugural session was followed by technical sessions which included presentations by 23 internationally renowned speakers followed by presentation of country reports from India, Thailand and Southeast Asia, China, Japan and

Inaugural session of ASRT 2014

Korea. Drs. Dani Zamir, The Hebrew University of Jerusalem, Israel, Roland Schafleitner, AVRDC – The World Vegetable Center, Taiwan, Maarten A. Jongsma, Plant Research International, Wageningen University, The Netherlands, Shelly Praveen, IARI, New Delhi, India, S. K. Tikoo, Global Leader (Tomato), Tierra Seeds, Hyderabad, N. Anand, Director Research, Namadhari Seeds Pvt. Ltd., Bengaluru, A.T. Sadashiva, IIHR, Bengaluru, M.S. Dhaliwal, Dept. Vegetable Science, PAU, Ludhiana, S. Nirmala Devi, KAU, Trichur, Kerala, Byoung Cheorl Kang, Seoul National University, Seoul, Korea, Lindsay Wyatt and Michael Mazourek, Cornell University, Ithaca, New York, USA, Manash Chatterjee, Bench Bio, Mumbai, Channarong Seepiban, BIOTEC, Thailand, K. Madhavi Reddy, IIHR, Bengaluru, S.K. Jindal, Dept. Vegetable Science, PAU, Ludhiana, Piyush Gupta, Verdenta Seeds, Kurukshetra, Haryana, H.C. Prasanna, IIVR, Varanasi, V.G. Malathi, TNAU, Coimbatore, M. Krishna Reddy, IIHR, Bengaluru, Peter Hanson, AVRDC – The World Vegetable Center, Taiwan *etc.* were some of the important resource persons, who made presentations on various topics. A field visit to the vegetable demonstration block of IIHR, Hesaraghatta, Bengaluru was also organized on September 11, 2014 for the benefit of the delegates. More than 250 researchers from seed companies, government organisations and research institutes in the Asia Pacific region involved in research on solanaceous vegetable crops participated in the deliberations.

Launching Program on Micronutrient Management in Horticultural Crops

The Institute organized launching program of a new initiative on 'Micronutrient management in horticultural crops' along with two other new initiative programs on 'Protected horticulture' and 'ORP on sucking pests' sanctioned in the XII five year plan period on September 10, 2014 at its campus. Dr. N.K. Krishna Kumar, DDG (Hort. Sci.), ICAR, New Delhi, Dr. T. Manjunatha Rao, Director, IIHR, Bengaluru, Dr. A. N. Ganeshamurthy, Dr. M. Prabhakar , Dr. Asokan, the Principal Investigators, Co-Investigators from the participating centers and other scientific staff from the Institute participated in the program. Separate technical sessions for each new initiatives were conducted. All the participating centers presented their technical programs. A detailed technical program for the entire period of the project was drawn including training for farmers and KVK's. An Extension Folder on Arka microbial consortium for sustainable vegetable production published, and a website on Micronutrient Management in Horticultural crops developed by the Institute were released/launched on the occasion

Launching program of projects on micronutrient management and protected horticultural

National Workshop/XXII Group Meeting of AICRP on Medicinal, Aromatic Plants and Betelvine

Indian Institute of Horticultural Research, Bengaluru and Directorate of Medicinal and Aromatic Plants Research, Anand organized the National Workshop XXII Group Meeting of AICRP on Medicinal, Aromatic Plants and Betelvine at IIHR, Bengaluru during September 17-20, 2014. The inaugural program of the Group Meeting was held on September 18, 2014 under the Chairmanship of Dr. Manjunatha Rao, Director, IIHR, Bengaluru. Dr. D. L. Maheshwar, Vice Chancellor, UHS, Bagalkot was the Chief Guest and Padmasree Darshan Sankar**,** Chairman, I-AIM, Bengaluru, Dr. S. K. Malhotra, ADG(Hort.), ICAR, New Delhi and Dr. S. B. Dandin, Formarly the Vice Chancellor, UHS, Bagalkot were the Guests of Honour on the Occasion. Inaugurating the Group Meeting and addressing the gathering Dr. Maheshwar gave a an account of development programs taken up by the state departments and also Govt. of India to promote cultivation of medicinal and aromatic crops and called upon collaborative programs between ICAR institutes and State Agricultural/ Horticultural universities. Padmasree Prof. Darshan Sankar, Dr. S. K. Malhotra and Dr. S. B. Dandin also spoke on the occasion. Dr. Jitendra Kumar, Project Coordinator, AICRP on MAP&B and Director, Directorate of Medicinal and Aromatic Plants, Anand presented the progress report of AICRP Project. An extension bulletin on 'Herbs for household', an extension folder on 'Ashwagandha- an ancient medicinal herb' and proceedings of 'National Meet on Betelvine – Farmers Traders and Researchers, Interface' held at IIHR, Bengaluru during February 22-23, 2014 were released during the Group Meeting and an exhibition on Medicinal and Aromatic plants was also organized on the occasion.

Dr. Krishna Kumar DDG (Hort. Sci.), ICAR, New Delhi presided over the Plenary Session on September 19, 2014. Addressing the participants Dr. Krishna Kumar said that more emphasis may be given for conservation of genetic resources and domestication,

and work on increasing the active principles in these crops and non- chemical management of pest and diseases in medicinal and aromatic plants may be intensified. Progress of work under the project of all the AICRP centers during the last year was reviewed and technical program for the coming year was formulated. During the three days deliberations, apart from identifying Isabgol- DPO 1 for release, many technologies in crop production in Asalio (*Lepidium sativum* L.), Long pepper (*Piper longum*), Mandukaparni (*Centella asiatica*), Makoi (*Solanum nigrum*, Neel (*Indigofera tinctoria*), Asparagus (*Asparagus racemosus*) and Tulsi (*Ocimum sanctum)* were also identified for various regions for inclusion in production technologies.

Publications being released on the occasion of AICRP meeting on medicinal and aromatic plants

National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits

The ICAR-IIHR-Central Horticultural Experiment Station, Chettalli and the Society for Promotion of Horticulture (SPH), Bengaluru organized National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits at Chettalli, Kodagu, Karnataka on December 01-03, 2014. Dr. T. Janakiram, ADG (Horticulture), ICAR, New Delhi inaugurated the Seminar. Addressing the delegates Dr. Janakiram emphasized on conservation and utilization of these less known fruits for food and nutritional security of the common people and expressed that a Centre of Excellence for Underutilized Fruits be started to provide momentum to the research and development of on these crops which are called future fruits. Dr. T. Manjunatha Rao, Director, IIHR, Bengaluru presided over the inaugural session. Dr. V.A. Parathasarthy, National Co-coordinator for UNDP-TFT Project present on the dais emphasized the role of underutilized fruits and tree spices in the livelihood security of rural and tribal people. Dr. N.A. Prakash, Dean, College of Forestry, Ponnampet also spoke on the occasion. During this three days seminar, technical sessions on status, PGR, production, protection, utilization, marketing, value addition *etc.* were conducted. More than 25 lead papers and 125 posters presentation were made during the seminar. Dr. V.A. Parathasarthy, National Co-coordinator for UNDP-TFT Project, Dr S.K. Sharma, Director, CIAH, Bikaner , Dr P.L. Saroj, Director, DCR Puttur, Dr H. Ravisankar, Former Director, CISH, Lucknow, Dr. Vishal Nath, Director , NRC Litchi Muzzafarpur, Dr. P. Chowdappa, Director, CPCRI, Kasaragod, Dr Ramanath Rao, Bioversity International, Dr. N. Kumar, Former Dean, TNAU, Coimbatore, Dr. B.C. Uthaiah, Ex Dean College of Forestry, Ponnampet, Dr B.C. Deka Joint Director, ICAR - NEH, Barapani, Dr G.S. Pandey, Director, Agriculture, Andaman & Nicobar, Dr M.R. Dinesh , Head, Division of Fruits, IIHR, Bengaluru were among the lead speakers. Scientists, entrepreneurs, students *etc*. from ICAR institutes, SAUs, KVKs and other Govt. and Non - Govt. organizations from across the country associated with underutilized fruits and more than 500 farmers from Karnataka, Tamil Nadu, Maharashtra and Kerala participated in the Seminar. An exhibition was also organized on the occasion, inaugurated by Dr. T. Janakiram. Many ICAR Institutes, Research Station, KVKs, CHES, IISR, DCR, DASD, UNDP TFT Project, Spices board, Coffee board other research institutes participated in the exhibition and displayed their achievements and technologies. Three farmers who are maintaining and utilizing underutilized fruits were given certificate of appreciation on the occasion.

Dr. T. Janakiram inaugurating the exhibition

Steering Committee Meeting on Technology Demonstration Component of NICRA Project

The Steering Committee Meeting on "Technology Demonstration Component (TDC) of NICRA Project" was conducted at Krishi Vigyan Kendra, Hirehalli, Tumkuru district on October 10, 2014.

Dr. L.B. Naik, Principal Scientist, Section of Seed Science & Technology, Member of NICRA-TDC and formerly the In-charge Head, CHES, Hirehalli under whose leadership the project started gave a brief introduction of the project and its past achievements.

Dr. Loganandhan, N., Programme Co-ordinator, KVK Hirehalli gave an account of the progress of the project till to date under the guidance of Zonal Project Directorate, Zone VIII Bengaluru. Officials from the different line departments and few NGOs invited for the meeting, offered their suggestions for effective implementation of various programs under the project in the ensuing season. A total of 18 official, nonofficial, special invitees and Subject Matter Specialists of KVK participated in the meeting. A field visit to NICRA Village D. Naganehalli, Koratagere, Tumkuru district where all the technological interventions of NICRA are demonstrated was organized for Steering Committee Members. Dr. Sreenivas Reddy, Principal Scientist, ZPD, Zone VIII, Bengaluru, appreciated the accomplishments of KVK, Hirehalli in transferring the need based technologies to the farmers of the NICRA village and also acknowledged the support extended by the host institute for overall development of the D. Nagenahalli, a Model village under NICRA.

Visit of the steering committee to D. Nagenahalli

46th Scientific Advisory Committee (SAC) Meeting of KVK, Gonikoppal

The Krishi Vigyan Kendra, Gonikoppal, Kodagu conducted the 46th SAC meeting on October 21, 2014 under the Chairmanship of Dr. T. Manjunatha Rao, Director, Indian Institute of Horticulture Research, Bengaluru. Dr. Saju George, Program Coordinator presented the progress report for the year 2013-14 and plan of work for the forthcoming season. . Dr. B. T. Rayudu, Principal Scientist, ZPD, Bengaluru in his remarks appreciated the efforts of KVK in transferring need based technologies to the farming community of the Kodagu very effectively. Dr. V. V. Sulladmath, Principal Scientist, Division of fruit crops, Dr. L. B. Naik, Principal Scientist, Section of Seed Science technology, Dr. M. V. Dhananjaya, Principal Scientist, Division of Ornamental crops from IIHR, Bengaluru, Dr. P. C. Tripathi. Principal Scientist and Head, CHES, Chettalli, Dr. Loganandan, Programme Coordinator, KVK, Hirehalli, Dr. G. Karunakaran, Senior Scientist, CHES, Hirehalli and Mr.Arun Balamatti, Programme Coordinator, JSS KVK, Mysore present in the meeting offered their valuable suggestions. Presiding over the meeting, Dr. T. Manjunatha Rao appreciated the initiatives and efforts of faculty of KVK in overall development and dissemination of the need based technologies for the benefit of the farming community of the district. The KVK website www.kvkkodagu.org was launched and a technical bulletin on "Activities of ATMA-A KVK experience" was released on this occasion.

Technical bulletin on Activities of ATMA- A KVK experience being released

An exhibitions depicting different technological products produced in the KVK instructional farm were displayed for the benefit of the participants. Apart from the members and guests a total of 45 official, non-official, special invitees and progressive farmers and the Subject Matter Specialists of KVK participated in the meeting.

Interaction Meet on Emerging Pests and Diseases of Horticulture Based Cropping Systems in Eastern India

The IIHR-CHES, Bhubaneswar and the Applied Zoologists Research Association (AZRA), Bhubaneswar organised an Interaction Meet of Plant Protection Workers on "Emerging Pests and Diseases of Horticulture Based Cropping Systems in Eastern India" on November 17, 2014 at the station. Dr B K Mishra, Dean, OUAT, Bhubaneswar, Dr Anand Prakash, Secretary, AZRA, Dr R. S. Mishra, Head, RC-CTCRI and Dr. H. S. Singh, Head, CHES, Bhubaneswar shared their views about the threat of emerging pests and diseases in horticulture production system. More than 50 participants from CRRI Cuttack, DRWA Bhubaneswar, NCIPM Bhubaneswar, OUAT Bhubaneswar, RC-CTCRI Bhubaneswar, CHES, Bhubaneswar and various KVKs in Odisha participated in the Interactive Meet.

The Interaction Meet in progress

2nd Task Force Meeting for Validation of DUS Test Guidelines

The Second meeting of the Task Force for validation of DUS test guidelines for China aster, jasmine, tuberose, papaya and custard apple was organized during October 07-08, 2014 at IIHR, Hessaraghatta Bengaluru. Dr. R.R. Hanchinal, Chairperson of the PPV &FRA, New Delhi chaired the meeting Co-chaired by Dr. T. Manjunatha Rao, Director, IIHR, Bengaluru. Dr. Manoj Srivastava, Registrar (Field Crops) and Dr. Tejbir Singh, Registrar (Horticulture) were also present in the meeting. On October 07, 2014, draft guidelines of China aster, jasmine and tuberose were presented by Dr. Rajiv Kumar, Dr. M. Ganga and Dr. T. Usha Bharathi, respectively. Dr. M. Jawaharlal, Dr. M. Kannan and Dr. M. Ganga from TNAU, Coimbatore, Dr. S.M. Katwate from NARP, Pune and Dr. C. Kameshwar Rao, Bengaluru also attended the meeting. On October 08, 2014, draft guidelines of papaya and custard apple were presented by Dr. C. Vasugi and Dr. P. Sampat Kumar, respectively. Dr. C.P.A. Iyer, former Director, CISH, Lucknow, Dr. Suryanantha Sundaram and Dr. N. Kumar from TNAU, Coimbatore, Dr. M.R. Dhinesh, Head, Division of Fruit Crops, and all the scientists of the Division of Fruit Crops, IIHR, Bengaluru also attended the meeting on October 08, 2014.

14.2. Other Events

Mango Diversity Fair

The Institute organized a Mango diversity Fair under the UNEP-GEF Project on Conservation and Sustainable Use of Cultivated & Wild Tropical Fruit Diversity: Promoting Sustainable Livelihoods, Food Security and Ecosystem Services, at its campus on June 03, 2014. Dr. Srinath Dikshit, Zonal Co-ordinator, Transfer of Technology, Bengaluru was the Chief Guest and Dr. S. B. Dandin, Former Vice Chancellor and Dr. B. Raju, Vice Chancellor (Acting),

Dr. B. Raju felicitating custodian farmers

UHS, Bagalkot were the Guests of Honour. Dr. Manjunath Rao, Director (A), IIHR, Bengaluru presided over the event. Work done under the project were presented by Dr. M.R. Dinesh for Chittoor site, Dr. Vasudev for Sirsi site and Dr. S.K. Singh for Pusa site. Dr. B. Raju felicitated five farmers as "custodians of genetic diversity" for maintaining indigenous mango varieties in their orchard. Dr. Lingaiah, Dean, Post Graduare and Research Center, Bengaluru campus, UHS, Bagalkot released flyers titled, `Traditional practices of mango growing at Chittoor' and 'Indigenous varieties of mango' brought out on this occasion.

Dr. Srinath Dikshit inaugurated Mango Diversity Fair arranged on this occasion. More than 300 unique varieties maintained by the Division of Fruit Crops, IIHR, Bengaluru were exhibited. One hundred and sixty indigenous varieties *viz.,* Appemidi, suitable for pickling from the Western Ghat region were also displayed. In addition, certain coloured indigenous varieties and value added products of mango were also displayed by six KVKs and NGO representatives. An interaction meeting between the farmers and scientists was also organized in which problems faced by the farmers in the production of quality mango fruits were dealt with. School children also visited the exhibition and showed keen interest in the mango diversity.

ICAR Foundation Day Celebration

The Institute celebrated 86th ICAR Foundation Day on July 16, 2014 by organizing Foundation Day Guest Lecture by Dr. S. V. Hithalamani, formerly Additional Director of Horticulture, Govt. of Karnataka, Bengaluru. Addressing the gathering, Dr. Hittalamani narrated the overall progress of horticulture andresearch and contribution of IIHR, Bengaluru. He lauded the services of stalwarts who contributed their mite in modernizing horticulture in Karnataka state and highlighted the growth of horticulture in Karnataka which gave impetus to the overall development of horticulture in the country. Dr. T. Manjunatha Rao, Director IIHR, Bengaluru presiding over the function highlighed IIHR technologies, guidelines and vision of IIHR. An exhibition displaying the activities, achievements and technologies developed by the Institute was organized for the benefit of the visiting public, particularly the farmers. More than 250 visitors comprising of high school and pre-university college students, teachers, farmers from Tumakuru, Kolar, Chikkaballapur and Bengaluru Rural districts and all the staff members of IIHR, Bengaluru participated in the celebration. Three innovative farmers *viz.,* Smt. Saroja, tomato grower, Shri K. Sreenivasa Gowda, mango grower from Chintamani and Shri Siddharthan, floriculturist, from

Tamil Nadu were felicitated on the occasion. Director, IIHR also felicitated Dr. Hittalamni for his yeomen service to the horticulture sector in Karnataka state. Licensing and Exchange of MoU with entrepreneurs through BPD and ITM & CPC Unit of IIHR, Bengaluru for commercialization of the technologies developed by the Institute was also organized on the occasion. Fifty farmers of NICRA project village were felicitated by giving 'Smart Farmer Certificates'.

Director, IIHR felicitating an innovative farmer

The Central Horticultural Experiment Stations at Bhubaneswar, Chettalli and Hirehalii and KVKs at Gonikoppal and Hirehalli also celebrated ICAR Foundation Day in a befitting manner by organizing various farmer friendly programs.

DG, ICAR Inaugurates Flower Seed Unit

Dr. S. Ayyappan, Secretary, DARE, Govt. of India and Director General, ICAR, New Delhi inaugurated the Flower Seed Unit at IIHR, Bengaluru, on August 16, 2014. Dr. N. K. Krishna Kumar, Deputy Director General (Hort. Sci.), ICAR, New Delhi and Dr. R. K. Jain, Dean

Director General, ICAR inaugurating the flower seed unit

and Joint Director, IARI, New Delhi, Dr. T. Manjunatha Rao, Director, IIHR, Bengaluru and Head, Division of Ornamental Crops, scientists and technical staff members of the Division of Ornamental Crops and other staff members of the Institute were present on the occasion. The basic objectives of the Flower Seed Unit are to produce quality seed and planting material of various flower crops *viz*., rose, gladiolus, tube rose, carnation, China aster, chrysanthemum and crossandra and evolving standards for seed and planting materials of flower crops. The Flower Seed Unit would cater to the needs of flower growers, gardeners, and urban landscapers of genuine and quality seed and planting materials of flower crops round the year at affordable cost. The flower seed unit is built under the financial assistance of RKVY project of Govt. of Karnataka at cost of Rs.30.00 lakhs.

Communal Harmony Fortnight

In commemoration of Communal Harmony Fortnight observed during August 20 - September 05, 2014, the CHES, Bhubaneswar organized a program on August 26, 2014 at the Station. Re. Bharma Kumari Geeta, Bhrama Kumari Vishwa Vidyalaya, Bhubaneswar was the Chief Guest and lead speaker on the occasion. Dr. Bani Singh, Deputy Director, National Horticulture Board, Bhubaneswar was the Guest of Honour. Re. Bharma Kumari Geeta delivered an extensive sermon on the principles of harmony in one's life and cited real life instances and examples to impress upon the audience to practice the principle of 'forgive and forget', the essence of communal harmony. Dr. H S Singh, Head, CHES, Bhubaneswar presided over the function.

Institute Foundation Day Celebration

The Institute celebrated its 48th Institute Foundation Day on September 05, 2014. Padmashree Dr. Kishan Lal Chadha, Formerly Deputy Director General (Hort.), ICAR and President, The Horticultural Society of India, New Delhi was the Chief Guest and delivered the first Dr. G. S. Randhawa Memorial Foundation Day Lecture. Dr. T. Manjunatha Rao, Director, IIHR, Bengaluru presided over the function. Recognizing the contributions made by some of the retired staff members, the Institute felicitated Dr. R. Palaniappan, Shri J. S. Rao, Shri S. K. Ramakrishna Rao, Shri K. N. Ananthapadma-nabhan, Shri C.

Dr. K. L. Chadha delivering the foundation day lecture

Krishnappa, Shri Doddathimmaiah, Shri V. R. Kulkarni, Shri N Nagarajaiah, Shri M. Hanumantharayappa, Shri H. Thimmappa, Shri H. N. Rajanna and Shri Chikkamarasiddiah which has been a tradition of the Institute. Two progressive farmers, Shri Babu Reddy and Shri N. C. Patel who have adopted and transferred/popularized the technologies developed by the Institute were also honoured on the occasion. Awards of Excellence instituted for the staff members were presented on the occasion to Dr. Sudhamoy Mandal from scientific category, Dr. B. L. Kashinath, Shri, Somasekhar and N. Shivarudraiah from technical category, Shri R. Gopal from administrative category and Shri Channarayappa from supporting category for the year 2014. Winners of various sports events conducted as a part of Foundation Day celebration for the staff members of the Institute were also given prizes on the occasion. A common lunch for the Guests and all the staff members was organized in the afternoon followed by light entertainment program performed by the staff members.

5th Scientific Advisory Committee (SAC) Meeting of KVK, Hirehalli

The Krishi Vigyan Kendra, Hirehalli conducted the 5th SAC meeting under the Chairmanship of Dr. T. Manjunatha Rao, Director, IIHR, Bengaluru on September 30, 2014. Dr. N. Loganandhan, Program Coordinator of KVK presented the progress report for the year 2013-14 and plan of work for the forthcoming season. Appreciating the initiatives and efforts of KVK in overall development and dissemination of the need based technologies for the benefit of farming community of the district, Dr. Manjunatha Rao emphasized on the importance of farm mechanization in the present agricultural scenario. The KVK website - www.iihrkvk.org - was launched by Dr. Manjunatha Rao. Dr. Raghavendra Bhatta, Director, NIANP, Bengaluru a Special Invitee on the occasion, released the updated brochure on KVK, Hirehalli. An exhibitions was also organized on the occasion depicting different technological products produced in the KVK for the benefit of the participants. Dr. M. R. Hegde, Dr. L. B. Naik and Dr. Tejaswani from IIHR, Bengaluru, Dr. G. S. Karibasappa and Dr. G. Karunakaran from CHES, Hirehalli, Dr. Saju George, Programme Coordinator, KVK, Gonikoppal, Dr. Sukanaya, Programme Coordinator, KVK Konehalli, Tiptur, and Dr. B. T. Rayudu, and Dr. Sairam from ZPD, Bengaluru, officials from the different line departments, NGOs, NABARD, lead banks and progressive farmers participated in the meeting.

Launching of Swachh Bharat Mission

Responding to the nationwide call given by Honorable Prime Minister of India for the Swachh Bharat Mission in commemoration of birth anniversary of Mahatma Gandhi ji, the father of the Nation, the ICAR-Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru launched Swachh Bharat Mission on October 02, 2014. All the staff members of the Institute attended the office on October 02, 2014 and took Cleanliness Oath (Swachh Sapath) in Hindi and English administered by Dr. T. Manjunatha Rao, Director of the Institute. Addressing the staff members Dr. T. Manjunatha Rao appealed to practice the mission of Swachh Bharat in letter and spirit in their offices, their homes and their surroundings and also motivate their family members, friends and relatives and neighbors to achieve the dream of clean India. To create awareness about the ill effects of wet waste and dry waste on human health and environment and utilization of the solid waste generated in the day to day life of the

Shri C. Basavaiah delivering the guest lecture

civilians for the wellbeing of the human kind, a guest lecture by Shri C. Basavaiah, formerly the Managing Director, Karnataka Compost Development Corporation, Bengaluru was organized on the topic 'Municipal solid waste management made easy' followed by screening of a short film on the success story of Solid waste management by a citizens' society in Bengaluru for the benefit of the staff members. Later the staff members voluntarily attended cleaning of inside and outside the Institute premises.

The Central Horticultural Experiment Stations at Bhubaneswar, Chettalli and Hirehalli and Krishi Vigyan Kendras at Gonikoppal and Hirehallii also launched the Swachh Bharat Mission on October 2, 2014. All the regional Stations and KVKs were kept open on the day and functioned as usual. The respective Heads of the stations and the KVKs administered the Swachh Sapath (Cleanliness Oath) in Hindi and also in the regional languages to the staff members of their

respective stations at 9.45 a. m. Later on the staff members of the Stations and KVKs took part in mass cleaning of the inside /outside premises of the office, farm and the surroundings. Banners and hoardings depicting the message of Swachh Bharat Mission were displayed in the campus of the respective stations to create awareness and motivate the staff members and also the general public visiting the stations for clean and prosperous India

The staff members of CHES, Bhubaneswar cleaning the campus.

ICAR South Zone Sports Meet

The ICAR- Indian Institute of Horticultural Research, Hesraghatta hosted the ICAR South Zone Sports Meet at Sree Kanteerava Stadium Bengaluru during October 13-17, 2015. The five days tournament brought together nearly 745 athletes from 25 institutes to compete in 18 sports events. Mr. C. Ramesh Arjuna Award Winner and formerly Captain of National Kabaddi team, was the Chief Guest, inaugurated and declared the Meet open on October 13, 2015. Dr. T Manjunatha Rao, Director, IIHR, Bengaluru presided over the inaugural session. Officials from State Sports Associations of respective games and athletics conducted the events as per schedule.

Competitions were held for men in athletic events 100, 200, 400, 800 & 1500 m races, Relay (100x4) and Cycle Race (5000 m), Long jump, High jump, Shot put, Javelin and Discus Throw and games, Volley ball (Shooting) Volley ball (Smashing), Kabaddi, Badminton, Basketball, Table-Tennis, Football, Carrom, Chess and for women in Badminton (Singles & Doubles), Table Tennis (Singles & Doubles), Long Jump, High Jump, Discus throw, Javelin throw, shot-put, Races 100 & 200 m, Carrom, Chess in the five day sports meet. IIHR, Bengaluru bagged the overall Champions for the fourth consecutive time with 74 points. The Sports Meet was concluded on October 17, 2015. Ms. Rosa Kutty, two times Olympian and an Arjuna Award winner was the Chief Guest on the occasion who distributed the prizes to the winners of the events

The victorious IIHR Sport contingent with Dr. G.S. Randhawa memorial overall champion's Trophy with Ms. Rosa Kutty

Cutting-edge Lecture Series

The Institute organized "Cutting-edge lecture series in insect physiology, toxicology and RNAi for pest management" on December 09-10, 2014. Dr. Palli Subba Reddy, insect physiologist, University of Kentucky, US made presentations on various topics. About 60 scientists, research scholars from different ICAR institutes and Agricultural University in Bengaluru attended the lecture. Role of next generation technologies in pest management: approaches and opportunities, Role of RNAi in pest management, Applications of genomics and functional genomics technologies in insecticide resistance management, GM crops in pest management and Exciting opportunities for students and early career scientists were discussed during the event.

Union Minister for Agriculture visits Yelahanka Farm of the Institute

Shri Radha Mohan Singh, Hon'ble Union Minister for Agriculture and President , ICAR, New Delhi visited Yelahanka Farm IIHR, Bengaluru on January 9, 2015. An exhibition was arranged on the occasion showcasing the varieties and technologies developed

The Union Ministers interacting with scientists

by the Institute including display of seed and planting material. The Union Minister was accompanied by Shri D.V. Sadananda Gowda, Hon'ble Union Minister for Law & Justice, GOI, Shri S.R. Vishwanath, Hon'ble Member of Legislative Assembly, Karnataka, and Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR, New Delhi. The Union Minister and other accompanying guests interacted with the Director and Heads of the Divisions on the activities and achievements of the Institute and also about the impact made by the varieties/hybrids and technologies developed by the Institute. Commenting on the extent of coverage of these technologies in the farmers' field and their adoption, the Union Minister stressed the need for reaching the unreached in extensive and professional manner. Shri D.V. Sadananda Gowda, Hon'ble Union Minister for Law & Justice, GOI, mentioned about the effective linkage between the Institute and State Government, which has helped in the spread of technology and emphasized on better marketing facilities for the horticulture produce.

National Science Day

The Institute at Hesaraghatta observed the 'National Science Day' February 28, 2015 to commemorate the invention of 'Raman Effect' by the Great Indian Physicist Sir CV Raman which brought him the prestigious 'Nobel Prize'. The Institute was declared open for the school students on the day to sensitize them about innovations of ICAR-IIHR in the field of horticulture science. The schools in and around Hesaraghatta were informed and invited for the programme. Students from nine schools visited the Institute. The students were briefed about the activities and achievements of the Institute in the field of horticulture. The students were taken to different labs and demonstration plots. More than 500 students visited the Institute and got benefitted.

Visit of Parliamentary Standing Committee on Agriculture

The ICAR-Indian Institute of Horticultural Research (IIHR) organized the visit of the Parliamentary Standing Committee on Agriculture, comprising of 12 Members from Loksabha, four Members form Rajyasabha, officers from Ministry of Agriculture, GOI and officers from ICAR, New Delhi under the Chairmanship of Honourable Shri Hukum Deo Narayaya Yadav to Bengaluru on February 02-03, 2015. The committee had discussions with various state departments on agriculture and allied sectors in the country on February 02, 2015.

The Committee visited ICAR-Indian Institute of Horticultural Research (IIHR), Hesaraghatta, Bengaluru on February 03, 2015. An exhibition

Shri Hukum Deo Narayan Yadav addressing during his visit to IIHR, Bengaluru

depicting the achievements and success stories of technologies developed by the Institute was organized for the benefit of the visiting delegation.Grape Special; a micronutrient formulation, a red fleshed soft seeded guava hybrid selection 'Arka Rashmi', a high yielding and yellow vein mosaic virus resistant French bean variety 'Arka Arjun' and a high yielding marigold variety 'Arka Bangara' were released on the occasion. The Committee visited various labs and demonstration fields. The Committee under the Chairmanship of Honorable Shri Hukum Deo Narayaya Yadav had informal discussion with the Director and senior Officers of the Institute and Assistant Director General (Hort.), ICAR, New Delhi on the programs and progress of the ongoing research activities and appreciated the Institute for its excellent research work in the field of horticulture.

Group photo of the Parliamentary Standing Committee with Director, IIHR

15. Women Empowerment

15.1. Research

15.1.1. Gender Mainstreaming in Horticulture

Gender is the socially constructed role designated to men and women. Systematic study on mainstreaming gender in agriculture will result in pragmatic strategies for appropriate policy decisions. With this aim, a research project on 'Gender Mainstreaming in Horticulture' is being implemented. As a part of this study, the time utilization and decision making pattern of horticulture farmers were studied. Primary data was collected from 120 respondents (horticultural workers and their spouse) and analysed. Following were the findings.

- Most of the women respondents spent more number of man days/year in horticultural activities, where drudgery is involved, implying the need for drudgery reducing machinery in horticulture.
- Women respondents were not involved in taking horticulture related decisions alone.
- Most of the respondents perceived that field preparation, harvesting, carrying fertilizer and harvested crops, seed treatment and use of various kinds of implements involved drudgery.
- The correlation analysis implied that personal characteristics such as age, education, risk orientation and achievement motivation were significantly but negatively correlated whereas, land holding, annual income and innovativeness were positively and significantly correlated with time utilization among male respondents. In case of female respondents, personal characteristics such as age and education were significantly but negatively correlated, while, land holding and annual income were significantly and positively correlated with time utilization.
- Family education status among male and cosmopoliteness among female respondents were significant with respect to decision making in horticulture.

Based on the results of the study, it can be concluded that reducing gender-based constraints, improving social dynamics and facilitating environment where women can thrive are keys to success in gender mainstreaming.

15.1.2. Skill Development

In order to bring women into the mainstream of agriculture and rural development, various interventions were introduced. Women Interest Groups were formed to technically empower women (1174), for whom 19 off and on-campus trainings and demonstrations were organized on product development from dried mushroom and incorporation of mushrooms in daily diet, use of dried flower technology for income generation, establishment of kitchen garden, use of drudgery reducing implements, grafting technique in propagation of fruit crops and use of fruit fly traps. The knowledge gain by the participants is presented below.

Rural women (135) were also imparted training on the

Knowledge gain by Women Interest Groups

Theme	Mean	SD	't' value
Use of ready to fruit bags and methods of value addition	5.39	5.10	14.32**
Use of dried flower technology	11.4	2.11	42.98**
Use of drudgery reducing tools/ equipments	8.48	2.31	35.29**

** significant at 1%

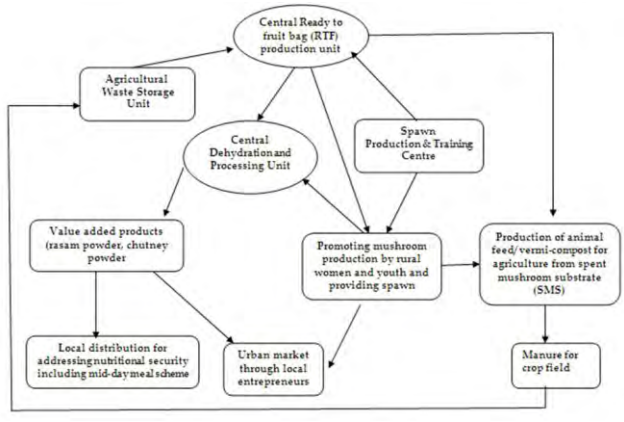
nutritional and cultivation aspects of oyster mushrooms. Each woman was given ready to fruit bags to cultivate mushrooms in a very short period and use the mushrooms as nutritional supplement and for income generation. This has led to better awareness about the usage of mushrooms and its health benefits among the rural population of the adjoining villages and the demand for the purchase of ready to fruit bags is on the rise. As a result, a total of 405 Ready to Fruit (RTF) bags were distributed to the women to grow mushrooms at home, whereas 1300 RTF bags were purchased by these rural women to continue mushroom production after the training.

Mushroom training for rural women

15.1.3. A Model for Sustainable Village-level Production and Utilization of Mushroom

Mushroom is a versatile crop. It is being utilized for food/medicine, bridging the protein gap among vegetarians and tackling malnutrition, creating self-employment especially for women and develop rural–urban agricultural network. Based on the research and development experience on mushroom production technology, IIHR, Bengaluru has developed a model, by which the agricultural wastes generated at the village level can be recycled through mushroom cultivation. This model aims to create self-employment among unemployed youth, women in the village, address environmental pollution and help enhance nutrition among the village population. The model consists of the following steps:

- ❖ Collection and storage of agricultural waste.
- ❖ Establishment of a central mushroom spawn (seed) storage and training unit.
- ❖ Establishment of a central substrate preparation, sterilization, inoculation and incubation centre.
- ❖ Establishment of a central dehydration and processing unit.
- ❖ Distribution of the fully grown ready to fruit (RTF) bags to the village women, unemployed youth to grow mushroom at home.
- ❖ Sale of the fresh and dry mushroom for mid-day meals in village schools.
- ❖ Use of dry mushrooms to make value added products like mushroom rasam powder, mushroom chutney powder etc., as nutritious diet at village and/or sale in the urban market.
- ❖ Use of the spent mushroom substrate (SMS) generated after mushroom cultivation as animal feed or converted into vermi-compost which can be used as organic manure for the agricultural fields.



Model for Sustainable Village-level Production and Utilization of Mushroom

15.1.4. Drudgery Reduction

Twin Wheel Hoe Weeder

It was observed that manual weeding is done by small and marginal farm women. Hand tools are used for weeding, which results in hand pain, back pain and leg pain apart from being time consuming and labour intensive. To address this issue, Twin Wheel Hoe Weeder from Central Institute of Agricultural Engineering (CIAE), Bhopal was brought for demonstration. It is a manually operated equipment for weeding and inter-culture in upland row crops in black soil region. Use of the weeder was demonstrated among the women labours. The feedback was collected for further refinement. The weeder was re-fabricated as per the felt needs and distributed to the respondents. The feedback received from the respondents clearly indicated that the weeder was effective in reducing the drudgery experienced by them by using hand tools. The overall field capacity was observed 0.08- 0.1 ha/ day. Time spent on weeding was reduced from 300 man days/ha to 180 man days/ha/ quarter.

Women-Operated Onion Seeder

A women-operated onion seeder was fabricated based on the felt needs of farm women, in which the seed chambers were made of plastic boxes mounted on nickel chromium plated tube, a MS frame, two plastic wheels and a handle made out of PVC pipe. Such seeders were introduced at Bagepalli village, Chelur (Hobli), Bagepalli (Taluk). The farm women operated the seeder with ease on an area of three acres. It was assessed that about 50 % labour, time and seeds were saved compared to broadcasting method of onion sowing.

Women operated onion seeder

15.1.5. Development of Bio-agent and Mycorrhiza Colonized Seedlings of Horticultural Crops by Rural Women

A protocol for production of mycorrhizal and bio-agent colonized seedlings of horticultural crops *viz.,* capsicum, cauliflower, cabbage and papaya *etc.,* was standardized. The protocol was imparted to 1125 women farmers through conducting 15 skill development programs in Karnataka and Tamil Nadu in collaboration with KVK, Adanahalli (GKVK, Bengaluru), KVK Sirsi, KVK Hirehalli, University of Agricultural and Horticultural Sciences Shimoga, Karnataka and KVK Thoraiyur, Tamil Nadu. Non-Governmental Organizations (NGOs) *viz.,* Centre for Natural Biological Resources and Community Development (CNBRCD), Hoskote, Karnataka, Organic Farmers Association and Marketing Agency (OFAMA) and HOPE – Foundation for Innovative Research, Science and Technology (HOPE-FIRST) actively participated in the training programmes.

15.1.6. Ensuring Livelihood Security of Farm Women through Appropriate Horticulture Innovations

Baseline survey was conducted to study the profile and information needs of the farm women in Tumkur and Chikkaballapur districts of Karnataka. Based on the needs, the technologies developed by IIHR, Bengaluru in beans, tomato, chilli, okra, amaranthus, button mushroom, tuberose, drumstick, ridge gourd and neem soap, pongamia soap, microbial consortium, vegetable special and seed kits were introduced among the farm women beneficiaries (205).

15.2. Awareness Programs

15.2.1. International Women's Day

The Institute at Hesaraghatta celebrated 'International Women's Day' on March 10, 2015. Dr T Manjunatha Rao, Director, presided over the function. Smt. H. G. Vijaya Kumari, 53rd Additional District Judge, City Civil Court, Bengaluru was the Chief Guest. Smt. B. G. Rama, 51st Additional District Judge, City Civil Court, Bengaluru, Smt. C. R. Geetha, Police Inspector, Vigilance, BESCOM, Bengaluru, Smt. Rama Devi, Senior Advocate, City Civil Court, Bengaluru and Smt. Geetha Rani, Superintendent, Department of Horticulture, Lalbagh, Bengaluru were the Guests of Honour on the occasion. All the women staff members of the Institute including the women casual labours participated in the event. Dr. T. Manjunatha Rao, presiding over the event mentioned about the important role of woman in her family and emphasized on women education that intern will benefit family and society at large. The woman achievers of IIHR, Hesaragahtta, Bengaluru were felicitated on the occasion. There was an interaction session between resource persons and the audience, which was followed by cultural programmes. In the beginning, Dr. Girija Ganeshan, Chairman, Woman Cell of the Institute welcomed the guests and the participants.

15.2.2. Women in Agriculture Day

At IIHR, Hesaraghatta, Bengaluru

'Women in Agriculture Day' was observed at IIHR, Hesaraghatta, Bengaluru on December 12, 2014. Dr. T. Manjunatha Rao, Director of the Institute presided over the function. Mrs. Chaya Nanjappa, Nectar Fresh Honey, Bengaluru, Dr. Geetha Suresh, Novel Biotech, Bengaluru and Mrs. Susheelamma, Sumangali Sevashram, Bengaluru were invited as Guests of Honour. All the women employees of the Institute participated in the program. Presiding over the program, Dr. T. Manjunatha Rao mentioned that a family can be empowered, if a woman becomes an entrepreneur and reiterated the need for women empowerment in research as well as in development sector.

Mushroom spawn bags were distributed to farm woman to popularize how farm waste could be utilized in remunerative way. During the post noon session

Director, IIHR distributing mushroom spawn bags.

presentations on few technologies developed by the Institute were made by the women scientists of the Institute *viz.,* 'Contribution to Horticulture', Dry Flower Arrangements' 'Processing and Handling of Horticultural Produce' and 'Financial Assistance to Farm Women'.by Central Bank of India, IIHR, Hesaraghatta Branch, Bengaluru. A quiz competition was organized for all the staff members of the Institute and farm women.

At CHES, Bhubaneshwar

The Central Horticultural Experiment Station (CHES), Bhubaneswar also celebrated "Women in Agriculture Day on December 4, 2014. Dr. Neelam Grewal, Director, Directorate of Research on Women in Agriculture (DRWA), Bhubaneswar was the Chief Guest and inaugurated the program. Dr. (Mrs.) Meena Senapati, Director, Centre for Plant Tissue culture and Bhubaneswar and Mrs. Anupama Raut, Joint Endeavour for Emancipation and Tribal Awareness (JEETA) – Land Entitlement for Tribal Women, Deogarh, Odisha were the Guests of Honour. All the staff members, students and women farmers from near by villages of Bhubaneswar participated in the program.

Dr. H. S. Singh welcoming the guests

16. Tribal Sub Plan and NEH Program

16.1. Tribal Sub-plan

16.1.1. Promotion of horticulture for tribal livelihood in the tribal belts of Bhubaneswar under tribal sub-plan on promotion of horticulture

In 32 tribal dominated gram panchayats (Kashipur, Talajhiri, Chandragiri, Sunger, Mainkancha, Hadigura and Manusagaon, Gajapati and Rayagada) horticultural interventions were made under the Tribal Sub plan project of CHES, Bhubaneswar. Training-cum-demonstration programs were conducted. The interventions at the station included distribution of critical inputs like fertilizers, micronutrients, farm tools, tree pruner, sprayers, portable fruit analysis equipment, *etc.* among 750 beneficiaries to disseminate the suitable technologies and to make the cultivation more profitable. These interventions have increased the income of the tribal farmers considerably. Nurseries were established by the tribal youth after getting hands-on training at Rayagada.

In Gajapati district (Gudisahi, Kendupada, Sanakhani, Denlakhani, Anlaguda, Mallipadar, and Kanteikoli), demonstration of backyard nutritional gardens for nutritional security and supplementary income for tribal households, commercial cultivation of cucurbit crops, production of quality planting material for regional self-sustainability for planting material, value addition of raw jack fruits through minimal processing and packaging and capacity building of rural youth and women folk were taken up. Two hundred fifty farmers of six villages have been provided with seed kits for backyard kitchen gardening and two training have been conducted.

Tribal youth raising mango nursery

Training programs conducted under TSP

S. N.	Date	Sponsoring agency	Topic	No. of Participants
1	1st September, 2014	CHES, Bhubaneswar	Canopy management and INM in mango	30
2	29th Dec 2014	CHES, Bhubaneswar	Horticultural interventions for enhancing tribal livelihood at Mohna block of Gajapati district, Odisha.	88
3	13th Feb 2015	CHES, Bhubaneswar	Skill augmentation of the tribal farm women for minimal processing of raw jackfruits for vegetable purpose for self-help groups of Mohna block of Gajapati, Odisha.	30
4	9th March 2015	CHES, Bhubaneswar	Skill augmentation of the tribal farmers on backyard kitchen gardening and commercial cultivation of cucurbits for the different villages of Mohna block of Gajapati of Odisha.	35
5	12th March, 2015	HARPAL, a tribal NGO of Kashipur and CHES, Bhubaneswar	Mango production technology	30

One day training programme on "Horticultural interventions for enhancing tribal livelihood" on

One day training programme on "Mango Production Technology" on March 12, 2015

16.1.2. Skill Up-gradation and Input Distribution Programs for Tribal Farmers at CHES, Chettalli

Under the project on Tribal Sub plan the CHES Chettalli has taken up skill up-gradation training programme and input distribution to the tribal farmers of the region. The Station organized 20 off campus trainings and one on-farm training-cum-demonstration on various aspects of horticulture for skill upgradation of tribal farmer in four villages of Kodagu district of Karnataka. Scientific methodologies of fruit, vegetable cultivation, poultry and piggery management, mushroom cultivation were explained along with practical demonstrations. Inputs like poultry chicks, poultry feed, poultry rearing cages, poultry medicines, vegetable seed kits, protrays, coir pith media, water cans, sprayers, mango grafts, coffee seedlings, amla grafts, drumstick seedlings, pepper cuttings and fertilizers were distributed to all the beneficiaries of these villages. Four hundred participants from 142 tribal families participated in these training programs.

Tribal farmers training at CHES, Chettalli

The CHES, Chettalli and KVK, Gonikoppa jointly organized a meeting-cum-workshop at KVK, Gonikoppal on August 04, 2014 in which more than 30 tribal beneficiaries, scientists from CHES, Chettallii and KVK, Gonikoppa, and official from Forest College and Research Institute, Ponnampet participated and analyzed the importance of these livelihood programs and formulated action plan.

Training programs on nursery management were conducted at the CHES Chettalli on 5th and 8th November 05 and 08, 2014. Twenty trainees from Awaregunda and Basavanahalli villages underwent training on basics of nursery management like preparation of soil mixtures, filling in bags, planting and propagation methods and maintenance aspects were explained in detail. Practical exposures of all nursery practices were also given to the trainees. The details of multiplication of Coorg mandarin and other fruit crops through budding and grafting were also explained and demonstrated. Inputs like nursery shade nets, coir pith blocks, polythene bags, fertilizers and mother plants of black pepper cv. Panniyur-1 were provided to all the trainees to start nursery activities in their respective villages.

The CHES, Chettalli organized aTribal Mela at a tribal village, Avaregunda on March 24, 2015 to create awareness about the various technologies developed by IIHR, Bengaluru and CHES, Chettalli and motivated the tribal farmers to adopt new technologies. Various aspects on cultivation of fruits, vegetables, nursery production and fruit preservation were explained to the tribal farmers.

Tribal Mela at Avaregunda

16.2. NEH Program

The Institute as lead centre obtained a project on North Eastern Hill (NEH) region program in horticulture. Under this program, more than 250 trainings/ demonstrations of sustainable technologies developed by the Institute were conducted on the respective aspects in nine North Eastern states by KVKs located in the respective districts and NASTEC institute.

Some of the local varieties of mushroom were collected and conserved in the mushroom laboratory at IIHR, Bengaluru. Two training programs on mushroom cultivation were conducted at KVK, Dimapur and KVK, Senapati.

Mushroom training at NEH region

The Institute is supplementing the horticulture accomplishments of NEH region through many externally aided projects exclusively for NEH states.

Development of sustainable formulation using indigenous strains of NE India for crop improvement: A combined holistic approach (DBT)

Potential strains from IBSD effective against nematodes have been identified and evaluated for their bio-efficacy and a liquid consortia formulation with IBSD strains *viz., Pseudom-onas fluorescens* (P-137), *Bacillus subtilis* (P-203) and *Trichoderma viride* (T-20) was developed.

Popularization and dissemination of technology of bio-pesticide formulations among poor and marginal farmers of North East Region (DST)

- Promising native bacterial strains of *Bacillus subtilis, Bacillus megaterium* and *Pseudomonas putida* were identified based on their bio-efficacy tests under *in vivo* and *in vitro* conditions. Cell free culture filtrates showed 94.65% and 96.26% reduction in egg hatching and 91.26% and 92.92% in root-knot nematode juvenile mortality by *B. subtilis* and *B. megaterium,* respectively.
- Liquid bio-agent formulation, DST NER MIRACLE (Consortium of *B. subtilis* (N-06), *B. megaterium* (N-41) and *Pseudomonas putida* (N-13) a liquid consortia formulation of native efficient strains was developed.
- An experiment was conducted under protected conditions by applying bio-pesticides enriched FYM in the field. Capsicum seeds (var: Orobelle) were treated with NER biopesticide formulations at 20 ml/kg seed and sown in portrays filled with substrate (cocopeat) enriched with biopesticides at 10 ml/kg. In the main field, 5 tons of Farm Yard Manure (FYM) enriched with 5 kg of *B. subtilis* or *B. megaterium* or *P. putida*s train or combi-formulation of three strains was applied per hectare. After 180 days, significantly higher yields were recorded for *B. subtilis, B. megaterium, P. putida* strain treated combi-formulation treated plots (59, 61, 65 and 71 tonnes/ha, respectively) compared to untreated control (42 t/ha).

Distribution of bio-pesticides in Meghalaya, Nagaland and Assam by IIHR, NEHU and NASTAC

- Bio-pesticide formulations of *Trichoderma viride, Trichoderma harzianum, Pochonia chlamydosporia, Paecilomyces lilacinus, Bacillus megaterium, Pseudomonas fluorescens* from indigenous strains of North East and mass produced by IIHR and IIHR accredited Industries. These bio-pesticide products were distributed to respective North East Stations (NASTAC-Nagaland, NEHU-Meghalaya and AAU-Assam). Training programs and field demonstrations were conducted among the local farmers of Meghalaya, Nagaland and Assam and bio-pesticide formulations were distributed to the farmers. About 600 poor and marginal farmers were educated on the use of bio-pesticides and their delivery systems for oranges, large cardamom, Naga chilly, ginger, turmeric, potato, tomato, cabbage, rice, *etc*.

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 2014-15.

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 07-01-2014, 28-06-2014, 28-08-2014, and 31-12-2014 respectively.

Hindi Workshops

The Institute organised the following Hindi Workshops during 2014-15

- A table workshop on "Work in Hindi easily?" was conducted on 11.06.2014 for the staff members Establishment Section.
- A Hindi workshop on "How to install Unicode?" was conducted on 29.09.2014 for the staff members of Administration.
- A Hindi table workshop on "Noting & Drafting" was conducted on 29.09.2014.

Hindi Training

- Hindi Pragya training is being organized at the Institute for the staff members of the Institute during July-November 2014 with the cooperation of Central Hindi Training Sub-Institute, Bengaluru.

Hindi Week Celebration

The Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru observed Hindi Saptah during September, 15-23, 2014. Various competitions viz., Hindi Recitation, Hindi Reading, Hindi Terminology and Noting, Handwriting, Hindi Conservation, Hindi Song and Pre-written Hindi Essay, Debate were organized for the benefit of the staff members of the Institute.

Dr. Aditya Shukla, Lead Scientist, ITC Life Science & Technology Centre, Bengaluru inaugurated the Hindi

Dr. Aditya Shukla inaugurating Hindi Week

Saptah on September 15, 2014. Vol. V of the Official Language Magazine 'Bagwani' was released on this occasion. The Hindi Saptah was concluded on September 23, 2014 with Dr. Vijaya Mallik, Rtd. Sr. Hindi Officer, Central Power Research Institute, Bengaluru as the Chief Guest and Dr.Feroz Khan, Head, Central Inland Fisheries Research Institute, Bengaluru as Guest of Honour, who distributed prizes to winners of various competitions organised.

National Seminar on Hindi

A National Seminar in Hindi was organized at IIHR on "Khadya evam Poshan Suraksha Mein Krishi Vigyan evam Proudyogiki Ki Bhumika (Role of Agricultural Science and Technology in Food and Nutritional Security)" during 04-05th June 2014 with an objective to encourage and promote the scientists and other officials of different ICAR institutes for writing and presenting scientific papers in Hindi.

The inaugural function was organized on June 04,2014 under the Chairmanship of Dr. T. Manjunath Rao, Director (Acting), IIHR. Prof. Anand Das Gupta, Indian Institute of Plantation Management, Bangalore was the Chief Guest. On this occasion, a technical bulletin in Hindi, entitled, 'I I H R Utkrishtatha Ki Or' was released by the Chief Guest and other dignitaries.

A total of 30 papers were presented in five sessions during the seminar. Apart from the scientists of IIHR, scientists and technicians from different ICAR institutes viz., Indian Agricultural Research Institute, New Delhi, Directorate of Groundnut Research, Junagarh, Gujarat, Central Institute for Cotton Research, Nagpur, Maharashtra, Central Island

Inauguration of the seminar by lighting the lamp

Agricultural Research Institute, Port Blair, Indian Institute of Spices Research, Calicut, Kerala, Central Research Institute for Dry land Agriculture, Hyderabad, Central Inland Fisheries Research Institute, Bangalore, Krishi Vigyan Kendra, Hirehalli and also from Indian Space Research Organization, Bangalore were participated in the seminar.

During the seminar 10 best paper awards were distributed for the papers presented in different sessions.

Valedictory function of the seminar was held on June 05,2014 under the chairmanship of Dr.M. Krishna Reddy, Director I/C, IIHR. Dr. Krishna Reddy distributed best paper awards and certificates to the participants.

Hindi Publications

- Official Language Magazine "Bagwani" Vol. V
- IIHR Annual Report 2013-14 (Hindi)
- IIHR Utkrishthatha Ki Or (Hindi)

E-Compendiums

E-Compendiums have been prepared in Hindi for following training programmes conducted at the Institute:

- Training programme organized for the farmers of Manipur during 17-22 June 2014 on "Post harvest processing of fruits and vegetables".
- Training programme organized for the farmers of Chalisgaon and Bodwad during 02-06 September 2014 on "Importance of fruit and vegetable crops".
- Training programme organized for the farmers of Ranchi, Jharkhand during 20-23 October 2014 on "Improved production technology of horticultural crops".
- Training programme organized for the farmers of Assam during 24th February to 01 March 2015 on "Advancement in important vegetable, fruit and ornamental crops".

Hindi Incentive Scheme

- Hindi incentive scheme was implemented at the Institute for working in Hindi originally and during the year out of the total 11 participants 02 secured first, 03 secured second and 06 secured third prizes. The prizes and certificates for the participants were distributed during the valedictory function of Hindi Week Celebration.

Award

- ICAR-IIHR, Bengaluru received the First Prize of "Rajarshi Tondon Rajbhasha Award" from Indian Council of Agriclture Research, New Delhi for the year 2012-13 among the institutes located in 'C' regions for the excellent contribution in the use of Hindi in official work. The award has been received in the month of April 2014.

17.2. CHES, Chettalli

Hindi Workshop

A Hindi workshop was organized at CHES, Chettalli on July 8, 2014 . Dr. R.B. Tiwari, Principal Scientist, Shri, A.K. Jagdeeshan Assistant Director, Official Language, Indian Institute of Horticultural Research , Bengaluru were the chief guests for the workshop. All Scientific, administrative and technical staff of CHES, Chettalli and Head, Krishi Vigyan Kendra, Gonikoppal and Scientists of Coffee Research Sub Station, Chettalli participated in the workshop. Dr. P. C. Tripathi, Head CHES Chettalli highlighted the importance of Hindi in day to day life. He thanked Shri, A.K. Jagdeesan Assistant Director (OL), IIHR, Bengaluru for conducting Hindi workshop at the CHES, Chettalli for increasing the knowledge of Hindi of the staff. Shri A. K. Jagdeesan, Assistant Director (Official Language), IIHR, Bengaluru gave orientation to the staff of CHES, Chettalli about the use of Hindi and the constitutional position of Hindi and implementation procedures of official Language, use of Hindi on computers Hindi typing and Hindi Software. During the programme, Dr. R.B. Tiwari spoke about Hindi speaking and conversation in a very simple and effective way. Certificates were distributed to all the participants.

Hindi Week Celebration

Hindi Week was celebrated at CHES Chettalli during September 15-20, 2014. Dr. P.C. Tripathi, Principal

Inauguration of Hindi Week

Scientist and Head of this Station inaugurated the Hindi Saptah programme. During Hindi week various competitions various *viz.,* dictation in Hindi, identification of things, Hindi meanings, copy writing, poem reading and description of an object in Hindi, picture description were organized for the staff. The valedictory function was held on 20 September 2014. Smt. Shanthalaxmi Principal, Degree College, Bettadapura , Kushal Nagar and Shri.N.S. Tiwari Lecturer Hindi Sainik School Kudige were the invitee guests for the function. Smt. Nageena Bhanu, Hindi teacher, Mookambica High School, Kushalnagar was the judge for various competitions. The guests and other speakers emphasized on the importance of Hindi week celebration and role of Hindi in day to day life. Prizes were distributed to the successful participants by the guests.

17.3. CHES, Bhubaneswar

Second Quarterly Meeting

Central Horticultural Experiment Station organized quarterly meeting (April-June) of Hindi Cell on 30th June, 2014 under the Chairmanship of the Dr. T. Manjunatha Rao, Director, Indian Institute of Horticultural Research, Bengaluru Dr. Deepa Samant, Chairperson, Hindi Cell presented the agenda items for discussion. Detailed deliberations were held on the use of official language at the centre. Mrs. Suvasini Pradhan, Personal assistant and Mr. Banshidhar Mohapatra, AF&AO presented the quarterly report on the progressive use of Official language for the quarter April-June. Dr. T. Manjunatha Rao Director, IIHR, Bangalore appreciated the initiatives taken by the centre to achieve the targets, prescribed in the annual programme of the Dept. of Official language, Govt. of India.

Hindi Week Celebration

Central Horticultural Experiment Station, Bhubaneswar observed "*Hindi Saptah*" during September, 15-22, 2014. Various competitions viz., poem recitation, debate, dictation and singing were organized for promoting the use of Hindi language among the staff. Dr. Anand Prakash, Head (Retired), Division of Crop protection, CRRI, Cuttack and Dr. H.S. Singh, Head, CHES, Bhubaneswar inaugurated the "*Hindi Saptah*" on September 15, 2014. Valedictory function of week-long event was organized on September 22, 2014. Dr. P.C. Lenka, Ex. Director, DPME, OUAT, Odisha, Dr. G. Naik, Ex. Principal Scientist, CHES, Bhubaneswar graced the occasion as Chief Guest and Guest of Honour, respectively. Prizes were distributed by the Chief Guest, Guest of Honour and Head of the station among the winners of different competitions.

Workshop on "*Hindi Akshar Gyaan*" organized at CHES, Bhubaneswar

In order to promote use of Hindi in official works, Central Horticultural Experiment Station (IIHR), Bhubaneswar organized a Hindi workshop on "*Hindi Akshar Gyaan*" on 27 September, 2014 for its staff. The workshop was inaugurated by the Head of the station, Dr. H.S. Singh and the Chief Guest of the function, Dr. Deepa Khulbe, Associate Prof. (Plant Pathology), College of Agriculture, OUAT, Bhavanipatna. Dr. H.S. Singh welcomed all the participants and encouraged them to use Hindi in their official work. Dr. Deepa Samant, Scientist and Chairperson Hindi Cell, briefed about the workshop and the books provided to the participants. Dr. Deepa Khulbe taught "*Hindi Varnamala*" to the participants and provided basics of Hindi language and necessary guidance regarding use of Hindi in a better and simpler way in the office. Books on Hindi *Varnamala* (1&2), essay writing, letter writing and Hindi translation were provided to all the participants for further use in daily Hindi works. The workshop was ended with the vote of thanks by Sri. B. Mohapatra, AF&AO, CHES, Bhubaneswar.

Participants of Hindi Workshop

18. Distinguished Visitors

18.1. IIHR, Hesaraghatta, Bengaluru

- Dr. N. K. Krishna Kumar, DDG (HS), ICAR, New Delhi (30.05.2014, 16.08 2014 & 19.09.2014).
- Dr. Rekha Choudhary, NABMGR, NBPGR, New Delhi (30.05.2014).
- Dr. P. Manivel, Director I/C, DMAPR and PC MAPB (30.05.2014).
- Dr. Srinath Dikshit, Zonal Co-ordinator, Transfer of Technology, Bengaluru (03.06.2014).
- Dr. S. B. Dandin, former Vice Chancellor, UHS, Bagalkot (03.06.2014).
- Dr. B. Raju, Vice Chancellor (Acting), UHS, Bagalkot (03.06.2014).
- Dr. Lingaiah, Dean, P G and Research Center, Bengaluru, UHS, Bagalkot (03.06.2014).
- Prof. Anand Das Gupta, IIPM, Bengaluru (04.06.2014).
- Dr. R. R. Hanchinal, Chairman, and Dr. R C Agarwal, Registrar General, PPV&FRA, New Delhi (12.06.2014).
- Dr. Jun Acedo, Dr. Yoonpyo and Dr. Hsin Yi, AVRDC, Taiwan (25.06.2014).
- Dr. Peter Hanson, Tomato Breeder and Dr. Lawrence, Virologist, AVRDC-the World Vegetable Center, Taiwan (26.06.2014).
- Dr. S. V. Hithalamani, former Additional Director of Horticulture, Govt. of Karnataka, Bengaluru (16.07.2014).
- Dr. S. Balaji, General Manager Technical, EID Parry, Chennai (22.07.2014).
- Mr. A. K. Jha, ICAR –RAC & RMC member from Bihar (04.08.2014).
- Dr. S. Ayyappan, Secretary, DARE, GoI and DG, ICAR, New Delhi (16.08 2014).
- Dr. R. K. Jain, Dean and Joint Director, IARI, New Delhi, (16.08 2014).
- Prof. Ramakrishna, Centre for Intellectual Property Research and Advocacy, National Law School of India University, Bengaluru (22.08.2014).
- Mr. Pranav Kumar Mysore, Senior Associate, K&S Partners; a company of Intellectually Property Attorneys, Bengaluru (22.08.2014).
- Mr. Anne Ramesh, SIFA President and Director of IFAB, Bengaluru (22.08.2014).
- Mr. Venkat Rao, MD, Iris Biotech, Bengaluru (22.08.2014).
- Mr. V. H. Prasad, Director Blooms & Greens Pvt. Ltd, Bengaluru (22.08.2014).
- Mr. Sridhar Chowdhary, MD, Vinayaka Agritech Ltd., Bengaluru (22.08.2014).
- Mr. Robert de Bos, Director, Bangalore Plants First, Bengaluru (22.08.2014).
- Dr. Tilak Subbaiah, Floriculture Consultant, Bengaluru (22.08.2014).
- Dr. K. R. Kranthi, Director, CICR, Nagpur (30.08.2014).
- Dr. B. V. Patil, former the Vice Chancellor, UAS, Raichur (30.08.2014).
- Dr. Irani Mukerjee, IARI, New Delhi (30.08.2014).
- Dr. N. Srinivasa, GKVK, Bengaluru, (30.08.2014).
- Dr. K. S. Mohan, Monsanto, Bengaluru, (30.08.2014).
- Dr. G. M.V. Prasada Rao, ANGRAU, Guntur, (30.08.2014).
- Padmashree Dr. K. L. Chadha, former DDG (Hort.), ICAR, New Delhi (05.09.2014).
- Dr. R. K. Jain, Project Coordinator, AICRP on Nematodes (08.09. 2014).
- Dr. P. Parvata Reddy, former Director, IIHR, Bengaluru (08.09. 2014).
- Dr. Uma Rao, Head, Division of Nematology,

IARI, New Delhi (08.09. 2014).

- Dr. Basavaraj, Executive Director, Karnataka State Horticulture Mission (08.09. 2014).
- Dr. Niger Godley, Global Product Development Manager (Insecticides), Bayer Crop Science, Germany (10.09.2014).
- Dr. Aditya Shukla, Lead Scientist, ITL Ltd., Bengaluru (15.09. 2014).
- Mrs. Sudha Murthy, Chairperson, Infosys Foundation (17.09. 2014).
- Dr. Jitendra Kumar, Director, DMAPR, Anand, Gujarat, (17.09.2014).
- Padmasree Darshan Shankar, Chairman I-AIM, Bengaluru1 (18.09.2014).
- Dr. S. K. Malhothra, Horticulture Commissioner, GOI and ADG (Hort-I) ICAR, New Delhi, (18.09.2014).
- Dr. D. L. Maheshwar, VC, UHS, Bagalkot, (18.09.2014).
- Dr. J. Venkatesh, Director (R), UHS, Bagalkot, (18.09.2014).
- Dr. S. B. Dandin, former VC, UHS, Bagalkot (18.09.2014).
- Dr. U. V. Singh, APCCF and CEO, KAMPA, Bengaluru (18.09.2014).
- Dr. T. U. Haqqi, Asst. Adviser, NMPB, New Delhi, (18.09.2014).
- Mr. Bhaktha Ramegowda, Special Deputy Commissioner (Revenue), Tumakuru (20.09.2014).
- Dr. Warwick Easdown Regional Director, AVRDC, Taiwan, Dr. Doug Pachico, Plant Breeder and Dr. Jun Acedo, Postharvest Specialist AVRDC, Taiwan (22.09.2014).
- Dr. Vijaya Malik, Retd. Sr. Hindi Officer, Central Power Research Institute, Bengaluru (23.09.2014).
- Mr. C. Basavaiah, former the Managing Director, Karnataka Compost Development Corporation, Bengaluru (02.10.2014).
- Dr. Hanchinal, R. R. Chairman (PPV & FRA), New Delhi, Dr. Manoj Srivastava,
- Registrar (Field crops), PPV & FRA and Dr. Tejbir Singh, Registrar (Horticulture), PPV & FRA (08.10.2014).
- Dr. Dutta, O. P. former Head, Division of Vegetable Crops, ICAR- IIHR, Bengaluru (25.10.2014).
- Dr. Palli Subba Reddy, Insect Physiologist, University of Kentucky, USA (09.12.2014).
- Mrs. Chaya Nanjappa, Nector Fresh Honey, Dr. Geetha Suresh, Novel Biotech, Bengaluru and Mrs. Susheelamma, Sumangali Sevashram, an NGO, Bengaluru (12.12.2014).
- Shri Radha Mohan Singh, Hon'ble Union Minister for Agriculture, GOI, Shri D.V. Sadananda Gowda, Hon'ble Union Minister for Law & Justice, GOI, Shri S. R. Vishwanath, Hon'ble Member of Legislative Assembly, Govt. of Karnataka and Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR, New Delhi (09.01.2015 visit at Yelahanka Farm of ICAR-IIHR, Bengaluru).
- Parliamentary Standing Committee on Agriculture, Govt. of India comprising of 12 Loksabha MPs, four Rajyasabha Members, officers from Ministry of Agriculture, GOI and officers from ICAR, New Delhi under the Chairmanship of Honourable Shri Hukum Deo Narayaya Yadav (03.03.2015).
- Smt. H. G. Vijaya Kumari, 53rd Additional District Judge, City Civil Court, Bengaluru, Smt. B. G. Rama, 51st Additional District Judge, City Civil Court, Bengaluru (10.03.2015).

18.2. CHES, Chettalli

- Dr. Lawande, K. E., Vice Chancellor, Dr. Bala Saheb Konkan Krishi Vidyapeeth, Dapoli, Maharashtra (14-15.04.2014).
- Dr. M. Anandaraj, Director, IISR, Calicut, Kerala (21.06.2014 & 30.08.2014).
- Dr. Javed Akhar, Chairman, Coffee Board, Bengaluru (06.09.2014).
- Dr. Ranvir Singh, Principal Scientist, ICAR, New Delhi (08.09.2014).
- Dr. Janakiram, T. ADG, (Hort), ICAR, New Delhi (01.12.2014 & 19.02.2015).
- Dr. Manjunatha Rao, T, Director, ICAR-IIHR, Bengaluru (01.12.2014).

- Dr. Parthasarathy, V. A. National Coordinator TFT Project. (01.12.2014).
- Dr. Sharma, S. K. Director, ICAR-CIAH, Bikaner. (01.12.2014).
- Dr. Kumar, N. former Dean, Hort, TNAU, Coimbatore. (01.12.2014).
- Dr. Saroj, P. L. Director, ICAR-DCR, Puttur. (01.12.2014).
- Dr. Vishal Nath, Director, ICAR-NRC for Litchi, Muzzafarpur. (01.12.2014).
- Dr. Korikanthimath, former Director, ICAR Research Complex for Goa. (01.12.2014).
- Dr. Chowdappa, P. Director, ICAR-CPCRI, Kasargod. (01.12.2014).
- Dr. Pandey, G S. Director, Agril, Andaman & Nicobar. (01.12.2014).
- Dr. Ramanath Rao, Bioversity International (01.12.2014).
- Dr. N. Kumar, former Dean, TNAU, Coimbatore (01.12.2014).
- Dr. B.C. Uthaiah, former Dean College of Forestry, Ponnampet (01.12.2014).
- Dr. B.C. Deka, Joint Director, ICAR - NEH, Barapani (01.12.2014).
- Dr. N.K. Krishna Kumar, DDG (Hort. Sc.), IIHR, New Delhi (23.01.2015).
- Dr. Abraham Varghese, Director, NBAII, Bengaluru (17.03.2015).
- Dr. Y. Raghumamulu, Director, Central Coffee Research Institute, Chikmagalur (17.03.215).
- Dr. S. V. Hittalmani, former Additional Director, Dept. of Hort, Govt of Karnataka, Bengaluru (11.03.2015).

18.3. CHES, Bhubaneswar

- Mr. A. Chandra, Special Secretary, Govt. of Odisha (18.05.2014).
- Nepalese delegates, Department of Agriculture, Govt. of Nepal (20.05. 2014).
- Mr. S. K. Chaddha, Director, Directorate of Horticulture, Govt. of Odisha (30.06.2014).
- Dr. S. S. Nanda, Dean, DEE, OUAT, Bhubaneswar (30.06.2014).
- Dr. S. C. Panwar, NHB, Bhubaneswar (30.06.2014).
- Dr. T. Manjunatha Rao, Director, IIHR, Bengaluru (30.06.2014).
- Dr. E Aravezhi, Deputy Director, Coconut Development Board, Bhubaneswar (16.07.2014).
- Dr. N. K. Krishna Kumar, DDG (Hort. Sci.), ICAR, New Delhi (09.08.2014).
- Dr. T. Janakiram, ADG (Hort. Sc.), ICAR, New Delhi (09.08.2014 & 22.01.2015).
- Dr. S. Kumar, former Head, HARP, Ranchi (11.08.2014).
- Re. Bharma Kumari Geeta, Bhrama Kumari Vishwa Vidyalaya, Bhubaneswar (26.08.2014).
- Dr. Bani Singh, Deputy Director, National Horticulture Board, Bhubaneswar (26.08.2014).
- Prof. Manoranjan Kar, Vice Chancellor, OUAT, Bhubaneswar (02.09.2014).
- Dr. S. K. Chadha, Director, Directorate of Horticulture, Govt. of Odisha (02.09.2014).
- Dr. Neelum Grewal, Director, DRWA, Bhubaneswar (02.09.2014).
- Mr. P. Routray, General Manager (marketing services) and Mr. Sudhanshu Patra, Sr.Manager, PPL (04.09.2014).
- Dr. Sikhamany, S. D., former Director, IIHR (25.09.2014).
- Dr. Pandey, S. N. Ex-ADG, ICAR, New Delhi (30.10.2014).
- Justice B. P. Ray and Justice Pujaharhi, S. Orissa High Court (15.11.2014).
- Dr. B K. Mishra, Dean, OUAT, Bhubaneswar (17.11.2014).
- Dr. Anand Prakash, Secretary, AZRA, Bhubaneswar (17.11.2014).
- Dr. R. S. Mishra, Head, RC-CTCRI, Bhubaneswar (17.11.2014).
- Prof. Akhtar Haseeb, Vice Chancellor, NDUAT, Faizabad (24.11.2014).
- Dr. Neelam Grewal, Director, DRWA, Bhubaneswar, Dr. Meena Senapati, Director,

Centre for Plant Tissue Culture and Biotechnology, Bhubaneswar, Mrs. Anupama Raut of Joint Endeavour for Emancipation and Tribal Awareness (JEETA)-Land Entitlement for Tribal Women, Deogarh, Odisha (04.12.2014).

- Mr. Nanda, S. Director, Directorate of Horticulture, Govt. of Odisha (19.12.2014).
- Mr. Niten Chandra, Principal Secretary, General Administration, Govt. of Odisha (02.02. 2015).
- Dr. A. A. Deshpande, former Principal Scientist, IIHR (05.03.2015).
- Dr. S. S. Sindhu, Head, Floriculture & Landscaping, IARI, New Delhi (19.03.2015).
- Dr. Vishal Nath, Director, NRC on Litchi, Muzaffarpur (21.03.2015).
- Dr. Acharya, Vegetable Scientist (26.03.2015).

18.4. KVK, Gonikoppal

- Mr. T.B. Jayachandra, Minister for Veterinary Science, Govt. of Karnataka (26.04.2014).
- Dr. Narasimhan, Ornithologist and Wild life Photographer (26.04.2014).
- Dr. P C. Tripathi, Principal Scientist and Head, CHES, Chettalli, (26.04.2014).
- Mrs. Sri Vidya, Chief Executive Officer, Zilla Panchayath (26.04.2014).
- Dr. Sreenath Dixith, Project Director, ZPD, Zone VIII, Bengaluru (21.07. 2014).
- Dr. B. T. Rayudu, Principal Scientist, ZPD, Bengaluru (21.10.2014).
- Dr. T. Manjunatha Rao, Director, ICAR-IIHR, Bengaluru (21.10.2014 & 13.01.2015).

18.5. KVK, Hirehalli

- Dr. D. L. Maheshawar, Director, Dept. of Horticulture, Govt. of Karnataka, Dr. Eshwara-ppa & Dr. Prabhakar, Consultants to Dept. of Horticulture (24-25.04.2014).
- Dr. A. R. Sadananda, Maize Seed Systems Specialist for South Asia & Dr. B.S. Vivek, Maize Breeder from International Maize and Wheat Improvement Centre (CIMMYTT) (08.05.2014 & 06.08.2014).
- Dr. Prabhu Kumar, ZPD Zone I, Ludhiana & Dr. Y. G. Prasad, Coordinator, TDC of NICRA, CRIDA, Hyderabad and Principal Scientists of ZPD I & ZPD VIII., Dr. Prabhu Kumar, ZPD, Zone I, Dr. H.S. Dhaliwal, Dean, PAU, Dr. Keshava, Principal Scientist, ZPD Zone I and team of 20 Programme Co-ordinators from Zone I (13.05.2014). .
- Mr. Jaspreet Sidhu, Consultant, Advisory Services and Mr. T. Sayooj, M/S Ernst & Young Co., Bengaluru (27.05.2014).
- Dr. P. Manivel, Director I/C, DMAPR and PC MAPB (29.05.2014).
- Mr. Shivanna, Ex-MLA, Tumakuru (17.07.2014).
- Dr. Sreenath Dixit, Director, ZPD, Zone VIII, Bengaluru (20.02.2015).
- Mrs. B. Jayashree, Hon'ble Members of Parliament (Rajya Sabha), Mr. K. Ananda Raju and Mr. R.V. Mahesh (24.03.2015).

19. Personnel

DIRECTOR

Manjunatha Rao, T. (Acting) w.e.f . 07.05.2014

SCIENTIFIC STAFF

IIHR, Hesaraghatta, Bengaluru, Karnataka

Division of Fruit Crops

Chithiraichelvan, R. Ph. D.
Principal Scientist (Horticulture) Up to 30.04.2014

Srinivas, K. Ph. D.
Principal Scientist (Agronomy) Up to 31.03.2014

Sulladmath, V.V. Ph. D.
Principal Scientist (Horticulture)

Karibasappa, G.S. Ph. D.
Principal Scientist (Horticulture) w.e.f. 01.01.2015

Reddy, Y.T.N. Ph. D.
Principal Scientist (Horticulture) Up to 28.02.2015

Srinivas Murthy, B.N. Ph. D.
Principal Scientist (Horticulture)

Dinesh, M.R. Ph. D.
Principal Scientist (Horticulture) &
Head w.e.f . 28.08.2014

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)

Vasugi, C. Ph. D.
Senior Scientist (Horticulture)

Manjunath, B.L. Ph. D.
Principal Scientist (Agronomy) w.e.f. 02.06.2014

Sankaran, M. Ph. D
Senior Scientist (Horticulture) w.e.f. 01.09.2014

Awachare Chandrakant Madhav, M. Sc
Scientist (Fruit Sci.) w.e.f. 09.04.2014

Satisha, J. Ph. D.
Principal Scientist (Horticulture) w.e.f. 01.12.2014

Division of Vegetable Crops

Sadashiva, A.T. Ph. D.
Principal Scientist (Horticulture) & Head

Prabhakar, M. Ph. D.
Principal Scientist (Agronomy) Up to 30.09.2014

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)

Varalakshmi, B. Ph. D.
Principal Scientist (Horticulture)

Shankar Hebbar, S. Ph. D.
Principal Scientist (Agronomy)

Anil Kumar Nair, Ph. D.
Principal Scientist (Agronomy)

E. Sreenivasa Rao, Ph. D.
Senior Scientist (Vegetable Science)

Susmitha Cherukuri.
Scientist (Gen. & Plant Breed) w.e.f. 10.04.2015

Division of Ornamental Crops

Manjunatha Rao, T. Ph. D.
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Meenakshi Srinivas Ph. D.
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Tejaswini Ph. D.
Principal Scientist (Plant Breeding)

Aswath, C. Ph. D.
Principal Scientist (Horticulture)

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. (Hort)
Scientist (Horticulture)

Usha Bharathi, T. Ph. D. (Hort)
Scientist (Horticulture-Floriculture)

Division of Post Harvest Technology

Harinder Singh Oberoi, Ph. D.
Principal Scientist & Head w.e.f. 17.11.2014

Narayana, C.K. Ph. D.
Principal Scientist (Horticulture)

Doreyappa Gowda, I.N. 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.
Senior Scientist (Pl.Biochem.)

Bhuvaneshwari, S. M.E., Ph. D.
Scientist (ASPE) (Agricultural Engineering)

Ranjitha. K, Ph. D.
Scientist (Microbiology) (Agricultural Science)

Division of Plant Pathology

Krishna Reddy, M. Ph. D.
Principal Scientist (Plant Pathology) & Head

Ramesh, C.R. Ph. D
Principal Scientist (Plant Pathology)

Girija Ganeshan, Ph. D.
Principal Scientist (Plant Pathology)

Meera Pandey, Ph. D.
Principal Scientist (Plant Pathology)

Chowdappa, P. Ph. D.
Principal Scientist (Plant Pathology) Up to 05.09.2014

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)

Division of Entomology and Nematology

Chakravarthy, A.K. Ph. D.
Principal Scientist (Agricultural Entomology) &
Head w.e.f. 01.04.2014

Krishnamoorthy, A. Ph. D.
Principal Scientist (Agricultural Entomology)

Krishna Murthy, P.N. M.Sc., (Ag)
Principal Scientist (Agricultural Entomology)
Up to 31.12.2014

Sreenivas Rao, M. Ph. D.
Principal Scientist (Nematology)

Ranganath, H.R. Ph. D.
Principal Scientist (Entomology)

Gopalakrishna Pillai, K. Ph. D.
Principal Scientist (Agricultural Entomology)

Ganga Vishalakshy, P.N. Ph. D.
Principal Scientist (Entomology)

Sridhar, V. Ph. D.
Principal Scientist (Entomology)

Venkat Rami Reddy, P. Ph. D.
Principal Scientist (Agricultural Entomology)

Kamala Jayanthi, P.D. Ph. D.
Senior Scientist (Agricultural Entomology)

Uma Maheshwari, Ph. D.
Scientist (Nematology)w.e.f. 02.06.2014

Division of Plant Physiology and Biochemistry

Shivashankar, S. Ph. D.
Principal Scientist (Biochemistry) & Head

Bhatt, R.M. Ph. D.
Principal Scientist (Plant Physiology)

Ravindra, V. Ph. D.
Principal Scientist (Plant Physiology)

Upreti, K.K. Ph. D.
Principal Scientist (Organic Chemistry)

Shiva Shankar, K.S. Ph. D.
Principal Scientist (Plant Physiology)

Laxman, R.H. Ph. D.
Principal Scientist (Plant Physiology)

Keshava Rao, V. Ph. D.
Senior Scientist (Organic Chemistry)

Division of Soil Science and Agricultural Chemistry

Ganeshamurthy, A.N. Ph. D.
Principal Scientist & Head

Debi Sharma, Ph. D.
PrincipalScientist (Agricultural Chemistry)

Raghupathi, H.B. Ph. D.
PrincipalScientist (Soil Science)

Shivananda, T.N. Ph. D.
Principal Scientist (Soil Science)

Soudamini Mahopatra, Ph. D.
Principal Scientist (Organic Chemistry)
Varalakshmi, L.R. Ph. D.
Principal Scientist (Soil Science)

Selvakumar, G. Ph. D.
Principal Scientist (Microbiology)

Sathisha, G.C. Ph. D.
Principal Scientist (Soil Science)

Panneer Selvam, P. Ph. D.
Senior Scientist (Microbiology)

Kalaivanan, D. M.Sc
Scientist (Soil Science) w.e.f 17.11.2014

Division of Extension and Training

Doijode, S.D. Ph. D.
Principal Scientist (Horticulture) &
Head Up to 31.07.2014

Venkattakumar, Ph. D.
Principal Scientist & Head w.e.f 30.10.2014

Hegde, M.R. Ph. D.
Principal Scientist (Agronomy)

Ravishankar, H. Ph. D.
Principal Scientist (Horticulture) &i/c ATIC

Nita Khandekar, Ph. D.
Principal Scientist (Agricultural Extension)

Achala Paripurna, Ph. D.
Senior Scientist (Agricultural Extension)

Balakrishna, B. Ph. D.
Principal Scientist (Agricultural Extension)

Narayanaswamy, B. Ph. D.
Principal Scientist (Agricultural Extension)

Division of Plant Genetic Resources

Ganeshan, S. Ph. D.
Principal Scientist (Genetics & Cytogenetics) & Head

Rajashekharan, P.E. Ph. D.
Principal Scientist (Economic Botany)

Anuradha Sane, Ph. D.
Principal Scientist (Horticulture)

Shivaramu, K. Ph. D.
Senior Scientist (Entomology)

Linta Vincent, M. Sc
Scientist (Fruit Science) w.e.f. 08.04.2014

Anushma, P.L. M. Sc
Scientist (Fruit Science) w.e.f. 08.04.2014

Division of Biotechnology

AkellaVani, Ph. D.
Principal Scientist (Genetics & Cytogenetics)
Head w.e.f20.10.2014

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 (Agril.Biotechnology)

Kanupriya, Ph. D.
Scientist (Horticulture)

Lakshmana Reddy, D.C. Ph. D.
Scientist (Agril.Biotechnology)

Radhika, V. M. Sc., (Maths)
Scientist (SS) (Computer Application)

Usharani, T.R. Ph. D.
Scientist (Agril.Biotechnology)

Nandeesha, P. Ph. D.
Scientist (Agril.Biotechnology)

Section of Medicinal & Aromatic Crops

Vasantha Kumar, T. Ph. D.
Principal Scientist (Genetics & Cyto genetics) & Head

Eugene Sebastian, J.N. Ph. D.
Principal Scientist (Organic Chemistry)

Sukanya, D.H. Ph. D.
Principal Scientist (Plant Breeding)

Hima Bindu Ph. D.
Principal Scientist (Plant Breeding)

Suryanarayana, M.A. Ph. D.
Principal Scientist (Horticulture)

Section of Seed Science & Technology

Naik, L.B. Ph. D.
Principal Scientist (Agronomy) & Head

Yogeesha, H.S. Ph. D.
Principal Scientist (Seed Technology)

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)

Carolina Rathina Kumari, Ph. D.
Scientist (FM&P)

Section of Economics & Statistics

Gajanana, T.M. Ph. D.
Principal Scientist (Agricultural Economics) & Head

Sudha Mysore, Ph. D.
Principal Scientist (Agricultural Economics)

Sreenivasa Murthy, D. Ph. D.
Principal Scientist (Agricultural Economics)

Venugopalan, R. Ph. D.
Principal Scientist (Statistics)

Chandraprakash, M.K. MCA.
Scientist (SS) (Computer Application)

Reena Rosy Thomas, MCA.
Scientist (SS) (Computer Application)

Project Coordinator's Cell (Fruits)

Prakash Patil, Ph. D.
Principal Scientist (Plant Physiology)

Nazeeb Naduthodi, M. Sc
Scientist (Fruit Science) w.e.f 08.04.2014

Central Horticultural Experiment Station, Chettalli

Tripathi, P.C. Ph. D.
Principal Scientist (Horticulture) & Head

Senthil Kumaran, R. Ph. D.
Principal Scientist (Fruits) w.e.f. 24.06.2014

Sankar, V.
Senior Scientist (Horticulture)

Reddy, T.M. Ph. D.
Scientist (SS) (Agricultural Extension)

Jayanthimala, B.R.
Scientist (Ag. Ento.)

Priti Sonavane, Ph. D.
Scientist (Plant Pathology)

Central Horticultural Experiment Station, Bhubaneswar

Hari Shankar Singh, Ph. D.
Principal Scientist (Agricultural Entomology)& Head

PetikamSrinivas, Ph. D.
Senior Scientist (Plant Pathology)

Bharathi, L.K. Ph. D.
Senior Scientist (Horticulture)

Sudhamoy Mondal, M.Sc.
Scientist (SS) (Plant Pathology)

Deepa Samant, Ph. D., Scientist (Hort.)

Kundan Kishore, Senior Scientist (Horticulture)

Sangeetha, G. Ph. D.
Senior Scientist (Plant Pathology)
Ponnam Naresh, M. Sc
Scientist (Vegetable Science) w.e.f. 9.04.2014

Gobinda Chandra Acharya, Ph. D.
Senior Scientist, (Hortculture) w.e.f 01.09.2014

Meenu Kumari, M. Sc
Scientist (Hortculture) w.e.f 13.10.2014

Central Horticultural Experimentation Station (CHES) and KrishiVigya Kendra, Hirehalli, Karnataka

Saju George, Ph. D.
Programme Coordinator w.e.f 05.05.2014

Karunakaran, G.
Senior Scientist (Horticulture)

Loganandha, N. Ph. D.
Programme Coordinator, KVK

TECHNICAL STAFF

Division of Fruit Crops

Prakash, B., M.Sc. (Org. Chem.), CTO (Lab.)

Ravindra Kumar, M.Sc. (Ag.), STO (Lab.)

Kotrabasappa T-5 (T.O.) (Lab.) up to 01.01.2015

Division of Vegetable Crops

Kashinath, B.L., M.Sc. (Ag), CTO (Seed Prod.)

Umashankar, B.E., B.Sc. (Ag), STO (Lab.)

Nage Gowda, N.S. B.Sc. (Ag), STO (Farm)

Anjanappa, M., T-5 (T.O.) (Field)

Rangaiah, M., T-5 (T.O.) (Field)

Division of Ornamental Crops

Huliyappa, B., T-5 (T.O.) (Field)

Lakshmisha, R., STO up to 11.06.2014

Division of Post Harvest Technology

Sarojini Jalali, M.Sc., CTO (Lab.) up to 28.02.2015

Nagappa, M.Sc. (Eco. Env.), STO (Lab.)

Reddappa, K., B.Sc., PGD (FT), ACTO (Lab.)

Division of Plant Pathology

SalilJalali, M.Sc., CTO (Lab)

Balasubramaniam, K. B.Sc., T-5 (T.O.) (Lab.)

Chandrashekhara, N., T-5 (T.O.) (Field) Up to 30.06.2014

Division of Entomology and Nematology

Sujatha, A. Ph.D., ACTO (Field)

Subbaiah, N., T-5 (T.O.) (Field)

Hanumantharayappa, S., T-5 (T.O.) (Field) Up to 31.12.2014

Siddaveeraaradhaya, H.C., T-5 (T.O.) (Field)

Lokesh, C., T-5 (T.O.) (Field)

Division of Plant Physiology and Biochemistry

Tapas Kumar Ray, M.Sc., CTO (Lab.)

Jayaram, H.L., M.Sc., PGD, CTO (Lab.)

Bujji Babu, C.S., M.Sc. (Biochem.), CTO (Lab.)

Nageswara Rao, A.D.D.V.S., B.Sc.
STO (Lab.) Up to 02.09.2014

Lakshmaiah, M., T-5 (T.O.) (Lab.)

Qazi, S.M., B.Sc., T-5 (T.O.) (Lab.)

Division of Soil Science and Agricultural Chemistry

Mazhar Jamil, B.Sc., STO (Lab)

Jyothi V. Divakar, M.Sc., STO (Lab.)

Gopala, D., T-5 (T.O.) (Field)

Somashekhar, K., T-5 (T.O.) (Lab)

Division of Extension and Training

Bhojappa Gowda, T-5 (T.O.) (T.A.) up to 07.06.2014

Murugesh, B.J., T-5 (T.O.) (Field)

Venkateshwar Rao, R., T-5 (TO) (Projection)

Division of Plant Genetic Resources

Shetti, D.L., M.Sc. (Agril. Ento.), STO (Lab.)

Dasappa, T-5 (T.O.) (Field) up to 31.05.2014

Division of Biotechnology

Sreedhara, S.A. M.Sc. (Food Tech.), CTO (Lab)

Chandrashekhara, S.C., M.Sc., ACTO (Lab.)

Madhusudhana Rao, B., M.Sc., T-5 (T.O.) (Field)

Venkateshaiah, S., T-5 (T.O.) (Field)

Dharma Naik, T-5 (T.O) (Lab.)

Section of Agricultural Engineering

Dayananda, P., T-5(T.O.) (Mechanic)

Economics & Statistics

Dakshinamoorthy, V. M.A., M.Phil (Econ.), CTO (Lab.)

Thippeswamy, S., MCA., ACTO (Computer Lab)

Kishore Kumar, N., B.Sc.
T-5 (T.O.) (Computer Lab) up to 31.12.2014

Seed Science & Technology

Arun, M.N., M.Sc. (Ag.), STO (Field)

Research Management and Coordination Unit

Janmay Jay Deveshwar, ACTO (Lab.)

Chandra Kumar, C., T-5 (T.O.) (Computer)

Publication

Gaddagimath, P.B., M.Sc., (Org. Chem.)
M.A. (MC & J),CTO (Inf. & Pub. Officer)

Aris Cell

Jayasankar, N., MCA, STO (Computer Operator)

Library

Shankara Prasad, K.V., M.Sc., STO (Lib.Sci.)

Photography & Artist Cell

Rajendra Astagi, M.F.A., STO (Artist)

Chandrashekaraiah, K., B.Com.T-5 (T.O.) (D.R.A.)

Medical and Paramedical

Mandakrantha Bhattacharya, MBBS, DLO
CTO (Medical)

Farm Management

Pandey, R.N., M.Sc. (Ag.), CTO (Farm)

Senthil Kumar, M., M.Sc. (Hort.) MBA
ACTO (Field) Up to 30.12.2014

Nursery

Annu, M., T-5 (T.O.) (Field)

Workshop

Bhanu, A., M.E. (Civil), ACTO (JME)

Robert Lewis, STO (Ref.)

Harish, K.M., B.E. (Civil), STO (Civil Oversees)

Mahishi, V.K., T-5 (T.O.) (Elect.)

Lakshmana Kanthan, A., T-5 (T.O.) (Turner)

Narendra, S., T-5 (T.O.) (Elect.)

Mahantesh, P.T., T-5 (T.O.) (Mech.)

Jagadeesh Kumar, D.N., T-5 (T.O) (Elect.)

Manjunath, R., T-5 (TO) (Welder)

Transport Section

Siddaram G. Kalashetty, B.E. (AE), STO (Transport)

Nagaraj E. Kodekal, T-5 (T.O.) (Mech.)

Sunder Raj, G., T-5 (T.O.) (Driver)

Security Wing

Siddegowda, C., T-5 (T.O.) (Field)

Central Horticultural Experimentation Station (CHES), Chettalli, Karnataka

Patil, C.S., M.Sc., B.Lib.Sci., STO (Lib.)

Ravi, M.B., B.Sc., T-5 (T.O.) (Field) Up to 31.05.2014

Appanna, H.C., T-5 (T.O.) (Field) Up to 30.04.2014

Varadarajachary, K.V., T-5 (T.O.) (Mech.)

Swathy, P. B., T-5 (T.O.) (Lab.)

Central Horticultural Experimentation Station (CHES), Bhubaneshwar, Odisha

Singray Majhi, B.Sc. (Ag.), Dip.(CA), T-5 (T.O.) (Lab.)

Central Horticultural Experimentation Station (CHES) and KVK, Hirehalli, Karnataka

Jagadish, K.N., M.Sc. (Agril. Extn.)
STO (SMS) (Agricultural Extension)

Ramesh, P.R., M.Sc. (Agri.)
STO (SMS) (Soil Science)

Prashanth, J.M., M.Sc. (Hort.)
STO (SMS) (Horticulture)

Hanumanthe Gowda, B., M.Sc. (Pl. Path.)
STO (SMS) (Plant Protection)

Radha R. Banakar, M.Sc. (Home Sci.)
STO (SMS) (Home Science)

Somashekhar, Ph.D., STO (SMS) (Plant Breeding)

Parashuram, H.D., T-5(TO)

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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.
T-5 (T.O.) (Field) – Programme Assistant

ADMINISTRATION AND ACCOUNTS

Main Institute, Hesaraghatta, Bengaluru

Administration

Charles Ekka, Senior Administrative Officer

Rama, S., MA, MBA,
Administrative Officer, up to 01.12.2014

Das, J.N., Administrative Officer, w. e. f 03.12.2014

Alok Kumar, Administrative Officer

Mohana, G., Assistant Administrative Officer

Tittu Kumar, K.B., Assistant Administrative Officer

Anasuya, N., B.A., Assistant Administrative Officer

Raghuraman V., B.Com. L.L.B.
Assistant Administrative Officer & DDO

Jagadeesan, A.K., M.A. (Hindi), PGD (Transl)
Assistant Director (Official Language)

Finance and Accounts

Balabrahmaiah
Chief Finance and Accts. Officer, Up to 01.01.2015.

Srinivasa Murthy, A., B.Com.
Finance & Accounts Officer

Ramanchandrappa, B.N., B.Com.
Assistant Finance & Accounts Officer

Lokanatha, B., Assistant Administrative Officer

Central Horticultural Experimentation Station (CHES), Chettalli, Karnataka

Administration

Mohan, C.M., Assistant Administrative Officer

Central Horticultural Experimentation Station (CHES), Bhubaneswar, Odisha

Administration

Banshsidhar Mohapatra
Assistant Finance & Accounts Officer

20. Meteorological Data

20.1. IIHR, Hesaraghatta, Bengaluru

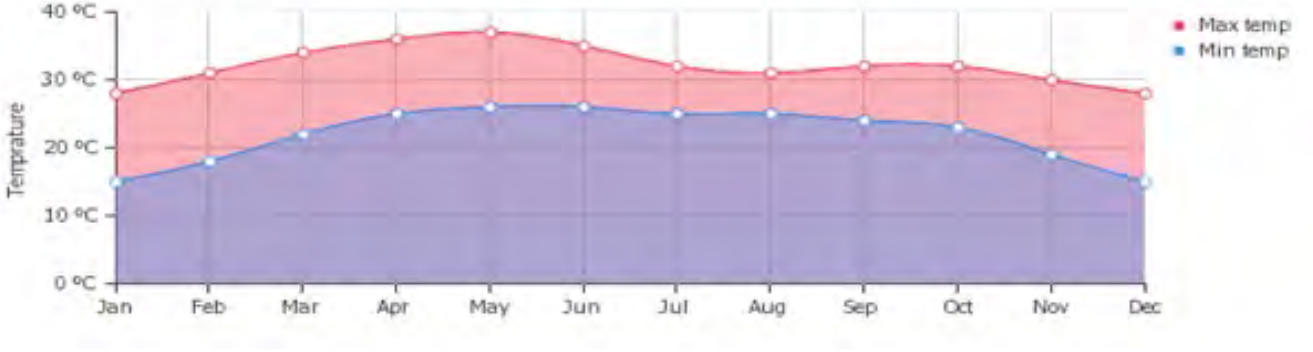
Month	Temperature (°C)		Relative Humidity (%)		U.S.W.B.Class	Mean wind speed (km/h)	Rainfall (mm)
	Max.	Min.	07.30 hrs.	14.00 hrs.			
April 2014	32.7	20.6	67.8	40.4	6.0	4.65	86.8
May 2014	32.0	20.1	74.8	46.3	5.0	4.87	87.2
June 2014	28.8	20.6	70.0	55.4	4.8	8.90	22.2
July 2014	26.6	20.1	83.3	55.3	3.2	7.10	32.3
August 2014	26.1	19.0	87.6	66.6	3.4	3.83	180.2
September 2014	28.6	19.6	80.2	57.4	3.8	4.46	25.5
October 2014	28.7	19.0	89.6	53.4	3.8	4.20	36.2
November 2014	26.2	13.5	75.3	56.0	3.4	5.6	11.0
December 2014	26.4	13.6	81.0	49.5	3.6	4.41	3.0
January 2015	27.8	13.9	82.7	38.9	4..4	4.10	-
February 2015	30.6	14.2	70.8	50.3	5.9	4.30	-
March 2015	33.25	15.3	72.5	35.9	6.8	4.70	-

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, 2014	33.68	19.00	99.64	39.55	107.4	3.57	7
May, 2014	31.78	17.35	85.42	18.85	161.3	3.58	7
June, 2014	27.67	19.92	98.88	70.33	101.1	3.96	11
July, 2014	25.20	19.04	99.76	82.04	514.5	2.49	20
August, 2014	25.65	18.83	100.00	75.26	224.9	2.35	18
September, 2014	27.12	18.60	99.68	74.40	174.9	2.89	12
October, 2014	28.62	19.52	100.00	66.81	135.1	2.83	10
November, 2014	28.29	15.43	99.00	49.10	5.6	2.94	1
December, 2014	27.96	15.64	96.48	50.28	15.4	2.46	3
January , 2015	28.22	12.22	95.04	35.83	0.0	2.69	0
February, 2015	29.14	13.82	90.41	30.18	0.0	2.90	0
March,2015	31.92	16.76	86.48	21.84	24.60	3.47	3
Average	28.77	17.18	95.90	51.21	1464.80	3.01	92

20.3. CHES, Bhubaneswar

In 2014 the average minimum and maximum temperature was 15.7 and 38.9° C, respectively. May was the hottest month and December was the coldest. Bhubaneswar has been quite humid throughout the year with the average humidity of 76%. The total annual rainfall was 1592 mm and July was the wettest month



21. Results-Framework Document (RFD)

Annexure : RFD

ICAR - Indian Institute of Horticultural Research (2013 – 2014)

Address: Hesaraghatta Lake P.O, Bengaluru – 560 089

Website: www.iihr.ernet.in

Section-1: Vision, Mission, Objectives & Functions

Vision

- Technology-led, demand-driven and need-based sustainable horticulture for attaining food and 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

- Increasing productivity and quality of horticultural crops through improvement.
- Enhancing productivity and quality of horticultural crops through sustainable integrated crop production practices.
- 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.

Section-2: Inter se priorities among key objectives, success indicators and targets

Sl. No.	Objectives	Weightage	Actions	Success indicators	Unit	Weightage	Target/Criteria value				
							Excellent	Very good	Good	Fair	Poor
							100%	90%	80%	70%	60%
1	Increasing productivity and quality of horticultural crops through varietal improvement	24	Collection and conservation of genetic resources for sustainable use	Germplasm accessions added to gene bank.	No.	4	225	200	175	150	100
			Development and introduction of improved hybrids/varieties	Hybrids/varieties developed	No.	20	10	9	7	5	3
2	Enhancing productivity and quality of horticultural crops through sustainable integrated crop production practices	50	Technologies and products to improve productivity of horticulture	Technologies and products developed	No.	20	15	13	12	10	8
			Production of breeder seed and planting material	Breeder seed of vegetable & ornamental crops	Q	10	220	200	180	160	140
				Mushroom spawn	Q	2	200	180	160	140	120
				Production of vegetative planting material	Lakhs	8	2.0	1.75	1.00	0.80	0.60
			Development of protocols and products for minimizing post harvest loss	Protocols and products developed for reducing post harvest losses	No.	10	8	6	5	4	2

3	Dissemination, popularization, adoption, refinement and impact assessment of IIHR technologies	15	Conduct of trainings to farmers and development department officials	Trainings conducted	No.	7	22	20	16	18	15
			Use of innovative extension methodologies, including ICT, for dissemination of horticultural technologies	Programmes conducted	No.	8	600	550	500	450	400
4	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	May15, 2013	May 16, 2013	May 17, 2013	May 20, 2013	May 21, 2013
			Timely submission of results for RFD (2012-13)	On-time submission	Date	1	May 1, 2013	May 2, 2013	May 5, 2013	May 6, 2013	May 7, 2013
	Administrative reforms	4	Implement ISO 9001 as per the approved action plan	% implementation	%	2	100	95	90	85	80
			Prepare an action plan for innovation	On- time submission	Date	2	July 30, 2013	Aug 10, 2013	Aug 20, 2013	Aug 30, 2013	Sept 10, 2013
	Improving internal efficiency/responsiveness/service delivery of ministry /department	4	Implementation of Sevottam	Independent Audit of implementation of Citizen Charter	%	2	100	95	90	85	80
				Independent Audit of implementation of public grievance redressal system	%	2	100	95	90	85	80

Section-3: Trend Values of the Success Indicators

Sl. No.	Objectives	Actions	Success Indicators	Unit	Actual value for 2011-12	Actual value for 2012-13	Target value for 2013-14	Projected value for 2014-15	Projected value for 2015-16
1	Increasing productivity and quality of horticultural crops through varietal improvement	Collection and conservation of genetic resources for sustainable use	Germplasm accessions added to gene bank.	No.	900	150	200	225	250
		Development and introduction of improved hybrids/varieties	Hybrids/varieties developed	No.	11	8	9	9	10
2	Enhancing productivity and quality of horticulture crops through sustainable integrated crop production practices	Technologies and products to improve productivity of horticulture	Technologies and products developed	No.	18	21	13	15	17
		Production of breeders seed and planting material	Breeders' seed of vegetable and ornamental crops	Q	200	80	200	225	250
			Mushroom spawn	Q	160	190	180	200	220
			Production of vegetative planting material	Lakhs	0.75	1.50	1.75	2.0	2.20
		Development of protocols and products for minimizing post harvest loss	Protocols and products developed for reducing post harvest losses	No.	4	5	6	8	10

3	Dissemination, popularization, adoption, refinement and impact assessment of IIHR technologies	Conduct of trainings to farmers and development department officials	Trainings conducted	No.	20	15	20	25	30
		Use of innovative extension methodologies, including ICT, for dissemination of horticultural technologies	Programmes conducted	No.	400	450	550	625	700
4	Efficient Functioning of the RFD System	Timely submission of draft RFD (2013-14) for approval	On-time submission	Date	–	–	May 16, 2013	–	–
		Timely submission of results for RFD (2012-13)	On-time submission	Date	–	–	May 2, 2013	–	–
	Administrative reforms	Implement ISO 9001 as per the approved action plan	% implementation	%	–	–	95	–	–
		Prepare an action plan for innovation	On time submission	Date	–	–	Aug 10, 2013	–	–
	Improving internal efficiency/responsiveness/service delivery of ministry /department	Implementation of Sevottam	Independent Audit of implementation of Citizen Charter	%	–	–	95	–	–
			Independent Audit of implementation of public grievance redressal system	%	–	–	95	–	–

*No. : Number; Q: Quintals

Section 4 : Acronyms

Sl.No	Acronym	Description
1	IPM	Integrated Pest Management
2	INM	Integrated Nutrient Management
3	DAC	Department of Agriculture and Cooperation
4	ICT	Information and Communication Technologies
5	TV	Television
6	NHM	National Horticultural Mission
7	NHB	National Horticulture Board
8	SAU	State Agriculture University
9	KVK	Krishi Vigyan Kendra
10	R&D	Research and Development

Section 4: Description and definition of success indicators and proposed measurement methodology

Sl. No.	Success indicator	Description	Definition	Measurement	General comments
1	Germplasm accessions added to gene bank	Germplasm is genetic resource of horticultural crops which is a source of genetic variability	Germplasm collection of cultivars, landraces, wild species 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
2	Hybrids/varieties developed	Breeding lines are developed and evaluated along with checks and the best performing entries are released for cultivation	Best performing entry is identified as a new variety for release	Number of such hybrids/ varieties identified	Targets for varieties identified given in Section 2, their respective trend values in Section 3 may vary as, the identification of varieties depends upon the availability of superior material for yield, biotic and abiotic resistance /tolerance over the existing varieties

3	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 mat ch growth stage of crop and facilitate optimal output resulting in saving of valuable resources like water and energy adopting a location specific, field specific and crop specific approach. INM refers to the maintenance of soil fertility and plant nutrient supply at an optimum level 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 for • off-season production • protected cultivation • organic production • reduction in water requirement • markers for pyramiding genes • new protocols for transformation • customized fertilizers developed • seed priming, • machineries developed for improving labour efficiency • management of insect pests • liquid formulation of microbes to be used as biopesticide, biological control of insect pests • IPM packages • identification of emerging and invasive plant pathogens • identification of resistance sources for major plant pathogens • disease diagnostics and forecasting systems

4	Breeders' seed of vegetable and ornamental crops	Produce from nucleus seed and breeder seed is the starting point in seed chain of producing quality seeds for farmers	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
5	Mushroom spawn	Mushroom spawn is the *in vitro* product of the desirable mushroom fruit body and multiplied in the form of mycelium to create genetically pure culture	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
6	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 grafts/layers/budded plants (in lakhs)	In a wider sense, planting material arising from vegetative propagation including cuttings, layering, division, budding, grafting and tissue culture
7	Protocols and products developed for reducing post-harvest losses	Losses during storage, particularly under non-refrigerated conditions continue to remain high. To reduce the glut in the market, it is important to convert the excess material into value addition products.	Shelf life of the product mainly depends on pre harvest practices as well as post harvest handling. It is required to bridge this gap. Value addition is defined as adding the value to the product to translate its natural form	Number of protocols for reduction of post harvest loss and value added products developed	-

8	Trainings conducted	Development programmes conducted for farmers, rural youth and extension personnel	Training is a process of imparting knowledge to the personnel involved in improving farm productivity	Number of trainings conducted	Depending upon the sponsoring agencies like DAC, State Governments and Extension agencies.
9	Programms conducted	Trials, demonstrations, field visits, ICT, radio and TV programmes conducted for technology transfer	On-farm trials aim at testing new technologies/ varieties in farmers field using farmers own practice as control. Frontline demonstration is the field demonstration conducted on farmers field under the close supervision of scientists. New extension methods like ICT (Information and communication technologies) to transfer technologies are also included	Number of programmes conducted	

Section 5: Specific performance requirements from other Departments

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 the organisation

Sl. No.	Outcome/ Impact of the Organization	Jointly responsible for influencing this outcome / impact with the following department (s) / ministry(ies)	Success Indicator (s)	Unit	2011/12	2012/13	2013/14	2014/15	2015/16
1.	Enhanced vegetable productivity, nutritional security and higher income	State Dept/SAU's KVKs, etc.	Increase in productivity of vegetables due to IIHR intervention	%	0.10	0.15	0.17	0.2	0.22
			Increase in per capita availability of vegetables	%	1.0	1.1	1.2	1.3	1.5
			Impact on socio-economic status and livelihood of farmers due to adoption of IIHR varieties/ technologies	Per cent income increase	10	15	20	22	25

Annual (April 1, 2013 to March 31, 2014) Performance Evaluation Report of RSCs i.e. Institutions for the year 2013-2014
Name of the Division: HORTICULTURE
Name of the Institution: ICAR-Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru
RFD Nodal Officer: Dr. C.Aswath

1	2	3	4	5	6	7	8	9	10	11	12	13	*14*	*15*	16	17
Sl. No.	**Objectives**	**Weightage**	**Action**	**Success indicators**	**Unit**	**Weightage**	**Target/Criteria value**					Achievements	Performance		% achievements against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	**Very good 90%**	**Good 80%**	**Fair 70%**	**Poor 60%**		*Raw score (%)*	*Weighted score*		
1	Increasing productivity and quality of horticultural crops through varietal improvement	24	Collection and conservation of genetic resources for sustainable use	Germplasm accessions added to gene bank.	No.	**4**	**225**	**200**	**175**	**150**	**100**	**229**	**100**	**4**	**114.5**	
			Development and introduction of improved hybrids/varieties	Hybrids/ varieties developed	No.	**20**	**10**	**9**	**7**	**5**	**3**	**10**	**100**	**20**	**111.11**	
2	Enhancing productivity and quality of horticulture crops	50	Technologies and products to improve productivity of horticulture	Technologies and products developed	No.	**20**	**15**	**13**	**12**	**10**	**8**	**15**	**100**	**20**	**115.38**	

Enhancing productivity and quality of horticulture crops through sustainable integrated crop production practices	50	Technologies and products to improve productivity of horticulture	Technologies and products developed	No.	**20**	**15**	**13**	**12**	**10**	**8**	**15**	**100**	**20**	**115.38**	
		Production of breeder seed and planting material	Breeders, seed of vegetable and ornamental crops	Q	**10**	**220**	**200**	**180**	**160**	**140**	**221**	**100**	**10**	**110.5**	
			Mushroom spawn	Q	**2**	**200**	**180**	**160**	**140**	**120**	**201**	**100**	**2**	**111.66**	
			Production of vegetative planting material	Lakhs	**8**	**2.0**	**1.75**	**1.0**	**0.80**	**0.60**	**2.027**	**100**	**8**	**115.82**	
		Development of protocols and products for minimizing post harvest loss	Protocols and products developed for reducing post harvest losses	No.	**10**	**8**	**6**	**5**	**4**	**2**	**9**	**100**	**7**	**150**	

Dissemination, popularization, adoption, refinement and impact assessment of IIHR technologies	15	Conduct of trainings to farmers and development department officials	Trainings conducted	No.	**7**	**22**	**20**	**16**	**18**	**15**	**23**	**100**	**7**	**115.0**	—
		Use of innovative extension methodologies, including ICT, for dissemination of horticultural technologies	Programmes conducted	No.	**8**	**600**	**550**	**500**	**450**	**400**	**608**	**100**	**8**	**110.54**	—
Efficient Functioning of the RFD System	**11**	Timely submission of RFD for 2013-14	On time submission	Date	**2**	**May15, 2013**	**May 16, 2013**	**May 17, 2013**	**May 20, 2013**	**May 21, 2013**	**May20 2013**	**70**	**1.4**		—
		Timely submission	On-time submission	Date	**1**	**May 1, 2013**	**May 2, 2013**	**May 5, 2013**	**May 6, 2013**	**May 7, 2013**	**April 30, 2013**	**100**	**1.0**		—

Implement ISO 9001 as per the approved action plan	% implementation	%	**2**	**100**	**95**	**90**	**85**	**80**	**0**	**0**	**0**	–	–
Prepare an action plan for innovation	On time submission	Date	**2**	**July 30, 2013**	**Aug 10, 2013**	**Aug 20, 2013**	**Aug 30, 2013**	**Sept 10, 2013**	**100% (30-7-2013)**	**100**	**2.0**	–	–
Implementation of Sevottam	Independent Audit of implementation of Citizen Charter	%	**2**	**100**	**95**	**90**	**85**	**80**	**100**	**100**	**2**	–	–
	Independent Audit of implementation of public grievance redressal system	%	**2**	**100**	**95**	**90**	**85**	**80**	**100**	**100**	**2**	–	–
Composite Score:					**97.4**	**-**	**Excellent**						

भाकृअनुप
ICAR

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

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.

November 01, 2014

Director

भा कृ अनु प – भारतीय बागवानी अनुसंधान संस्थान
हेसरघट्टा लेक पोस्ट, बैंगलूरू – 560089

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